

Amendment-VIII dated 03.03.2025 to the Request for Proposal Documents for selection of bidder as Transmission Service Provider to establish “Transmission system for proposed Green Hydrogen / Green Ammonia projects in Tuticorin area” through tariff based competitive bidding process.

Sl. No.	Clause No.	Existing/New Clause	New/Revised Clause
1.	Project Description RFP & TSA	<p>Project Description</p> <p>A meeting was held on 19.10.2023.....</p> <p>...</p> <p>The National Committee on Transmission in its 22nd meeting held on 23.08.2024 has recommended the implementation of the subject transmission scheme through TBCB route and has identified the RECPDCL as BPC for bidding of the transmission scheme.</p> <p>Ministry of Power vide Gazette notification dated 12.09.2024 has notified the transmission scheme for implementation through TBCB route.</p>	<p>Project Description</p> <p>A meeting was held on 19.10.2023.....</p> <p>...</p> <p>The National Committee on Transmission in its 22nd meeting held on 23.08.2024 has recommended the implementation of the subject transmission scheme through TBCB route and has identified the RECPDCL as BPC for bidding of the transmission scheme.</p> <p><u>The scheme was also deliberated in the 25th NCT meeting held on 28.11.2024 wherein it was agreed that the Tuticorin GH S/s may be implemented as GIS instead of AIS. Further, + 300 MVAr STATCOM with 2x125 MVAr MSC at Tuticorin 765/400 kV GH GIS S/s was also agreed.</u></p> <p>Ministry of Power vide Gazette notification dated 12.09.2024 <u>and 26.12.2024</u> has notified the transmission scheme for implementation through TBCB route.</p>
2.	Annexure C Technical Specifications of Transmission System RFP & TSA	<p>The Annexure C enclosed with RFP & TSA stands deleted</p>	<p>Revised Technical Specifications of Transmission System is enclosed.</p>

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3.	2.7.1 of RFP	The Bidders should submit the Bids online through the electronic bidding platform before the Bid Deadline i.e., on or before 1600 hours (IST) on 06.03.2025 . In addition to the online submission, the Bidder with lowest Final Offer will be required to submit original hard copies of Annexure 3, Annexure 4 (if applicable), Annexure 6 (if applicable) and Annexure 14 before issuance of Lol.	The Bidders should submit the Bids online through the electronic bidding platform before the Bid Deadline i.e., on or before 1600 hours (IST) on 20.03.2025 . In addition to the online submission, the Bidder with lowest Final Offer will be required to submit original hard copies of Annexure 3, Annexure 4 (if applicable), Annexure 6 (if applicable) and Annexure 14 before issuance of Lol.																																				
4.	2.7.2 of RFP	<p>Important timelines are mentioned below:</p> <table border="1" data-bbox="401 508 1199 1081"> <thead> <tr> <th data-bbox="401 508 583 545">Date</th> <th data-bbox="583 508 1199 545">Event</th> </tr> </thead> <tbody> <tr> <td data-bbox="401 545 583 618">06.03.2025</td> <td data-bbox="583 545 1199 618">Submission of Bid (Online submission of Bid through electronic bidding portal)</td> </tr> <tr> <td data-bbox="401 618 583 656">06.03.2025</td> <td data-bbox="583 618 1199 656">Opening of Technical Bid</td> </tr> <tr> <td data-bbox="401 656 583 730">17.03.2025</td> <td data-bbox="583 656 1199 730">Shortlisting and announcement of Qualified Bidders on bidding portal</td> </tr> <tr> <td data-bbox="401 730 583 768">18.03.2025</td> <td data-bbox="583 730 1199 768">Opening of Financial Bid - Initial Offer</td> </tr> <tr> <td data-bbox="401 768 583 844">19.03.2025</td> <td data-bbox="583 768 1199 844">Electronic reverse auction (Financial Bid – Final Offer) for the Qualified Bidders.</td> </tr> <tr> <td data-bbox="401 844 583 959">24.03.2025</td> <td data-bbox="583 844 1199 959">Submission of original hard copies of Annexure 3, Annexure 4, Annexure 6, as applicable and Annexure 14 by the bidder with lowest Final Offer</td> </tr> <tr> <td data-bbox="401 959 583 997">27.03.2025</td> <td data-bbox="583 959 1199 997">Selection of Successful Bidder and issue of LOI</td> </tr> <tr> <td data-bbox="401 997 583 1081">07.04.2025</td> <td data-bbox="583 997 1199 1081">Signing of RFP Project Documents and transfer of Tuticorin Power Transmission Limited</td> </tr> </tbody> </table>	Date	Event	06.03.2025	Submission of Bid (Online submission of Bid through electronic bidding portal)	06.03.2025	Opening of Technical Bid	17.03.2025	Shortlisting and announcement of Qualified Bidders on bidding portal	18.03.2025	Opening of Financial Bid - Initial Offer	19.03.2025	Electronic reverse auction (Financial Bid – Final Offer) for the Qualified Bidders.	24.03.2025	Submission of original hard copies of Annexure 3, Annexure 4, Annexure 6, as applicable and Annexure 14 by the bidder with lowest Final Offer	27.03.2025	Selection of Successful Bidder and issue of LOI	07.04.2025	Signing of RFP Project Documents and transfer of Tuticorin Power Transmission Limited	<p>Important timelines are mentioned below:</p> <table border="1" data-bbox="1228 508 2007 1115"> <thead> <tr> <th data-bbox="1228 508 1411 545">Date</th> <th data-bbox="1411 508 2007 545">Event</th> </tr> </thead> <tbody> <tr> <td data-bbox="1228 545 1411 618">20.03.2025</td> <td data-bbox="1411 545 2007 618">Submission of Bid (Online submission of Bid through electronic bidding portal)</td> </tr> <tr> <td data-bbox="1228 618 1411 656">20.03.2025</td> <td data-bbox="1411 618 2007 656">Opening of Technical Bid</td> </tr> <tr> <td data-bbox="1228 656 1411 730">28.03.2025</td> <td data-bbox="1411 656 2007 730">Shortlisting and announcement of Qualified Bidders on bidding portal</td> </tr> <tr> <td data-bbox="1228 730 1411 768">01.04.2025</td> <td data-bbox="1411 730 2007 768">Opening of Financial Bid - Initial Offer</td> </tr> <tr> <td data-bbox="1228 768 1411 844">02.04.2025</td> <td data-bbox="1411 768 2007 844">Electronic reverse auction (Financial Bid – Final Offer) for the Qualified Bidders.</td> </tr> <tr> <td data-bbox="1228 844 1411 997">07.04.2025</td> <td data-bbox="1411 844 2007 997">Submission of original hard copies of Annexure 3, Annexure 4, Annexure 6, as applicable and Annexure 14 by the bidder with lowest Final Offer</td> </tr> <tr> <td data-bbox="1228 997 1411 1034">11.04.2025</td> <td data-bbox="1411 997 2007 1034">Selection of Successful Bidder and issue of LOI</td> </tr> <tr> <td data-bbox="1228 1034 1411 1115">21.04.2025</td> <td data-bbox="1411 1034 2007 1115">Signing of RFP Project Documents and transfer of Tuticorin Power Transmission Limited</td> </tr> </tbody> </table>	Date	Event	20.03.2025	Submission of Bid (Online submission of Bid through electronic bidding portal)	20.03.2025	Opening of Technical Bid	28.03.2025	Shortlisting and announcement of Qualified Bidders on bidding portal	01.04.2025	Opening of Financial Bid - Initial Offer	02.04.2025	Electronic reverse auction (Financial Bid – Final Offer) for the Qualified Bidders.	07.04.2025	Submission of original hard copies of Annexure 3, Annexure 4, Annexure 6, as applicable and Annexure 14 by the bidder with lowest Final Offer	11.04.2025	Selection of Successful Bidder and issue of LOI	21.04.2025	Signing of RFP Project Documents and transfer of Tuticorin Power Transmission Limited
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5.	2.13.1 of RFP	<p>.....</p> <p>Opening of Envelope (Technical Bid): 1630 hours (IST) on <u>06.03.2025</u></p> <p>.....</p> <p>Opening of Initial Offer: Initial Offer shall be opened by the Bid Opening Committee in presence of the Bid Evaluation Committee at 1630 hours (IST) on <u>18.03.2025</u> in the office of CEA.</p>	<p>.....</p> <p>Opening of Envelope (Technical Bid): 1630 hours (IST) on <u>20.03.2025</u></p> <p>.....</p> <p>Opening of Initial Offer: Initial Offer shall be opened by the Bid Opening Committee in presence of the Bid Evaluation Committee at 1630 hours (IST) on <u>01.04.2025</u> in the office of CEA.</p>
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Annexure – C

TECHNICAL SPECIFICATIONS OF TRANSMISSION SYSTEM

SPECIFIC TECHNICAL REQUIREMENTS FOR TRANSMISSION LINE

The design, routing and construction of transmission lines shall be in accordance with Chapter V, Part A of CEA (Technical Standards for Construction of Electrical Plants and Electric Lines) Regulations 2022, as amended from time to time. Other CEA Regulations/ guidelines as amended up to date and Ministry of Power (MoP) guidelines, as applicable, shall also be followed.

- A.1.0 Selection of tower type shall be made as per CEA Regulations, however, in case lattice type towers are used, the following shall also be applicable:
- A.2.0 Steel section of grade E 250 and/or grade E 350 as per IS 2062, only are permitted for use in towers, extensions, gantry structures and stub setting templates. For towers in snowbound areas, steel sections shall conform to Grade-C of IS-2062.
- A.3.0 Towers shall be designed as per IS-802:2015, however the drag coefficient of the tower shall be as follows: -

Solidity Ratio	Drag Coefficient
Up to 0.05	3.6
0.1	3.4
0.2	2.9
0.3	2.5
0.4	2.2
0.5 and above	2.0

- A.4.0 Transmission Service Provider (TSP) shall adopt any additional loading/ design criteria for ensuring reliability of the line, if so desired and /or deemed necessary.
- A.5.0 Transmission line shall be designed considering wind zones as specified in wind map given in National Building Code 2016, Vol.1. The developer shall also make his own assessment of local wind conditions and frequent occurrences of High Intensity Winds (HIW) due to thunderstorms, dust storms, downburst etc. along the line route and wherever required, higher wind zone than that given in wind map shall be considered for tower design for ensuring reliability of line. Further, for transmission line sections passing within a distance of 50 km from the boundary of two wind zones, higher of the two wind zones shall be considered for design of towers located in such sections.
- A.6.0 Selection of reliability level for design of tower shall be as per CEA Regulation (Technical Standards for Construction of Electrical Plants and Electric Lines) Regulations 2022, as amended from time to time.
- A.7.0 A) In case of construction of transmission line of Voltage level of 400 kV and above, under crossing of the existing transmission line shall not be allowed. In the case where it is inevitable to under-cross the existing transmission line then TSP shall seek prior approval from Chief Electrical Inspector, CEA with detailed study

ensuring that all statutory electrical clearances and Electric Field limit of 10 kV/m at 1 m and 1.8 m from ground level is not violated.

B) For power line crossing of 400 kV or above voltage level, large angle and dead end towers (i.e. D/DD/QD) shall be used on either side of power line crossing.

C) For power line crossing of 132 kV and 220 kV (or 230 kV) voltage level, angle towers (B/C/D/DB/DC/DD/QB/QC/QD) shall be used on either side of power line crossing depending upon the merit of the prevailing site condition and line deviation requirement.

D) For power line crossing of 66 kV and below voltage level, suspension/tension towers shall be provided on either side of power line crossing depending upon the merit of the prevailing site condition and line deviation requirement.

E) For crossing of railway tracks, national highways and state highways, the rules/regulations of appropriate authorities shall be followed.

A.8.0 The relevant conductor configuration for 765 kV shall be as follows: -

For all 765 kV lines under present scope:

Type of conductor: ACSR / AAAC / AL59

Basic Parameters:

Transmission line	ACSR Conductor specified	Equivalent AAAC conductor based on 53.5% conductivity of Al Alloy	Equivalent minimum size of AL59 conductor based on 59% conductivity of AL Alloy*	Sub-conductor Spacing
765 kV D/C (Hexa Bundle) Transmission Lines	Zebra : Stranding 54/3.18 mm-Al + 7/3.18 mm-Steel, 428 mm ² , Aluminium area, 28.62 mm diameter Maximum DC Resistance at 20°C (Ω/km): 0.06868 Minimum UTS:	Stranding details: 61/3.19 mm, 487.5 mm ² Aluminium alloy area 28.71 mm diameter Maximum DC Resistance at 20°C (Ω/km): 0.06815 Minimum UTS: 135.6 kN	Stranding details: 61/3.08 mm, 454 mm ² Aluminium alloy area 27.72 mm diameter Maximum DC Resistance at 20°C (Ω/km): 0.0653 Minimum UTS: 108 kN	457 mm

Transmission line	ACSR Conductor specified	Equivalent AAAC conductor based on 53.5% conductivity of Al Alloy	Equivalent minimum size of AL59 conductor based on 59% conductivity of AL Alloy*	Sub-conductor Spacing
	130.32 kN			

Note:

1. *To select any size above the minimum, the sizes mentioned in the Indian standard IS-398 (part-6) shall be followed.
2. The transmission lines shall have to be designed for a maximum operating conductor temperature of 85 deg C.

A.9.0 The required phase to phase spacing and horizontal spacing for 765 kV line shall be governed by the tower design as well as minimum live metal clearances for 765 kV voltage level under different insulator swing angles. However, the phase to phase spacing for 765 kV line shall not be less than 15 m.

A.10.0 All electrical clearances including minimum live metal clearance, ground clearance and minimum mid span separation between earth wire and conductor as given below shall be considered:

Minimum live metal clearances for 765 kV line:

- a) (i) Under stationary conditions
From tower body: For 765 kV D/C: 6.1 m
For 765 kV S/C: 5.6 m
- (ii) Under swing conditions

Wind Pressure Condition	Minimum Electrical Clearance
a) Swing angle (25°)	4.4 m
b) Swing angle (55°)	1.3 m

- b) Minimum ground clearance for 765 kV line: 18 m
c) Minimum mid span separation between earth-wire and conductor for 765 kV line: 9.0 m

A.11.0 The shielding angle shall not exceed 10 deg for 765 kV D/C transmission line.

A.12.0 The Fault current for design of line shall be 50 kA for 1 sec for 765 kV.

A.13.0 In case of 400 kV and above voltage class lines, at least one out of two earth wires shall be OPGW and second earth wire, if not OPGW, shall be either of Galvanized Stranded Steel (GSS) or Aluminum Alloy Conductor Steel Reinforced (AACSR) or any other suitable conductor type depending upon span length and other technical consideration.

A.14.0 Each tower shall be earthed such that tower footing impedance does not exceed 10

ohms. Pipe type or Counterpoise type earthing shall be provided in accordance with relevant IS. Additional earthing shall be provided on every 7 to 8 km distance for direct earthing of both shield wires. If site condition demands, multiple earthing or use of earthing enhancement compound shall be used.

- A.15.0 Pile type foundation shall be used for towers located in river or creek bed or on bank of river having scourable strata or in areas where river flow or change in river course is anticipated, based on detailed soil investigation and previous years' maximum flood discharge of the river, maximum velocity of water, highest flood level, scour depth and anticipated change in course of river based on river morphology data of at least past 20 years to ensure availability and reliability of the transmission line.
- A.16.0 Transmission line route shall be finalized, in consultation with appropriate authorities so as to avoid the habitant zones of endangered species and other protected species. Birddiverters, wherever required, shall be provided on the line. In order to optimize the route, use of GATISHAKTI platform shall also be made.
- A.17.0 Wherever, transmission lines are passing through cyclone prone areas i.e., areas up to 60 km from coast following shall also be applicable:
- a) Terrain category-I, with terrain roughness factor (K2) of 1.08 shall be considered for tower design for exposed open terrain with few or no obstruction, which also includes open sea coasts, open stretch of water, desert and flat treeless plains.
 - b) Importance factor for cyclonic region (K4) of 1.3 shall be considered for tower design.
 - c) The number of consecutive spans between the section points/ angle point shall not exceed 10 spans or 3 km instead of conventional practice of 15 spans or 5 km, in order to reduce the failure of such towers in coastal areas due to cascading effect. The section shall be terminated with tension tower/ angle tower and angle of deviation should be based on the site requirement.
- A.18.0 Wherever, transmission lines are passing through cyclone prone areas (i.e. areas up to 60 km from coast)/ creek regions/ aggressive soil areas following shall also be applicable:
- a) The fabricated tower parts and stubs shall have a minimum overall zinc coating of 900 g/m² of surface area except for plates and sections below 5 mm which shall have a minimum overall zinc coating of 610 g/m² of surface area. The average zinc coating for all sections and plates 5 mm and above shall be maintained as 127 microns and that for plates and sections below 5 mm shall be maintained as 87 microns.
 - b) Ready mix concrete of M30 Grade shall be used to avoid use of locally available saline water. However, design mix concrete of M30 Grade conforming to IS 456 with potable water can be used at locations where transportation of ready-mix concrete is not feasible. Minimum cement content in any case shall not be less than 330 kg/m³.
 - c) The surface of the reinforced steel shall be treated with epoxy-based coating to enhance corrosion performance of foundation. Use of epoxy coated

reinforcement in foundation shall be as per IS 13620. In addition, two (2) coats of bituminous painting of minimum 1.6 kg/m² per coat shall be applied on all exposed faces of foundation (i.e. pedestal and base slab).

- d) Double coat 20 mm thick cement plaster shall be provided on all exposed concrete surface as well as up to 300 mm below the ground level to provide protection to concrete surface from environmental and saline effect.
- e) Before coping of chimney top portion, three coats of anti-corrosive paint of minimum 30-35 microns dry film thickness each shall be applied on the stub in the 50 mm coping portion as well as up to 350 mm above CL portion.

A.19.0 The raised chimney foundation is to be provided in areas prone to flooding/water stagnation like paddy field /agricultural field and undulated areas to avoid direct contact of water with steel part of tower. The top of the chimney of foundation should be at least above High Flood Level(HFL) or the historical water stagnation/ logging level (based on locally available data) or above High Tide Level or 500 mm above Natural Ground level (whichever is higher).

A.20.0 Routing of transmission line through protected areas shall be avoided to the extent possible. In case, it is not possible to avoid protected areas, the towers of the transmission line up to 400 kV level, which are installed in protected areas shall be designed for Multi-circuit (4 circuits) configuration of same voltage level considering reliability level of at least two (2). The top two circuits of these multi-circuit towers shall be used for stringing of the transmission line under present scope and the bottom two circuits shall be made available for stringing of any future transmission line of any transmission service providers/ State transmission utilities/Central transmission utilities passing through the same protected area. Further, the configuration and coordinates of such transmission towers shall be submitted to CEA, CTU and BPC by the TSP.

A.21.0 The TSP shall abide by the Guidelines of CEA w.r.t. shifting of transmission lines for NHAI projects and other projects.

A.22.0 Safety precautions in regard to gas/oil pipelines in vicinity of Transmission lines shall be taken in coordination with gas/ petroleum authorities.

A.23.0 The stringing of the transmission line in forest area shall be carried out through drone.

A.24.0 The tower shall be designed considering the porcelain Insulators with creepage factor of 31 mm/ kV irrespective of type of insulator used.

A.25.0 RoW width and Span in different terrain shall be as per Schedule VII of CEA (Technical Standards for Construction of Electrical plants and Electric Lines) Regulations 2022 and RoW guidelines issued vide CEA-PS-14-86/2/2019-PSETD Division dated 24.09.2024

SPECIFIC TECHNICAL REQUIREMENTS FOR SUBSTATION

The proposed **Tuticorin (GH) S/s** shall be Gas Insulated Switchgear (GIS) type conforming to the requirements of CEA (Technical Standards for Construction of Electrical Plants and Electric Lines) Regulations, 2022, as amended from time to time.

Extension/Upgradation of proposed **Tuticorin PS, Dharmapuri (Salem New) S/s and Madhugiri S/s** shall be conventional AIS type conforming to the requirements of CEA (Technical Standards for Construction of Electrical Plants and Electric Lines) Regulations 2022, as amended from time to time.

Other CEA Regulations/guidelines as amended up to date and MoP guidelines, as applicable, shall also be followed.

B.1.0 Salient features of Substation Equipment and Facilities

The design and specification of substation equipment are to be governed by the following factors:

B.1.1 Insulation Coordination

The system design parameters for substations/switchyards shall be as given below:

Sl. No.	Description of parameters	765/400 kV Tuticorin (GH) S/s (GIS)		765/400 kV Tuticorin PS (AIS)	
		765 kV System	400 kV System	765 kV System	400 kV System
1.	System Operating Voltage	765 kV	400 kV	765 kV	400 kV
2.	Maximum voltage of the system (rms)	800 kV	420 kV	800 kV	420 kV
3.	Rated Frequency	50 Hz	50 Hz	50 Hz	50 Hz
4.	No. of Phases	3	3	3	3
5.	Rated Insulation Levels				
i)	Lightning Impulse Withstand Voltage for (1.2/50 micro sec.)				
	- for Equipment other than Transformer and Reactor	2100 kVp	1425 kVp	2100 kVp	1425 kVp
	- for Insulator String	2100 kVp	1550 kVp	2100 kVp	1550 kVp
ii)	Switching Impulse Withstand Voltage (250/2500 micro sec.) dry and wet	1425 kVp	1050 kVp	1550 kVp	1050 kVp
iii)	One minute power frequency dry withstand voltage (rms)	960 kV	650 kV	830 kV	630 kV
6.	Corona Extinction Voltage	508 kV	320 kV	508 kV	320 kV
7.	Max. radio interference voltage for frequency between 0.5 MHz and 2 MHz	2500 micro-volts at 508 kV rms	1000 micro-volts at 266 kV	2500 micro-volts at	1000 micro-volts at

Sl. No.	Description of parameters	765/400 kV Tuticorin (GH) S/s (GIS)		765/400 kV Tuticorin PS (AIS)	
		765 kV System	400 kV System	765 kV System	400 kV System
			rms	508 kV rms	266 kV rms
8.	Minimum creepage distance for insulator string/ longrod insulators/ outdoor bushings	24800 mm (31 mm/kV)	13020 mm (31 mm/kV)	24800 mm (31 mm/kV)	13020 mm (31 mm/kV)
9.	Minimum creepage distance for switchyard equipment	24800 mm (31 mm/kV)	13020 mm (31 mm/kV)	24800 mm (31 mm/kV)	13020 mm (31 mm/kV)
10.	Max. Fault Current	50 kA	63 kA	50 kA	63 kA
11.	Duration of fault	1 sec	1 sec	1 sec	1 sec

Sl. No.	Description of parameters	765/400 kV Dharmapuri (Salem New) (AIS)		765 kV Madhugiri (AIS)
		765 kV System	400 kV System	765 kV System
1.	System Operating Voltage	765 kV	400 kV	765 kV
2.	Maximum voltage of the system (rms)	800 kV	420 kV	800 kV
3.	Rated Frequency	50 Hz	50 Hz	50 Hz
4.	No. of Phases	3	3	3
5.	Rated Insulation Levels			
i)	Lightning Impulse Withstand Voltage for (1.2/50 micro sec.) - for Equipment other than Transformer and Reactor - for Insulator String	2100 kVp 2100 kVp	1425 kVp 1550 kVp	2100 kVp 2100 kVp
ii)	Switching Impulse Withstand Voltage (250/2500 micro sec.) dry and wet	1550 kVp	1050 kVp	1550 kVp
iii)	One minute power frequency dry withstand voltage (rms)	830 kV	630 kV	830 kV
6.	Corona Extinction Voltage	508 kV	320 kV	508 kV
7.	Max. radio interference voltage for frequency between 0.5 MHz and 2 MHz	2500 micro-volts at 508 kV rms	1000 micro-volts at 266 kV	2500 micro-volts at 508 kV rms

Sl. No.	Description of parameters	765/400 kV Dharmapuri (Salem New) (AIS)		765 kV Madhugiri (AIS)
		765 kV System	400 kV System	765 kV System
			rms	
8.	Minimum creepage distance for insulator string/ longrod insulators/ outdoor bushings	24800 mm (31 mm/kV)	13020 mm (31 mm/kV)	24800 mm (31 mm/kV)
9.	Minimum creepage distance for switchyard equipment	20000 mm (25 mm/kV)	10500 mm (25 mm/kV)	20000 mm (25 mm/kV)
10.	Max. Fault Current	50 kA	63 kA	50 kA
11.	Duration of fault	1 sec	1 sec	1 sec

B.1.2 Switching Scheme

The switching schemes, as mentioned below, shall be adopted at various voltage levels of substation/switchyard:

Substation	765 kV side	400 kV side
765/400 kV Tuticorin (GH) (GIS)	One and Half breaker	One and Half breaker
765/400 kV Tuticorin PS Extn. (AIS)	One and Half breaker	One and Half breaker
765/400 kV Dharmapuri (Salem New) Extn. (AIS)	One and Half breaker	One and Half breaker
765 kV Madhugiri S/s Extn (AIS)	One and Half breaker	----

Notes: -

- i) *For one and half breaker switching scheme, any double circuit line consisting of two numbers of feeders and originating from the same transmission or generating switchyard shall not be terminated in one diameter.*
- ii) *Two transformers of same HV rating shall not be connected in the same diameter and similarly two bus reactors of same HV rating shall also not be connected in the same diameter.*
- iii) *A diameter in one and half breaker scheme is a set of 3 circuit breakers with associated isolators, earth switches, current transformers etc. for controlling 2 (two) numbers of feeders.*
- iv) *In case of GIS substation where the bus scheme is One and Half breaker scheme, the diameters shall be complete with feeder/line side isolator and GIS*

duct of the future bay shall be brought outside the GIS hall/building with extension/interface module suitably.

- v) Connection arrangement of Switchable Line reactors shall be such that it can be used as Line reactor as well as Bus reactor with suitable NGR bypass arrangement. Further, Spare 1-phase Shunt Reactor unit shall be placed and connected in such a way that the spare unit can be utilized for all the bus and switchable line reactor banks (including future reactor banks) without its physical movement.
- vi) Space for 765 kV and 400 kV future line bays shall be kept considering provision of switchable line reactors.
- vii) **Provision for Bus sectionalizer:**
Space for One (1) set of future bus sectionalizer for 400 kV shall comprise Two (2) Nos. of bus sectionalizer bays with associated Circuit Breakers, Isolators and Current Transformers for both buses.
- viii) TSP shall plan connectivity of line and transformer feeders to bus bar in such a way that all power can be evacuated successfully without crossing thermal limit at any point of bus-bar.
- ix) For AIS type substation, TSP shall keep space provisions for future elements such that interconnection arrangement to the corresponding future bays can be done with overhead AIS type connection without any cable/ GIS duct.
- x) **765/400 kV Tuticorin (GH) PS :**

765 kV bay configurations (one and half breaker scheme) shall be as follows:

Configuration	Number of diameters
ICT- Tie- Line	2 (two)
ICT- Tie- Bus Reactor	1 (one)

400 kV bay configurations (one and half breaker scheme) shall be as follows:

Configuration	Number of diameters
ICT (400 kV side of 765/400 kV ICT)- Tie- STATCOM	1 (One)
ICT (400 kV side of 765/400 kV ICT)- Tie- Future Line	2 (Two)

Note (*): GIS modules for Line Bay shall be provided by TSP under present scope.

Provision for future 400 kV Bus Sectionalization shall be with the following feeder distribution.

400 kV Bus Section-1	400 kV Bus Section-2 (Future)
a) 3 Nos. of 765/400 kV ICT b) 1 No. 400 kV STATCOM c) 8 Nos. of Future 400 kV Lines with Switchable line reactor	a) 3 Nos. of Future 765/400 kV ICT b) 1 No. 400 kV future STATCOM c) 8 Nos. of Future 400 kV Lines with Switchable line reactor

- xi) **765/400 kV Tuticorin PS:** SLD (drawing ref. no.: C/Engg/SR/Tuticorin PS-EXT/SLD/01) provided with the RfP is to be referred for termination of 400 kV side of 765/400 kV ICTs.
- xii) **765/400 kV Dharmapuri (Salem New):** SLD (drawing ref. no.: C/Engg/SR/SALEM NEW-EXTN./SLD/01) provided with the RfP is to be referred for termination of 400 kV side of 765/400 kV ICTs.
- xiii) In one and half breaker scheme, both main bay and tie bay shall be completed for controlling a feeder. Further, all associated interconnection work shall also be in the present scope of TSP.

B.2.0 Substation Equipment and Facilities (Voltage level as applicable):

The switchgear shall be designed and specified to withstand operating conditions and duty requirements. All equipment shall be designed considering the following capacity.

Sl. No	Description of bay	765/400 kV Tuticorin (GH)		765/400 kV Tuticorin PS		765/400 kV Dharmapuri (Salem New)		765 kV Madhugiri
		765 kV	400 kV	765 kV	400 kV	765 kV	400 kV	765 kV
1.	Bus Bar	4000 A	5000 A	4000 A	4000 A	4000 A	4000 A	4000 A
2.	Line bay	3150 A	N/A	3150 A	N/A	3150 A	N/A	3150 A
3.	ICT bay	3150 A	3150 A	3150 A	3150 A	3150 A	3150 A	N/A
4.	Reactor bay	3150 A	N/A	3150 A	N/A	3150 A	N/A	N/A
5.	STATCOM Bay	N/A	3150 A	N/A	N/A	N/A	N/A	N/A

B.2.1 (765/√3)/(400/√3)/33 kV, Single Phase Autotransformer

500 MVA, (765/√3)/(400/√3)/33 kV, 1-phase autotransformer (including arrangement for 3-phase bank formation of 1500 MVA) shall conform to CEA's "Standard Specifications and Technical Parameters for Transformers and Reactors (66 kV and above voltage class)" as amended up to date available on CEA's website.

Spare 1-phase Transformer unit shall be placed and connected in such a way that the spare unit can be utilized to replace any unit of any of the transformer banks (including for future transformer banks) without physically moving it.

B.2.2 (765/√3) kV, Single Phase Shunt Reactor

80 MVAR and 110 MVAR, 765/√3 kV, 1-Phase Reactor (including arrangement for 3-phase bank formation of 240 MVAR and 330 MVAR, respectively) shall conform to

CEA's "Standard Specifications and Technical Parameters for Transformers and Reactors (66 kV and above voltage class)" as amended up to date available on CEA website.

Spare 1-phase Shunt Reactor unit shall be placed and connected in such a way that the spare unit can be utilized for all the bus and **switchable** line reactor banks (including for future reactor banks) without its physical movement.

Neutral Grounding Reactor and Surge Arrester for 765 kV Switchable Line Reactors (as applicable):

The neutral of the switchable line reactors (wherever provided) shall be grounded through adequately rated Neutral Grounding Reactors (NGR) to facilitate single phase auto-reclosure, provided that the NGR shall be provided with suitable bypass arrangement so that the switchable line reactor can be used as bus reactor as and when required. The neutral of bus reactor shall be solidly grounded.

NGR shall be oil filled or dry type air core for outdoor application. NGR shall conform to CEA's "Standard specifications and technical parameters of transformers and reactors (66 kV and above Voltage Class)", as amended up to date. Technical parameters of NGR shall be as specified in Annexure-A of above-mentioned document.

The surge arresters (rated voltage of arrester in co-ordination with ohmic value of NGR shall be decided by the TSP) shall be provided and physically located between the neutral of shunt reactor (brought out at 145 kV class bushing) and neutral grounding reactor. The surge arresters shall be of Station Medium (SM) class duty gapless Metal Oxide (ZnO) type conforming in general to IEC-60099-4. Arresters shall be hermetically sealed units, of self-supporting construction, suitable for mounting on structures.

The Ohmic value of NGR for Line Reactors shall be as follows:

Sl. No.	Line Name	Substation Name	NGR value (Ohm)
1.	Upgradation of Tuticorin PS - Dharmapuri (Salem New) 765 kV D/C line (presently charged at 400 kV level) at its rated 765 kV voltage level with 1x330 MVAR switchable Line Reactor on both ends of each circuit	Tuticorin PS end	500
		Dharmapuri (Salem New) end	500
2.	Upgradation of Dharmapuri (Salem New) – Madhugiri 765 kV 2xS/C lines (presently charged at 400 kV) to its rated voltage at 765 kV with 1x330 MVAR switchable Line Reactor on Dharmapuri (Salem New) end of each circuit	Dharmapuri (Salem New)	500

B.2.3 765 kV and 400 kV GIS Substation equipment

GIS (Gas Insulated Switchgear) shall be Indoor type in accordance to IEC: 62271-203.

The switchgear shall be designed and specified to withstand operating conditions and duty requirements. All the switchgear such as Circuit Breaker, isolator, earth switch including CT, PT etc. shall be GIS type. The Surge Arrestor and Voltage Transformer shall be either GIS or outdoor AIS type.

The GIS assembly shall consist of separate modular compartments e.g. Circuit Breaker compartment, Bus bar compartment filled with SF₆ Gas and separated by gas tight partitions so as to minimize risk to human life, allow ease of maintenance and limit the effects of gas leaks failures and internal arcs etc. These compartments shall be designed to minimize the risk of damage to adjacent sections and protection of personnel in the event of a failure occurring within the compartments. Rupture diaphragms with suitable deflectors shall be provided to prevent uncontrolled bursting pressures developing within the enclosures under worst operating conditions, thus providing controlled pressure relief in the affected compartment. The arrangement of gas sections or compartments shall be such as to facilitate future extension of any make without any drilling, cutting or welding on the existing equipment. To add equipment, it shall not be necessary to move or dislocate the existing switchgear bays. The layout of Gas Insulated Bus Ducts shall be properly planned to optimize the length of bus ducts and for easy accessibility for maintenance. The length of busbars, bus ducts, isolator sections shall be optimized considering effects of fast transient voltage due to isolator operations.

The bus bar modules including auxiliary bus modules (wherever applicable) shall be provided with suitable End Piece (Interface) module **on both sides** with the test link facility for future extension as per provisions of future requirements. The end piece module shall be designed in such a way so that future GIS modules may be tested without extending test voltage to existing bus and vice-versa by removing the test link.

TSP shall make available the complete details for the design of interface module such as cross section, enclosure material, enclosure dimensions (inner and outer), Flange diameter (inner and outer), conductor cross-section and connection arrangement, bolt spacing and dimension, rated gas pressure, Gasket detail etc. Further, adequate space for GIS busbar interface module shall be taken into account for future scope.

Each section shall have plug-in or easily removable connection pieces to allow for easy replacement of any component with the minimum disturbance to the remainder of the equipment. Inspection windows (View Ports) shall be provided for Disconnectors Switches and both type of earth switches i.e. Maintenance and fast operating.

Local Control Cabinets (LCC) shall be provided as per requirement. The alarm and annunciation of GIS equipment shall be wired to the SCADA System.

The material and thickness of the enclosures shall be such as to withstand an internal flashover without burns through for a period of 300 ms at rated short time withstand current. The material shall be such that it has no effect of environment as well as from the by-products of SF₆ breakdown under arcing conditions. This shall be validated with Type Test.

Service continuity requirement for GIS:

The GIS equipment with the given bus switching arrangement shall be divided into different gas compartments. During the work such as a fault repair or major

maintenance, requiring the dismantling of a gas compartment for which more than one compartments may need to be de-gassed.

TSP shall meet following Service continuity conditions (to the extent possible) with ensuring equipment and operating personnel's safety:

- For One and half breaker bus switching scheme, during a fault in Circuit Breaker compartment, no bus bar and feeder is permitted out of service during maintenance and repair/replacement.
- During a fault in a GIS compartment other than the Circuit Breaker compartment, maximum of one bus bar and/or one feeder is permitted out of service during maintenance and repair/replacement.

UHF sensors in GIS for PD (Partial Discharge) detection:

The adequate number of Ultra High Frequency (UHF) sensors shall be provided in the offered GIS along with suitable portable type Partial Discharge (PD) measuring instrument for detection of Partial discharge (of 5 pC and above as per IEC 60270). The number and location of these sensors shall be based on laboratory tests on the typical design of GIS as per recommendations of CIGRE Document No. 654 (Application Guide for sensitivity verification for UHF Partial discharge detection system for GIS).

B.2.3.1 Circuit Breakers (GIS)

GIS Circuit breakers shall in general be of C2-M2 class and comply to IEC-62271-100. The rated break time shall not exceed 40 ms (milli second) for 765 kV and 400 kV. Circuit breakers shall be suitable for single phase and three phase auto reclosing. Each breaker would have two sets of trip circuits which would be connected to separate DC supplies for greater reliability. The Circuit breakers controlling 765 kV lines shall be provided either with pre-insertion closing resistor of about 450 ohms with 9 ms insertion time or with Controlled Switching Device (CSD). The Circuit breakers controlling 400 kV lines wherever required shall be provided with pre-insertion closing resistor of about 400 ohms with 8 ms insertion time or Controlled Switching Device (CSD) for lines longer than 200 km. The short line fault capacity shall be the same as the rated capacity and this is proposed to be achieved without use of opening resistors. Controlled switching device shall be provided in the Circuit Breaker of the switchable line reactor bay and in Main and Tie bay circuit breakers of line with non-switchable line reactors, Bus reactors and Transformers for 400 kV and above voltage class.

B.2.3.2 Isolators (GIS)

The isolators shall comply to IEC 62271-102 in general. Earth switches shall be provided at various locations to facilitate maintenance. Main blades and earth blades shall be interlocked and interlock shall be fail safe type. All isolators and earth switches shall be motor operated type.

The isolator shall be of extended mechanical endurance class-M2 and suitable for Bus Transfer Current Switching duty as per IEC standards. High speed earthing switches shall be provided for grounding purposes at overhead line terminations and cable terminations and shall have fault making capability as specified. Earth switch for line isolator shall be of earthing switch class E1 and shall be suitable for induced current

switching duty as defined for Class-B as per relevant standard.

B.2.3.3 Current Transformers (GIS)

Current Transformers shall comply with IEC 61869 in general. All ratios shall be obtained by secondary taps only. Generally, Current Transformers (CT) shall have five cores (four for protection and one for metering) whereas; CT in Tie bays shall have six cores (four for protections and two for metering) suitably distributed on both sides of CB (for 400 kV and above voltage class). The burden and knee point voltage shall be in accordance with the requirements of the system including possible feeds for telemetry. The accuracy class for protection core shall be PX and for the metering core it shall be 0.2S. The rated burden of cores shall be closer to the maximum burden requirement of metering and protection system (not more than 20 VA for metering core) for better sensitivity and accuracy.

The instrument security factor shall be less than 5 for CTs up to 400 kV voltage class and less than 10 for CTs of 765 kV voltage class.

B.2.3.4 Voltage Transformer (GIS)

The voltage transformers shall conform to IEC-61869. Voltage transformers shall be of electromagnetic type with SF₆ gas insulation. The earth end of the high voltage winding and the ends of the secondary winding shall be brought out in the terminal box. The voltage transformers shall be located as a separate bay module and will be connected phase to ground and shall be used for protection, metering and synchronization. The voltage transformers shall be of inductive type, nonresistant and shall be contained in their own-SF₆ compartment, separated from other parts of installation. The voltage transformer shall be effectively shielded against high frequency electromagnetic transients. The voltage transformer shall have three secondary windings out of which two shall be used for protection and one for metering. The voltage transformer should be thermally and dielectrically safe when the secondary terminals are loaded with the guaranteed thermal burdens. The accuracy class for protection cores shall be 3P. The accuracy of 0.2 on metering core should be maintained throughout the entire burden range on all the three windings without any adjustments during operation. The rated burden of cores shall be closer to the maximum burden requirement of metering and protection system (not more than 50 VA for metering core) for better sensitivity and accuracy.

B.2.3.5 Surge Arresters (GIS) (if applicable)

624 kV Station High (SH) duty and 336 kV Station High (SH) duty gapless type Surge arresters with thermal energy (W_{th}) of minimum 13 kJ/ kV and 12 kJ/ kV respectively shall be provided for 800 kV and 420 kV system respectively conforming to IEC 60099-4 in general. Other characteristics of Surge arrester shall be chosen in accordance with system requirements. Surge arresters shall be provided at line entrances, near transformers and Reactors so as to achieve proper insulation coordination. A leakage current monitor with surge counter shall be provided with each surge arrester.

B.2.3.6 SF₆ to Air Bushing

Outdoor bushings, for the connection of conventional external conductors to the SF₆

metal enclosed switchgear, shall be provided. Bushings shall generally be in accordance with the requirements of IEC-60137. The creepage distance over the external surface of outdoor bushings shall not be less than 31 mm/ kV. SF₆ to air Bushing shall be of Polymer/ composite type and shall be robust and designed for adequate cantilever strength to meet the requirement of seismic conditions. The electrical and mechanical characteristics of bushings shall be in accordance with IEC-60137. Polymer/composite insulator shall be seamless sheath of silicon rubber compound. The housing and weather sheds should have silicon content of minimum 30% by weight. It should protect the bushing against environmental influences, external pollution and humidity. The hollow silicon composite insulators shall comply with the requirements of IEC 61462 and the relevant parts of IEC-62217.

B.2.4 765 kV and 400 kV AIS Substation equipment (as applicable)

B.2.4.1 Circuit Breakers (AIS)

The circuit breakers and accessories shall conform to IEC: 62271-100, IEC: 62271-1 and shall be of SF₆ Type. The circuit breakers shall be of class C2-M2 (as per IEC) with regard to restrike probability during capacitive current breaking and mechanical endurance. The rated break time shall not exceed 40 ms for 765 kV and 400 kV circuit breakers. The 765 kV and 400 kV circuit breakers shall be provided with single phase and three phase auto reclosing. Each breaker would have two sets of trip circuits, which would be connected to separate DC supplies for greater reliability. The circuit breakers controlling 765 kV lines shall be provided either with pre-insertion closing resistor of about 450 ohm maximum with 9 ms insertion time or with Controlled Switching Device. The Circuit breakers controlling 400 kV lines shall be provided with pre insertion closing resistor of about 400 ohm with 8 ms insertion time or Controlled Switching Device (CSD) for lines longer than 200 km. The short line fault capacity shall be same as the rated capacity and this is proposed to be achieved without use of opening resistors. The controlled switching device shall be provided in circuit breakers of switchable line reactor bay and in Main and Tie bay circuit breakers of line with non-switchable line reactors, Bus Reactors and Transformers of voltage class 400 kV and above.

B.2.4.2 Isolators (AIS)

The isolators shall comply with IEC 62271-102 in general. 765 kV Isolator design shall be double break or vertical break or knee-type. 400 kV isolators shall be double break type. All isolators and earth switches shall be motor operated. Earth switches shall be provided at various locations to facilitate maintenance. Isolator rated for 400 kV shall be of extended mechanical endurance class – M2 as per IEC-62271-102. Main blades and earth blades shall be interlocked and interlock shall be fail safe type. The 765 kV and 400 kV earth switches for line isolator shall be suitable for induced current switching duty as defined for Class-B.

B.2.4.3 Current Transformers (AIS)

Current Transformers shall comply with IEC 61869 in general. All ratios shall be obtained by secondary taps only. Generally, Current Transformers (CT) for 765 kV and 400 kV shall have six cores (four for protection and two for metering). The burden

and knee point voltage shall be in accordance with the requirements of the system including possible feeds for telemetry. The accuracy class for the protection core shall be PX and for the metering core it shall be 0.2S. The rated burden of cores shall be closer to the maximum burden requirement of the metering and protection system (not more than 20 VA for metering core) for better sensitivity and accuracy. The instrument security factor shall be less than five (5) for CTs up to 400 kV and less than ten (10) for CTs of 765 kV voltage class.

B.2.4.4 Capacitive Voltage Transformers (AIS)

Capacitive Voltage Transformers shall comply with IEC 61869 in general. These shall have three secondaries out of which two shall be used for protection and one for metering. The Accuracy class for protection cores shall be 3P and for metering core shall be 0.2. The Capacitive Voltage Transformers on lines shall be suitable for Carrier Coupling. The Capacitance of CVT for 400 kV shall be of 4400/8800 pF depending on PLCC requirements whereas the Capacitance of CVT for 765 kV shall be 8800 pF. The rated burden of cores shall be closer to the maximum burden requirement of metering and protection system (not more than 50 VA for metering core) for better sensitivity and accuracy.

B.2.4.5 Surge Arresters (AIS)

624 kV and 336 kV Station High (SH) duty gapless type Surge Arresters with thermal energy (W_{th}) of minimum 13 kJ/kV and 12 kJ/kV conforming to IEC 60099-4 in general shall be provided for 800 kV and 420 kV systems respectively. Other characteristics of Surge Arrester shall be chosen in accordance with system requirements. Surge arresters shall be provided at line entrances, near transformers and reactors so as to achieve proper insulation coordination. Surge Arresters shall be provided with porcelain/ polymer housing fitted with pressure relief devices. A leakage current monitor with surge counter shall be provided with each surge arrester.

B.2.5 Protection Relaying and Control System

The protective relaying system proposed to be provided for transmission lines, auto-transformers, reactors and bus bars to minimize the damage to the equipment in the events of faults and abnormal conditions, is dealt in this section. All main protective relays shall be numerical type with IEC 61850 communication interface and should have interoperability during integration of numerical relays to communicate over IEC61850 protocol with RTU/SAS/IEDs of different OEMs. All numerical relays shall have built in disturbance recording feature.

The protection circuits and relays of transformer and reactor 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 groups failing, to obtain redundancy, and to take protection systems out for maintenance while the equipment remains in service.

a) Transmission Lines Protection

765 kV lines shall have Main-I numerical three zone distance protection scheme with carrier aided inter-tripping feature. 765 kV lines shall also have Main-II numerical distance protection scheme like Main-I but from different make that of Main-I. The Main-I and Main-II protection relays of same make may be provided only if they are of different hardware and manufacturing platform or different principle of operation.

However, Line Current Differential Relay (with back up distance protection feature) as Main-I and Main-II shall be considered at both ends for short lines (line length below 30 km) having Fibre Optic Communication Link. Differential relay at remote end shall be provided by the TSP. The associated power and control cabling and integration with SAS at remote end shall be provided by respective bay owners.

In case of loop in loop out of transmission lines, the existing protection scheme shall be studied and suitable up-gradation (if required) shall be carried out.

Further, all 765 kV lines shall be provided with single and three phase auto-reclosing facility to allow reclosing of circuit breakers in case of transient faults. These lines shall also be provided with distance to fault locators to identify the location of fault on transmission lines.

All 765 kV lines shall also be provided with two stage over voltage protection. The over voltage protection and distance to fault locator may be provided as in-built feature of Main-I and Main-II protection relays. Auto reclose as built-in function of Bay Control Unit (BCU) is also acceptable.

The Main-I and Main-II protection relays shall be fed from separate DC sources and shall be mounted in separate panels.

For 765 kV transmission lines, directional Inverse Definite Minimum Time (IDMT) earth fault relay should be provided as standalone unit or in-built feature of Main-I and Main-II feature.

b) Auto Transformer Protection

These shall have the following protections:

- i) Numerical Differential Protection
- ii) Numerical Restricted Earth Fault Protection
- iii) Numerical Back-up Over-Current and Earth Fault Protection on High Voltage (HV) and Intermediate Voltage (IV) side
- iv) Numerical Over Fluxing Protection on HV and IV side
- v) Numerical Overload Alarm

Further, Numerical Back-up Over-current and earth fault protection on HV and IV side of autotransformer shall not be combined with other protective functions in the main relays and shall be independent relays. Besides these, power transformers shall also be provided with Buchholz relay, Magnetic Oil Gauge (MOG) with low oil level alarm, protection against high oil and winding temperature and pressure relief device etc.

Suitable monitoring, control (operation of associated circuit breaker and isolator) and protection for LT auxiliary transformer connected to tertiary winding of auto-

transformer for the purpose of auxiliary supply shall be provided. The over current and other necessary protection shall be provided for the auxiliary transformer. These protection and control may be provided as built-in feature either in the bay controller to be provided for the auxiliary system or in the control and protection IEDs to be provided for autotransformer.

c) Reactor Protection

Reactor shall be provided with the following protections:

- i) Numerical Differential Protection.
- ii) Numerical Restricted Earth Fault Protection
- iii) Numerical Back-up impedance protection

Besides these, reactors shall also be provided with Buchholz relay, Magnetic Oil Gauge (MOG) with low oil level alarm, protection against oil and winding temperatures and pressure relief device, etc.

d) Bus bar Protection

The high-speed low impedance type bus bar differential protection, which is essential to minimize the damage and maintain system stability at the time of bus bar faults, shall be provided for 765 kV and 400 kV buses. Duplicated bus bar protection is envisaged for 765 kV and 400 kV bus-bar protection. Bus bar protection scheme shall be such that it operates selectively for each bus and incorporate necessary features required for ensuring security. The scheme shall have complete bus bar protection for present as well as envisaged future bays i.e. input / output modules for future bays shall also be provided.

Bus Bar protection system for new substation shall be de-centralized (distributed) type.

The scheme shall have complete bus bar protection for present as well as envisaged future bays i.e. input/ output modules for future bays for the bus sections under present scope and PUs shall be provided by the respective bay owners. In case, the bus section is provided, then each side of bus section shall have separate set of bus bar protection schemes.

For existing substations, the existing bus bar protection shall be augmented as per requirement.

e) Local Breaker Back up Protection

This shall be provided for each 765 kV and 400 kV circuit breakers and will be connected to de-energize the affected stuck breaker from both sides.

Notes:

1. *LBB and REF relays shall be provided separately from transformer differential relay.*
2. *LBB relay may also be provided as built-in protection function of distributed bus bar protection scheme; however in such case separate LBB relay shall be provided for tie bays (in case of One and Half breaker scheme).*

3. *Over fluxing and overload protection can be provided as built-in feature of differential relay.*
4. *In 765 kV and 400 kV switchyard, if spare bay of half diameter is identified as future, Tie CB relay panel shall be with Auto-reclosure feature.*

B.2.6 Substation Automation System

- a) For all the new substations, state of art Substation Automation System (SAS) conforming to IEC-61850 shall be provided. The distributed architecture shall be used for Substation Automation System, where the controls shall be provided through Bay Control Units. The Bay Control Unit is to be provided bay wise for voltage level 220 kV and above. All Bay Control Units as well as protection units are normally connected through an Optical fibre high speed network. The control and monitoring of circuit breaker, dis-connector, re-setting of relays etc. can be done from Human Machine Interface (HMI) from the Control Room.

The functions of control, annunciation, disturbance recording, event logging and measurement of electrical parameters shall be integrated in the Substation Automation System.

At new substations, the Substation Automation System (SAS) shall be suitable for operation and monitoring of the complete substation including proposed future bays/elements.

In existing substations with Substation Automation System (SAS), augmentation of existing SAS shall be done for bays under present scope.

In existing Substations where Substation automation is not provided, control functions shall be done through control panels.

Necessary gateway and modems (as required) shall be provided to send data to RLDC/SLDC as per their requirement and shall be provisioned with 2+2 redundancy i.e. 2 channels for Main Control Centre and 2 channels for Backup Control Centre. In order to meet this requirement, suitable redundancy at port and card level need to be ensured by the TSP to avoid any single point of failure which may lead to interruption in real-time grid operation. Accordingly, all the hardware for communication services of station as stated above shall support dual redundancy for data transmission of station to respective main and backup RLDCs. Any augmentation work at RLDC/SLDC is excluded from TSP's scope. However, all the configuration work at substation end required to send data to RLDC/SLDC shall be in the scope of TSP.

b) Time Synchronization Equipment

Time Synchronization Equipment complete in all respect including antenna, cable, processing equipment required to receive time signal through GPS or from National Physical Laboratory (NPL) through INSAT shall be provided at new substations. This equipment shall be used to synchronize SAS and IEDs etc.

B.3.0 Substation Support Facilities

Certain facilities required for the operation and maintenance of substations as described below shall be provided at the new substation. In existing substation, these facilities have already been provided and shall be extended/ augmented as per requirement.

B.3.1 AC and DC power supplies

For catering the requirements of three phase and single phase AC supply and DC supply for various substation equipment (for present and future scope), the following arrangement is envisaged:-

- i) For LT Supply at each new Substation, two (2) Nos. of LT Transformers (minimum 800 kVA for substations with highest voltage rating as 765 kV) shall be provided which shall be fed from two independent sources as per the CEA (Technical Standards for Connectivity to the Grid) Regulations, 2007.

Metering arrangement with Special Energy Meters (SEMs) shall be provided by TSP at 33 kV tertiary of Transformer for drawing auxiliary supply at new substation. Such SEMs shall be provided by CTU at the cost of the TSP. Accounting of such energy drawn by the TSP shall be done by RLDC/RPC as part of Regional Energy Accounting.

Additionally, Active Energy Meters may be provided at the same point in the 33 kV tertiary of Transformer by local SEB/DISCOM for energy accounting.

- ii) 2 sets of 220V battery banks for control and protection and 2 sets of 48 V battery banks for PLCC/ communication equipment shall be provided at each new Substation. Each battery bank shall have a float-cum-boost charger.

At new substation, sizing of 220 V battery and battery charger shall be done based on the number of bays specified (including future bays) as per CEA Regulations and relevant IS. 2 sets of 48 V battery banks for PLCC and communication equipment for present and future scope shall be provided at each new Substation with at least 10-hour battery backup and extended backup, if required. 48 V DC can be achieved from 220 V DC battery bank using adapter, if so desired by TSP, without compromising backup time.

- iii) Suitable AC and DC distribution boards and associated LT Switchgear shall be provided at new substation.

- iv) For new substation, following switch boards shall be considered with duplicate supply with bus coupler/ sectionalizer and duplicate outgoing feeders except for Emergency lighting distribution board which shall have only one incoming feeder:

- (a) 415 V Main Switch board – 1 No.
- (b) AC distribution board – 1 No.
- (c) Main lighting distribution board – 1 No.
- (d) Emergency lighting distribution board – 1 No.
- (e) 220 Volt DC distribution board – 2 Nos.
- (f) 48 Volt DC distribution board – 2 Nos.

Sizing of LT Switchgear shall be suitable to cater the requirement for all present and

future bays. AC and DC distribution boards shall have modules for all the feeders (including future as specified).

- v) At new Substation, one No. of DG set (minimum 500 kVA for substations with highest voltage rating as 765 kV) shall be provided for emergency applications.
- vi) At new substation, sizing of battery and battery chargers shall be done based on the number of bays specified (including future bays).
- vii) For substation extensions, existing facilities shall be augmented as required.

B.3.2 Fire Fighting System

Fire-fighting system for substation including Transformer and Reactor shall conform to CEA (Measures Relating to Safety and Electric Supply) Regulations, 2023 as amended from time to time.

Further, adequate water hydrants and portable fire extinguishers shall be provided in the substations. The main header of the firefighting system shall be suitable for extension to bays covered under the future scope; necessary piping interface in this regard shall be provided.

Optical Beam type heat detection for GIS hall fire protection system shall be provided for all the GIS halls.

At existing substations, the fire-fighting systems as available shall be extended to meet the additional requirements.

B.3.3 Oil evacuating, Filtering, Testing and Filling apparatus

To monitor the quality of oil for satisfactory performance of transformers, shunt reactors and for periodical maintenance necessary oil evacuating, filtering, testing and filling apparatus would be provided at new substations. Oil storage tanks of adequate capacities for storage of transformer oil would be provided.

Online Transformer Oil Drying Out System (TODOS) shall be provided in line with the provisions of Standard Specification and Technical Parameters for Transformers and Reactors (66 kV and above Voltage Class) as amended up to date available on CEA website.

B.3.4 Illumination

Normal and emergency AC and DC illumination shall be provided adequately in the control room and other buildings of the substation. The switchyard shall also be provided with adequate illumination.

The lighting of the entire control room building, fire-fighting pump house, other building (if any) and switchyard shall be done by LED based low power consumption luminaries.

B.3.5 Control Room

For the new substation, substation control room shall be provided to house substation work stations for station level control (SAS) along with its peripheral and

recording equipment, AC and DC distribution boards, DC batteries and associated battery chargers, Fire Protection panels, Telecommunication panels and other panels as per requirements. Air conditioning shall be provided in the building as functional requirements. Main cable trenches from the control room shall have adequate space provision for laying of cables from the control room for all the future bays.

At existing substations, the adequacy of size of control room shall be ascertained and the same shall be augmented as per requirement.

B.3.6 GIS hall

The Gas Insulated Switchgear (GIS) of each voltage level along with other associated equipment shall be housed inside **separate** GIS building. The panels i.e. Bay level units, bay mimic, relay and protection panels, RTCC panels, PLCC panels, panels for telecommunication system etc. are to be placed in a separate room in the GIS building. The size of the room shall be such that all the panels for the bays under present scope shall be accommodated. The panel room shall be air-conditioned. Further, the temperature of the room shall be monitored through substation automation system by providing necessary temperature transducers. Ventilation system of suitable capacity shall be provided for each GIS hall. **GIS hall shall be constructed in such a way that its extension does not cause any hindrance to accommodate the bays of future expansion of substation.**

One EOT Crane of suitable capacity for erection and Maintenance of largest GIS component/assembly and all plant installed in the GIS switchgear room shall be provided in each GIS hall. The crane shall be capable of fulfilling all special requirements for erection and maintenance of GIS equipment. The capacity of the crane shall be sized to lift the heaviest GIS switchgear component.

B.3.7 Control Concept

All the EHV circuit breakers in substation/switching stations shall be controlled and synchronized from the switchyard control room/remote control center. All the isolators shall have control from remote/local whereas the earth switches shall have local control only.

B.3.8 Visual Monitoring System (VMS) for watch and ward of substation premises:

Visual Monitoring System for effective watch and ward of substation premises shall cover all the transformers and reactors, all other major AIS Equipment (such as CB, isolators, CT, CVT, SA etc. as applicable), GIS Bays, panel room, all the gates of switchyard and all entry and exit points of control room building and accordingly the location of cameras shall be decided. In addition to the gates of the switchyard, the cameras shall also be located around the boundaries at suitable locations. The camera shall be high-definition color CCD camera with night vision feature. The VMS data partly/completely shall be recorded (minimum for 15 days) at least @25fps (or better) and stored on network video recorder. The system shall use video signals from various cameras installed at different locations, process them for viewing on workstations/monitors in the control room and simultaneously record all the cameras.

The VMS data should go only to the intended personnel/facility and not to the remote server of the Camera (VMS supplier).

Mouse/keyboard controllers shall be used for pan, tilt, zoom and other functions of the desired camera. The Visual Monitoring System shall have provision of WAN connectivity for remote monitoring.

All camera recordings shall have Camera ID and location/area of recording as well as date/time stamp. The equipment should generally conform to Electromagnetic compatibility requirement for outdoor equipment in EHV substation.

Advisory on deployment of CCTV issued by Ministry of Electronics and Information Technology (MEITY) shall be followed.

At existing substations, the Visual Monitoring System if available shall be augmented as per existing or better specification as required.

B.4 General Facilities

- a) Line Gantry/Towers are envisaged for bays under the present scope only. However, for adjacent future line bay, gantry/tower shall be designed for extension (considering hexa conductors for 765 kV, Quad conductors for 400 kV and Twin conductor for 220 kV future lines) wherever applicable.
- b) Bay extension works at existing substation shall be executed by TSP in accordance with the requirement/provisions mentioned above. However, interface points shall be considered keeping in view the existing design/arrangement at the substation.
- c) TSP has to arrange for construction power and water on its own.
- d) All outdoor steel structures including anchor/foundation bolts shall be fully galvanized. The weight of the zinc coating shall be at least 610 g/m², however, for coastal/creek regions it shall be at least 900 g/m². (if applicable)
- e) In 765 kV and 400 kV switchyard, if spare bay of half diameter is identified as future, all the equipment for Tie and Future bay shall be designed considering the current rating of line bay i.e. 3150 A.
- f) Boundary wall shall be brick masonry wall with RCC frame or Stone masonry wall or Precast RCC wall under present scope along the property line of complete substation area including future switchyard area to prevent encroachment and unauthorized access. Minimum height of the boundary wall shall be of 1.8 m from Finished Ground Level (FGL).
- g) All electrical equipment shall be installed above the Highest Flood Level (HFL) and where such equipment is not possible to be installed above

Highest Flood Level, it shall be ensured that there is no seepage or leakage or logging of water.

- h) As per CEA (Technical Standards for Construction of Electrical Plants and Electric Lines) Regulations 2022/CEA Manual on Transmissions Planning criteria 2023, line approaching substation shall normally be perpendicular to the substation boundary for a stretch of 2-3 km. Accordingly, TSP shall ensure that line terminations at substations are arranged in a manner to avoid hindrance to future line terminations at the substations.

B.5 EXTENSION OF EXISTING SUBSTATION

The following drawings/details of existing substation are enclosed at **Appendix A** for further engineering by the bidder.

Sl. No.	Drawing Title	Drawing No./Details	Rev. No.
A.	Tuticorin PS		
1.0	Single Line Diagram	C/Engg/SR/Tuticorin PS-EXT/SLD/01	
2.0	General Arrangement	C/Engg/SR/Tuticorin PS- EXT/GA/01	
3.0	Earthmat Layout	O13056-E-SY-SY-GL-1010	A
4.0	Visual Monitoring System	Make : Qognify and Model: NiceVision Drawing No.- DEL-VMS-TUTI-001	
5.0	Bus Bar Protection	NR Electric (PCS 915)	
6.0	Substation Automation System (SAS)	NR Electric (PCS 9700) Drawing attached	
B.	Dharmapuri (Salem New)		
1.0	Single Line Diagram	C/Engg/SR/SALEM NEW-EXTN./SLD/ 01	0
2.0	General Arrangement	C/Engg/SR/SALEM NEW-EXTN./GA/01	0
3.0	Earthmat Layout	1-BP06-DSSYD-3-026	0
4.0	Visual Monitoring System	Make : Qognify and Model: NiceVision	
5.0	Bus Bar Protection	SIEMENS (SIPROTEC 7SS52)	
6.0	Substation Automation System (SAS)	SIEMENS PAS	
C.	Madhugiri S/s		
1.0	Single Line Diagram	C/Engg/Madhugiri-EXTN./400kV/SLD/ 001	0
2.0	General Arrangement	C/Engg/Madhugiri-EXTN./400kV/GA/ 001	0
3.0	Earthmat Layout	1TEIEA1615006XX	R0
4.0	Visual Monitoring System	Make/Model-Axis/ P5635E MK-II, Control Application-Nice Vision. (drawing attached)	

Sl. No.	Drawing Title	Drawing No./Details	Rev. No.
5.0	Bus Bar Protection	SIEMENS (SIPROTEC 7SS52)	
6.0	Substation Automation System (SAS)	Siemens/SICAM PAS-V 8.X (Drawing no. G719EA-MG9133-01-C500)	0

Note: The existing drawings provided above and in subsequent amendments to the RfP are as received from the developer of existing substation and provided only for reference. Bidders shall follow the RfP for scope of work. Actual site conditions may be different due to other schemes being executed or subsequent revisions by the developer. Thus, Bidders are advised to visit the substation sites and acquaint themselves with the actual site conditions, layout, topography, infrastructure such as the requirement of roads, cable trench, drainage, boundary etc. and also the design philosophy.

LOCATION DETAILS OF EXISTING / PLANNED SUBSTATIONS

a) 765/400/220 kV Tuticorin (GH):

New substation which is to be implemented under present scheme

b) 765 kV Dharmapuri (Salem New) S/s: 12° 7'52.81"N, 78° 1'42.14"E

c) 765 kV Tuticorin PS: 9° 7'33.55"N, 78° 0'6.90"E

d) 765 kV Madhugiri: 13°28'45.13"N, 77° 2'43.60"E

Note: The above coordinates/location of substation indicated is approximate in the substation area. Exact coordinates for the corresponding bays/gantry for termination of the respective line may be verified and finalized in coordination with actual site.

SPECIFIC TECHNICAL REQUIREMENTS FOR STATCOM

The proposed STATCOMs shall be conforming to the requirements of CEA (Technical Standards for Connectivity to Grid) Regulations, 2007 including amendments and CEA (Technical Standards for Construction of Electrical Plants and Electric Lines) Regulations 2022, as amended from time to time. Other CEA Regulations and MoP guidelines, as applicable, shall also be followed and complied with.

Note: These specifications are general in nature applicable to a STATCOM in combination of MSC and MSR. Since, ± 300 MVar STATCOM along with 2×125 MVar MSC has been specified under the present Scope of work at Kakinada PS, the specification may be read accordingly.

C.1 Introduction:

This technical specification for a STATCOM Station consists of STATCOM, MSCs (Mechanically Switched Capacitors) and MSRs (Mechanically Switched Reactors) (to be installed at MV bus) including associated coupling Transformer (rated 400/xx kV) and other equipment connected to the 400 kV bus. MV voltage level (xx kV) of the coupling Transformer can be chosen by the TSP to optimize the offered solution which meets functional requirement of this Technical Specification.

The STATCOM station shall operate asymmetrically in the leading and lagging MVar regions as applicable to reach the dynamic range specified. The purpose of the STATCOM station is to regulate the voltage of 400 kV Bus Point of Common Coupling (PCC). The Configuration and the nominal rating of the STATCOM station is specified in this document.

The main building block of the STATCOM should be single phase Voltage Source Converter (VSC) based convertor valve (multi-level) operating in a way to eliminate or minimize AC filter requirement to High pass filter only and connected to the xx kV bus through air core reactors.

The ± 300 MVar STATCOM with 2×125 MVar Mechanically switched Capacitor (MSC) shall be with control switching arrangement for 240 MVar, 765 kV.

C.1.1 Definitions and Abbreviations

For the purpose of this specification, the following definitions / abbreviations are used:

PCC: Point of Common Coupling (herein also called as Point of Interconnection (POI)). The connection point between the STATCOM and the ISTS at which performance requirements are defined.

Reference Voltage (V_{ref}): The Point on the voltage/current (V/I)

characteristics where the static synchronous compensator (STATCOM) is at zero output (i.e. where no reactive power is absorbed from, or supplied to, the transmission system where the voltage is controlled)

MV: Medium Voltage.

STATCOM Unit: Static Synchronous Compensator based on Multi-Module technology and including air cored reactors as needed, Valve cooling, switchgear and its control and protection.

STATCOM: Static Synchronous Compensator consisting of STATCOM Unit(s) connected to a common Coupling Transformer. A static synchronous generator operated as a shunt connected compensator, whose capacitive or inductive output current can be controlled independently of the AC system voltage.

MSC: Mechanically Switched Capacitor (Including Switchgear). A shunt-connected circuit containing a mechanical power-switching device in series with a capacitor bank and a current limiting reactor.

MSR: Mechanically Switched Reactor (Including Switchgear). A shunt-connected circuit containing a mechanical power-switching device in series with a reactor.

Sub Module: Basic single power module of a Multi Module STATCOM unit Valve. It is a Part of a STATCOM unit valve comprising controllable switches and diodes connected in full bridge arrangement, together with their immediate auxiliaries, and storage capacitor, if any, where each controllable switch consists of one or more switched valve device(s) connected in series.

Valve: Electrically and mechanically combined assembly comprising of forced commutated devices [for example insulated-gate bipolar transistor(IGBT)] assembled in levels, complete with all connections, auxiliary components, and mechanical structures, which can be connected in series with each phase of the reactor of a STATCOM unit.

Valve Section: Electrical assembly defined for test purposes, comprising one of several sub-modules.

Valve Structure: Physical structure holding valve(s), which is insulated to the full system voltage above earth potential.

STATCOM Station: STATCOM Station includes 400 kV Switchgear, Coupling Transformer, STATCOM, MSCs (as applicable), MSRs (as applicable) along with its switchgear and complete integrated control and protection whose outputs are coordinated. (Complete turnkey delivery at site).

CT: Current Transformer.

VT: Voltage Transformer.

SAS: Substation Automation System.

Response Time: the duration from a step change in control signal until the voltage changes by 90% of its final change, before any overshoot.

Settling Time: The duration from a step change in control signal input until the STATCOM output settles to within $\pm 5\%$ of the required control output.

Slope: The ratio of the voltage change to the current change over a defined controlled range of the STATCOM, normally the full (inductive plus capacitive) range at nominal voltage, expressed as a percentage.

VSC: Voltage Source Converter, A forced commutated device (for example, IGBT) based self-commutated converter that is capable of generating AC voltage from DC capacitor.

Voltage/Current (V/I) Characteristic: The relationship between the current of the STATCOM and the voltage at the point of connection.

Lagging Operation: Inductive operation or reactive power absorption of the STATCOM similar to a shunt reactor.

Leading Operation: Capacitive operation or reactive power generation of the STATCOM similar to a shunt Capacitor.

TSP: Transmission Service Provider

C.2 Relevant Standard:

STATCOM Station shall comply with the following standards (latest edition):

Sl. No.	Description	Standards
1	Voltage source converter (VSC) valves for STATCOM	IEC- 62927 IEEE- 1052 IEC-60747
2	Control, protection and monitoring	IEC-61000 IEC-60255
3	Valve Hall for housing the equipment as above comprising of: <ul style="list-style-type: none"> - wall bushings for connection between converter phases and decoupling reactors, - piping and tubing connections of the cooling system to converter - connection of the control cabinet with the converter through optical fibers - internal lighting, auxiliary power supply (AC and DC) and power socket system - internal HVAC system 	IEC-60071 IEC-60270 IEC-60137
4	X kV, dry insulated, air core and air self-cooled decoupling reactors. Mechanically Switched Reactors(MSRs), half-reactors stacked on above the other, Outdoor installation, Complete with supporting structures	IEC- 60076

Sl. No.	Description	Standards
5	Power Capacitors (MSC etc.)	IEC-60871-1
6	400 kV Power transformer (Coupling Transformer)	IEC-60076 IEC-60354
7	CT's and VT's	IEC- 61869
8	Dis-connectors and Earthing Switches	IEC- 62271
9	HV and MV Circuit Breakers	IEC- 62271
10	Surge Arresters	IEC- 60099
11	Auxiliary and grounding transformer	IEC- 60076 IEEE C57.32 IS- 5553 (Part 6)
12	Neutral Grounding Resistor, charging resistor	IEEE- C57.32
13	UPS, SMPS and Other Power supply units	IEC- 62040 IEC- 61558
14	Cyber Security	IEC-62243

C.3 Scope of work for STATCOM

The scope of work with regard to the works associated with the STATCOM shall comprise ± 300 MVar Modular Multi-level Voltage Source Converter (MMC-VSC) based STATCOM along with 2x125 MVar MSC (Mechanically Switched Capacitor).

STATCOM can either be Single/ multiple units. The minimum size of a unit allowed is 150 – 200 MVar. TSP shall ensure that there are no coordination issues between multiple STATCOM branches of STATCOM station. Further complete Dynamic range for STATCOM may also be installed based on appropriate studies instead of combination of VSC with MSC/MSR technology. Minimum MV bus voltage is to be decided by OEMs.

The TSP shall be responsible for the complete installation of STATCOM station along with the substation works as specified in the complete scope of work.

The TSP shall also perform the system studies (steady state and dynamic) according to the requirement mentioned and documentation of the same shall be preserved by TSP and to be submitted to CEA/CTU/GRID-INDIA, as per their request.

TSP shall carry out a detailed study on prevailing system conditions before interconnection of the STATCOM to assess the performance of the STATCOM. Parameters tuning to avoid any adverse impact on the grid with integration of the STATCOM shall also be identified and implemented at this stage. TSP shall carry out tuning of Power Oscillation Damping (POD) along with an interaction study with nearby HVDC/FACTS controllers.

TSP shall ensure interconnection study at the time of commissioning and shall also be responsible for tuning the POD during the license period as per relevant standards (e.g. IEEE 1052).

The switchgear for connection of STATCOM units, MSCs and MSRs provided on the secondary side of the coupling transformer shall be of standard voltage rating as per relevant IEC. The switchgear, structure, control, protection and substation automation on the 400 kV side shall be as per applicable Technical Specification of the substation equipment.

Generally, the purpose of STATCOM is to improve system stability, provide damping, and smooth out the step voltage change associated with MSCs, MSRs and external compensating equipment (i.e. any existing capacitor and reactor banks) switching and provide steady state VARs as needed to support the 400 kV bus voltage.

In order to get optimum control of MVar, the control of MSCs and MSRs, as well as reactor banks connected on the 400 kV HV side, may be integrated along with STATCOM control to provide steady state 400 kV bus voltage control in a smooth manner. MSRs and MSCs are to be switched to relieve the STATCOM from high level operation, reduce its continuous losses and maximize its dynamic control potential. There should be a provision for the independent operation of MSC/MSR after delinking it with STATCOM controls when STATCOM is out of service due to any reason. Switching of MSC/MSR shall be based on value of external bus voltage.

The operating functions of the STATCOM Station shall include:

- Steady state voltage control of 400 kV
- Balance steady state voltage at 400 kV
- Dynamic over-voltage control,
- Transient and Dynamic stability control
- Damping of Power Oscillations

It is assumed that the arresters will limit any transient and switching surge over voltages and may also, by design, limit dynamic over voltages.

The requirement of reactive power compensation (as defined above) guaranteed by the TSP shall not be less than the levels specified considering following.

- The total cumulative Capacitive (+) and Inductive (-) MVar rated Capacity of STATCOM Station as defined above comprising of STATCOM, MSCs (as applicable), MSRs (as applicable) coupling transformer, coupling reactor or any filter (if applicable) shall be rated at 1 p.u. voltage, for the

frequency range of 48.5 Hz-50.5 Hz and at 50 ° C (Celsius) ambient temperature at 400 kV Bus (Referred to as “Point of Common Coupling” or PCC).

- Capacity of one or more branches of MSC, MSR in STATCOM Station can be included in the STATCOM with equivalent capacity. Accordingly, ratings of STATCOM Unit/Branch equipment may be designed.

Example of equivalent acceptable solutions for each STATCOM Station is given below:

For ±300 MVar STATCOM:

Option 1: ±300 MVar STATCOM, 2x125 MVar Mechanically switched Capacitor (MSC).

Option 2: +425/-300 MVar STATCOM, 1x125 MVar Mechanically switched Capacitor (MSC).

Option 3: +550/-300 MVar STATCOM

- The rated capability of STATCOM, MSC (as applicable) and MSR (as applicable) shall be at 400 kV (Referred to as “Point of Common Coupling” or PCC) and in the steady state frequency range of 48.5 Hz-50.5 Hz.
- The STATCOM Station including STATCOM Units, MSCs and MSRs shall be designed to operate continuously under the worst possible combination of steady state voltage range of 360-440 kV and frequency range of 47.5 Hz – 52.5 Hz respectively and transient and temporary over voltages defined in Clause C.6.1-f).
- The AC voltage unbalance at fundamental frequency shall be assumed equivalent to a negative phase sequence component of 1.5% for equipment rating purposes.
- The reactive power compensation levels shall be determined by manufacturing tolerances of the components and measurements carried out using metering accuracy instrumentation at the 400 kV feed points to the STATCOM Station.
- The reactive power capability shall also be determined by calculations based on test values of appropriate quantities at the discretion of the owner.

- In calculations of capability and availability, the owner shall assume the most unfavorable combinations of control, manufacturing and measurement tolerances.
- In case more than one STATCOM Station are installed in a particular substation, each STATCOM Station shall be connected to 400 kV bus individually with complete separate downstream system. Each individual STATCOM station shall have complete independent yet coordinated control system to avoid simultaneous tripping of both STATCOM Stations. The system shall be design in such a way that single common contingency (other than loss of 400 kV voltage, abnormal system events) will not cause tripping of both STATCOM Stations.
- Operation of STATCOM Station shall not excite any resonance condition in connected Power System.
- Control of STATCOM Station shall be designed to prevent hunting between MSRs, MSCs and STATCOM.

C.3.1 STATCOM building

The STATCOM station shall have an independent building including a separate control room different from the main control room building of the 765/400 kV Substation.

The STATCOM Building shall comprise of following facilities:

1. Control and Relay Panel room
2. ACDB and DCDB room
3. Battery room
4. Service Room cum workshop
5. Conference room
6. Valve hall
7. Cooling system room
8. Lobby
9. Corridor with minimum width of 1600 mm
10. Portico
11. Common Toilet
12. Provision of shaft for electrical, sanitary, water supply facilities
13. Other facilities as per functional requirement of building
14. AHU Room

C.4 Ambient Condition

STATCOM Station should be designed to perform at 50°C ambient temperature.

C.5 Power System Characteristic

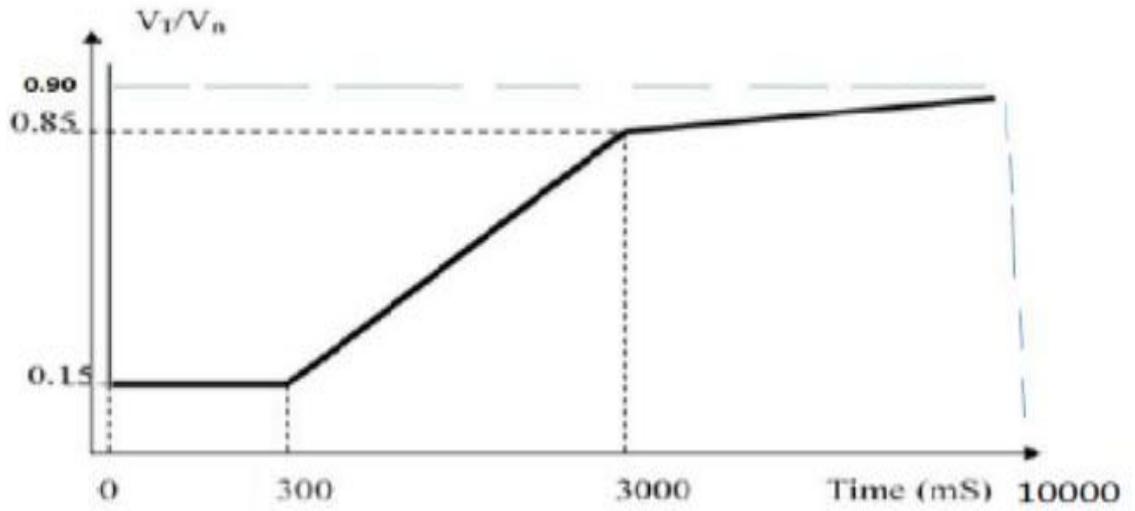
The following AC power system characteristics apply at the point of connection i.e. point of common coupling in this case (PCC). STATCOM station operation is required within the parameter value and duration given in following table:

S. No	Power System Characteristic	Value	unit
1.	Nominal ac system voltage, line-to-line	400	kV
2.	Maximum continuous ac system voltage, line-to-line	420	kV
3.	Minimum continuous ac system voltage, line-to-line	380	kV
4.	Maximum short-term ac system voltage, line-to-line	448	kV
5.	Maximum duration of item 4	10	s
6.	Continuous negative-sequence voltage component (used for performance calculation)	1	%
7.	Continuous negative-sequence voltage component (used for rating calculation)	1.5	%
8.	Continuous zero-sequence voltage component	1	%
9.	Nominal ac system frequency	50	Hz
10.	Maximum continuous ac system frequency (for rated output)	50.5	Hz
11.	Minimum continuous ac system frequency (for rated output)	48.5	Hz
12.	Maximum short-term ac system frequency	52.5	Hz
13.	Minimum short-term ac system frequency	47.5	Hz
14.	Basic Insulation Level (BIL)	1550	kV peak
15.	Switching impulse level (SIL)	1050	kV peak
16.	Power Frequency Withstand voltage	630	kV
17.	Maximum three-phase fault current a) for performance requirements b) for rating of STATCOM	a) 63 b) 63	kA kA for 1s

S. No	Power System Characteristic	Value	unit
	X/R (Positive/Negative Seq)* X/R (Zero Seq)* Clearing time - normal Clearing time – backup	2.6 23.5 0.1 0.75	s s
18	Maximum three-phase fault current	63	kA
19.	Minimum three-phase fault current # -for performance requirements -for safe operation	13 13	kA kA
20.	Maximum single-phase fault current	63	kA
21.	Minimum single-phase fault current#	3	kA
22.	Harmonic impedance sectors for each harmonic number up to the 49th harmonic or system impedance data as R-X values with frequency steps not larger than 1 Hz (for performance and/or STATCOM system component rating)	Chapter 7.3 of CIGRE Publication 139	
23	Background harmonic voltage (or current) spectrum (for STATCOM components rating) (Distortion up to 15th Harmonic	5th Harmonic 1.5% 7th Harmonic 1.0% Other Harmonics 0.5% (each)	
24	Power System Phase Rotation	CCW	

The STATCOMs shall remain connected to the grid and shall be able to operate at rated reactive power capability when voltage at the interconnection point, on single phase or three phases dips up to the level depicted by the thick lines in the following curve (for specified time) and up to at least 0.3 p.u. in case of two phase faults:

VT : Actual Voltage; Vn: Nominal Voltage



C.6 STATCOM Station Characteristics

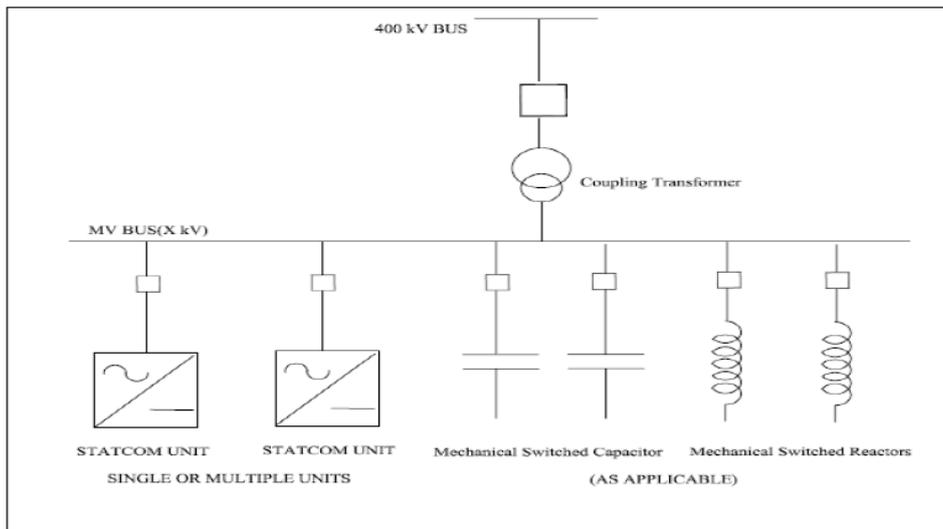


Figure-1: Conceptual Indicative Schematic diagram of STATCOM Station

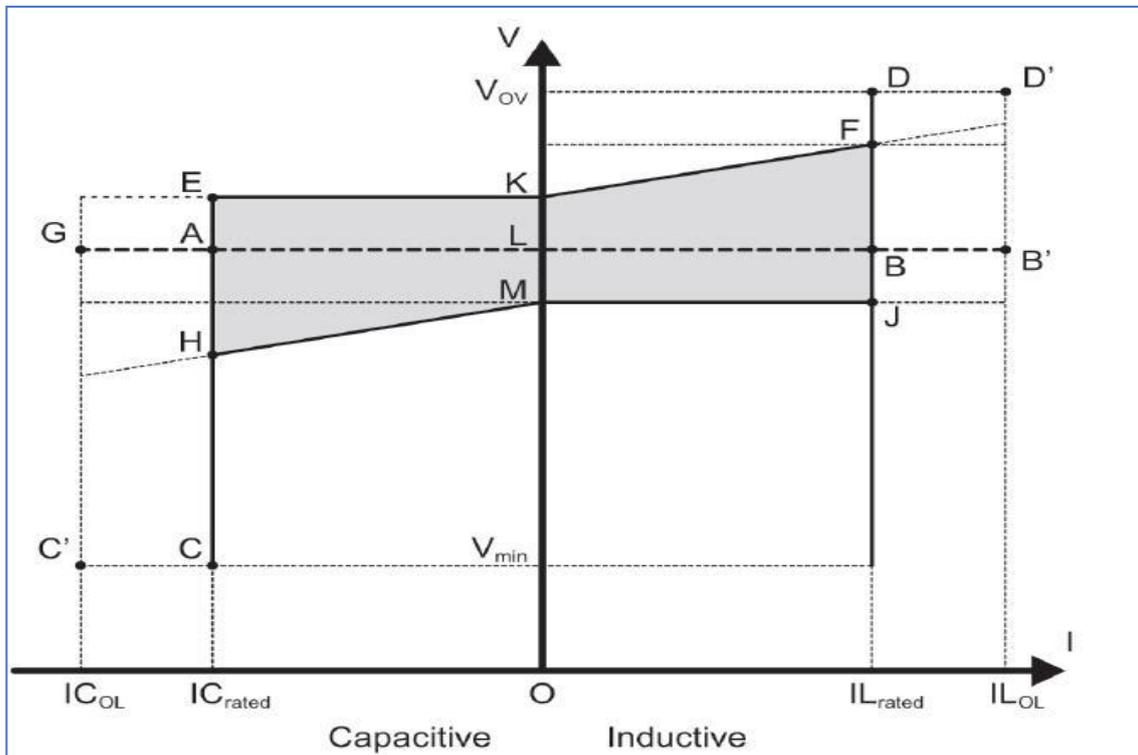


Figure-2: VI Curve of the VSC Portion

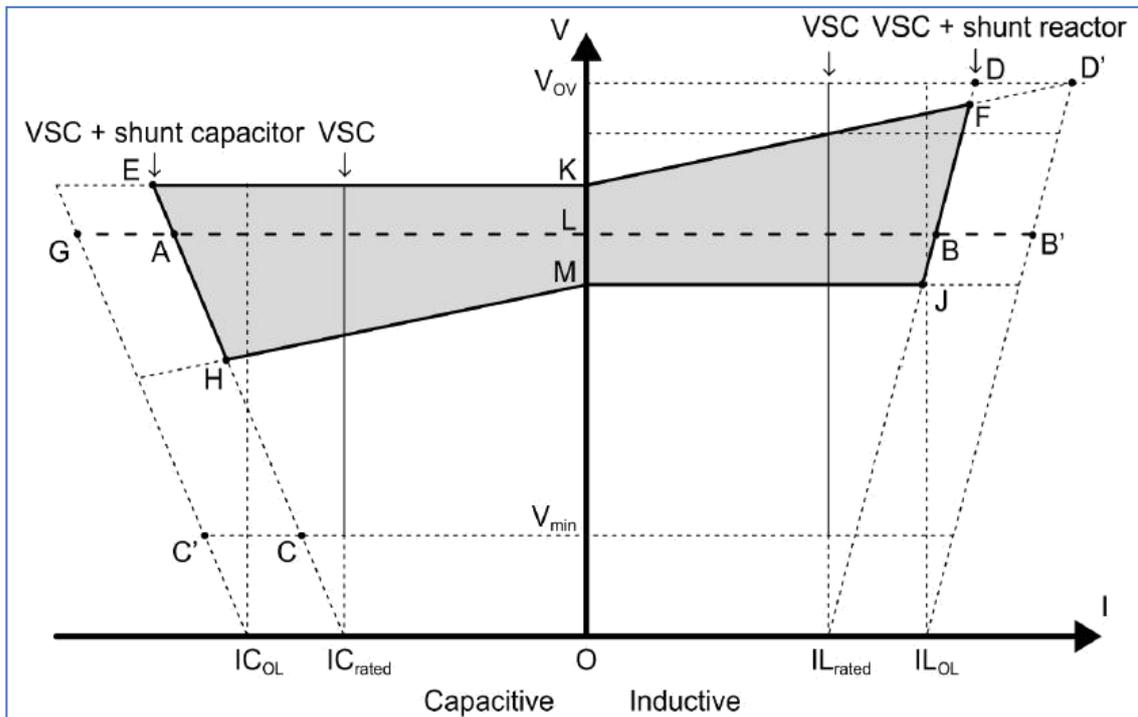


Figure-3: VI Curve of the STATCOM Station

C.6.1 STATCOM Station Ratings

The output of a STATCOM Station shall be adjusted continuously over the range illustrated in Figure-3.

The following items define the ratings of the STATCOM station equipment.

- a) The STATCOM Station should regulate the voltage of 400 kV bus to a reference voltage of 400 kV (1.0 per unit, Point L Figure-3), continuously adjustable between 0.95 per unit and 1.05 per unit.
- b) The nominal capacitive and inductive reactive power output of the STATCOM should be as defined in the scope, at 1.0 p.u. AC bus voltage and nominal system frequency (f), and 50°C ambient temperature (Point A and point B of figure-2).
- c) The slope of the STATCOM Station characteristic should be adjustable in steps of not greater than 0.5% between 1% and 8%, on a basis of cumulative MVA capacity of STATCOM Station (A+B in Figure-3).
- d) The STATCOM Stations shall continue to inject reactive power during temporary under voltage down to 60 kV (0.15 p.u.) for the duration 0.3 sec (Point C) and STATCOM behavior for voltages above 0.15 p.u. shall be as specified under section C.5 above. ; The STATCOM system may be blocked if the under voltage persists for time beyond limits specified under section C.5 above.
- e) The STATCOM shall continue to absorb reactive power during HVRT Conditions in a controlled manner as per the following.

Nominal Voltage (pu)	Minimum time for remaining connected to the Grid
$V > 1.50$	Instantaneous trip
$1.50 \geq V > 1.30$	100 milli seconds
$1.30 \geq V > 1.10$	10 seconds
$V \leq 1.10$	Continuous

STATCOM Station may be tripped if the respective temporary over voltages as mentioned above persists for more than its respective mentioned duration.

- f) The STATCOM Station should be capable of repeating temporary operation as defined in any one of item (d) and (e) as above for at least 3 charging cycles in 60 mins.
- g) The coupling transformer and all bus equipment, such as filter branches (if applicable), MSC and MSR branches etc. and the MV Bus should be rated to withstand the specified continuous and short-term operation, and to withstand or be protected against voltage and current stresses that exceed these conditions.
- h) All equipment in the STATCOM Station should be capable of sustaining, without damage, any fault limited by the maximum design short circuit level of the system and the Coupling transformer impedance.
- i) The TSP shall assume the negative sequence voltage of 1% at rated short circuit level and provide control to reduce this unbalance.

- j) The injected harmonics by STATCOM Station under the full operating range measured at 400 kV Bus (PCC) in accordance with IEEE standard.
- k) The STATCOM controls should be designed to correct negative sequence voltage during steady state operation.
- l) The switching module design should include an appropriate allowance for stray capacitance and component tolerances.
- m) The STATCOM should be designed to prevent, or alternatively to withstand, false firing events, i.e., the firing of any valve at an incorrect time in the cycle or when not ordered.

C.6.2 Control Objectives

The control system shall control the STATCOM, MSCs, MSRs required under this specification, as well as all bus reactors on the 400 kV HV bus of the substation.

Operation logic for the breakers, disconnectors and earth-switches in the STATCOM Station shall also be incorporated in the control system. The control shall be programmable and shall have sufficient scope and flexibility (software programming margin of at least 20%) to permit re-programming according to future changes/addition in the power system. The operator interface must be integrated in a latest version of Windows environment.

C.6.2.1 STATCOM Station Functions and Applications

C.6.2.1.1 Voltage Control mode (Automatic and Manual)

Control of the positive sequence component of the fundamental frequency voltage in steady state at POI shall be with slope in the range as specified at clause 6.1 (c) above.

There shall be following provisions in STATCOM System to operate in Voltage Control Mode:

- a) To adjust the reference voltage for changes by Grid Operator.
- b) To adjust the value of reactive power droop in p.u. to provide a stable, coordinated and dynamic response.
- c) To adjust the voltage dead band with a minimum magnitude of ± 0.05 p.u.

C.6.2.1.2 Fixed Reactive Power Mode

In this mode, the STATCOM system shall maintain a specified constant reactive power output at the POI under continuous / steady state operating region. The target reactive power level and mode (injection or absorption) shall be specified by the Grid operator. There shall be a provision to adjust the reactive power set point. The dynamic response of the STATCOM system to

any changes in reactive power shall be positively damped with a damping ratio of 0.3 or better.

C.6.2.1.3 Steady State Condition

The STATCOM Station (STATCOM along with MSCs and MSRs) shall provide necessary reactive power support to the 400 kV bus (PCC) to compensate for voltage variation under steady state.

C.6.2.1.4 Dynamic Over-voltage Control Performance

The STATCOM shall be required to provide necessary reactive power support with fast and smooth variation so that over-voltages under dynamic conditions are controlled. STATCOM shall smooth out the step caused by the switching of MSCs and MSRs.

The operation of each STATCOM over its range of MVA_r from full capacitive to full Inductive capacity and vice-versa shall be on the basis of smooth variation.

C.6.2.1.5 Transient and Dynamic Stability Performances

The STATCOM Station shall provide necessary reactive power so that the transient and dynamic stability of the Owner's system is enhanced.

C.6.2.1.6 Damping of Power Oscillations

The STATCOM shall provide necessary damping to power oscillations by modulating its output in its entire range based on the measured rate of change of power/frequency at the 400 kV bus. The damping controller would track local area oscillations as well as wide area oscillations and control would include several loops each focused on different frequencies.

TSP shall ensure the damping of oscillation during the entire license period including the pre-commissioning period as per relevant standards. (e.g. IEEE 1052).

C.6.2.1.7 Facility for compensation of phase imbalance

Provide negative phase sequence voltage control to minimize the presence of negative sequence content of the 400 kV bus voltage.

C.6.2.1.8 Start up and Initial Switching

The operation of STATCOM Station during start-up/initial switching on should not create significant energizing transients causing voltage drop, voltage distortion and swinging of transmission voltage angle at the PCC bus by more than +/-5%. TSP shall have to ensure this analytically during the design phase and also in the field after the commissioning of the facility. TSP shall prepare the design documentation and the same shall be preserved by TSP and to be submitted to CEA/CTU/GRID-INDIA, as per their requirement.

C.6.2.1.9 Gain Supervision and Control

To control the regulator gain in order to prevent oscillations and excessive overshoot in the STATCOM response, a gain supervision function shall be implemented. This shall be an essential function for the supervision of stability of closed-loop voltage control. The function of this controller is that when the supervision of the gain in the voltage regulator detects oscillations in the voltage controller output, the gain shall gradually be reduced until stability is reached. Normally it is a changed condition in the transmission system contribution to the closed loop gain that results in instability. The reduction in the voltage regulator gain shall only balance the external change. The control should be adaptive in order to maximize its effectiveness. Gain reductions should be indicated and the reduction of the gain shall be able to be reset to nominal value by means of commands from the operator interface or automatically. A relative gain factor shall also be able to be changed from a gain optimizer.

C.6.2.1.10 Coordinated reactive power control of external devices

To optimize the use of dynamic VARs versus steady state VARs, control of externally connected shunt capacitor or reactor banks shall be implemented. Such banks will be connected locally to a HV bus or/and at MV bus. For simultaneous control with the supplementary VSC current controller, coordination for the two functions shall be provided. External devices like mechanically switched capacitors (MSC)/mechanically switched reactors (MSR) can be switched ON or OFF to position the steady state operating point of the VSC so as to extend its dynamic range. There should be a provision for independent operation of MSC/MSR after delinking it with STATCOM controls when STATCOM is out of service due to any reason. The threshold values for switching the MSC/MSR on/off shall be configurable in all modes of operation.

C.6.2.1.11 Supplementary VSC current controller

To optimize the use of dynamic VARs versus steady state VARs, a control function that slowly reduces or offsets the STATCOM point of operation shall be implemented. By deliberately adjusting the voltage reference setting within a narrow window the STATCOM system output is pushed towards either a specific point or towards a window to preserve dynamic range. This slow operating function is meant to provide for slower controllers, such as externally connected shunt banks to operate and meet the slower long term voltage variations caused by daily or weekly load variations. Rapid changes in the system voltage that call for dynamic compensation will have priority over this type of controller.

C.6.2.1.12 Gain optimization

To provide operation at optimal regulator gain, a fully automatic optimizing function shall be implemented. This function operates by inducing a small

change in the STATCOM output. The gain is adjusted based on the network response signal.

C.6.2.1.13 Control of Direct Current

During STATCOM operations, any flow of direct current to the transformer's MV side must be less than 25% of the transformer magnetizing current. DC current flow in the transformer should be minimized by an independent control function that minimizes DC current. For presence of up to 0.2% second harmonic in 400 kV system, the STATCOM control should minimize DC current flow in the transformer.

C.6.2.2 Under Voltage Strategy

It is essential that the STATCOM Station operates in a robust manner when transmission system under voltages appears. In case of single phase or three phase faults, the STATCOM units must operate unrestricted, producing its rated capacitive current for transmission system voltages down to 0.15 p.u. In case of two phase fault, the STATCOM shall be capable to produce rated capacitive current atleast down to 0.3 p.u., however, it shall be designed to operate upto 0.15 p.u. The STATCOM must be designed to operate at transmission system under voltage, even considering that severe voltage unbalances can appear. The STATCOM must not be restricted by short term negative sequence voltages up to 1.5%, appearing in conjunction with under voltages.

Transmission system under voltages below 0.15 p.u. will appear in conjunction with transmission system faults. The STATCOM must ride through during faults and post fault under voltages. The minimum trip delay for the STATCOM Station, upon complete loss of the transmission system voltage shall not be less than 5 seconds. If station AC auxiliary power distribution is affected, critical loads must be fed from DC station batteries, uninterrupted power supply (UPS) without tripping the STATCOM Station. Adequate capacity must be kept in DC station batteries, UPS to feed critical loads for the smooth operation of the STATCOM Station facility. There must be redundant station battery system with each station battery system capable of delivering 100% load.

At under voltage conditions for the transmission system voltage, special control strategies are activated which override the normal control modes presented above. Normally if the voltage is low, the output from the STATCOM will be capacitive. If the voltage in all three phases goes below a level, but not greater than 0.15 p.u., a special under voltage strategy may be activated that controls the STATCOM output to 0 MVar. As soon as the voltage goes higher than 0.15 p.u., the under voltage strategy is deactivated and the normal control will be in operation (for the specified duration).

The STATCOM Station must not be tripped or shut down automatically due to

under voltages appearing for specified duration as specified under section C.5 above. STATCOM Station must continue to operate when AC system Voltage on any or all phases dips down to 0.15 p.u. voltage as per the characteristic given at section C.5.

C.6.2.3 Over Voltage Strategy

C.6.2.3.1 The TSP shall carry out dynamic stability study upfront in order to assess the dynamic overvoltage requirements. These studies shall include conditions with maximum and minimum short circuit system MVA conditions, single phase and three phase faults as well as stuck breaker, outage of the nearby generator and also with the outage of parts of the STATCOM Station. It is important that the STATCOM Station rides through temporary over voltages and not trip when it is needed the most.

C.6.2.3.2 The system should be able to withstand any 3 phase, 5 cycle (100 ms) and single phase 10 cycles (200 ms) fault with consequent loss of a 400 kV double circuit line and loss of a 500 MW generator. The fault duration mentioned above corresponds to time assumed for the persistence of fault. For other system parameters refer clause 5 above (Power System Characteristics). In addition to above requirement, system contingency cases as provided in Annexure-I need to be considered and satisfied.

C.6.2.3.3 The 400 kV system and equipment to which the STATCOM Station is connected is designed to withstand switching surge overvoltage up to 2.5 p.u. and power frequency over voltages up to 1.5 pu with initial value of the temporary overvoltage up to 2.0 p.u. for 1-2 cycles. Based on arrester coordination and under the worst case scenario the 400 kV system phase to ground peak over voltages may be expected as follows

- i) 650 kVp for 3 peaks
 - ii) 575 kVp up to 5 cycles
 - iii) 530 kVp up to 1 second
 - iv) 475 kVp up to 10 seconds
- a) The STATCOM Station shall be designed to withstand these sequential over voltages.
 - b) If the over voltages greater than 1.1 pu are exceeded in magnitude and duration due to any system contingencies, suitable control action shall be taken by STATCOM Station to bear this kind of contingency.
 - c) The TSP shall evolve the insulation co-ordination of the components of the STATCOM Station after studies have been conducted to determine the over-voltage profile with the STATCOM connected to the system.
 - d) The TSP shall ensure that STATCOM Station will not excite ferro-resonance and sub-synchronous oscillation in the AC system. The study report in this

regard shall be preserved and to be submitted to CEA/CTU/GRID-INDIA, if required.

- e) It may also be noted that the tripping action for 400 kV lines is initiated if the overvoltage exceeds 1.1 pu for 10 seconds. The tripping of 400 kV lines is initiated if 1.5 p.u. voltage persists for more than 100 milli seconds. The over voltage strategy shall be coordinated with these settings such that the STATCOM Station rides through up to these levels.

C.6.2.4 STATCOM Station Over load / Over Current

The overvoltage cycles mentioned in clause 6.2.3.3 above create a corresponding current overload in the STATCOM Station components; the STATCOM Station and its components shall be designed to withstand these.

In addition to the above the STATCOM Station and its components shall be designed to withstand overloading caused due to the following eventualities.

- i) Short circuits and ground faults in the 400 kV system especially those occurring near the STATCOM Station and medium voltage bus of the STATCOM Station.
- ii) Transient overvoltage due to switching operations and atmospheric effects.
- iii) Temporary over voltages.
- iv) Short circuits in the transformer secondary circuit such as:
 - Bushing terminal fault
 - Flashover across a reactor, Bus Bar and other connected components/switchgear etc.
- v) Protection system faults.

If the rated overvoltage is exceeded as a result of prolonged stressing or for other reasons, the protection specified elsewhere in the specification shall come into effect to prevent damage.

C.6.2.5 Dynamic Performance Controls of STATCOM Station

The TSP must describe in detail, the dynamic reactive power controls for enhancing stability margin and also damp oscillations of any critical frequencies. The dead band for continuous damping control must be very small so that there are no discernible sustained oscillations.

C.6.2.6 Protective Control Functions

TSP shall provide all necessary protections including Main and Back-up protections for all protective zones and equipment like transformers, STATCOM Units, MSCs (if applicable), MSRs (if applicable), MV Bus Bar etc. TSP shall provide any protective control functions to meet the performance requirement of STATCOM under the scope of the TSP.

a) Overvoltage Protection

TSP shall provide adequate overvoltage protection as a result of any normal operation, mal-operation or system event.

b) Over current Protection

TSP shall provide adequate over-current protection for the STATCOM Station as a result of any abnormal operation, mal-operation or system event.

c) Gate level control Supervision

TSP shall provide adequate Sub module Gate level control supervision.

C.6.2.7 STATCOM Station Response

STATCOM station response shall be such that the change in measured system voltage to small disturbance should reach 90% of the desired total change within 30 ms of initiating a 5% step change of voltage reference. The maximum overshoot should not exceed 120% of the total change and the settling time should not exceed 100 ms, after which the voltage should be within $\pm 5\%$ of the final value. This response characteristic within these limits must be respected when the system's three-phase fault MVA is between the minimum and maximum value defined in clause-5. The response of the system voltage using the actual controller should be validated on a real time simulator during the Factory Acceptance Test (FAT) at the manufacturer's premises. For the purpose of STATCOM Station, response time measurement and signal conversion of the voltage, the error should not exceed 0.3%. The voltage response acquisition circuit should have a response time of no longer than 10 ms. However, time longer than 10 ms can be allowed provided the requirement of STATCOM response time is met.

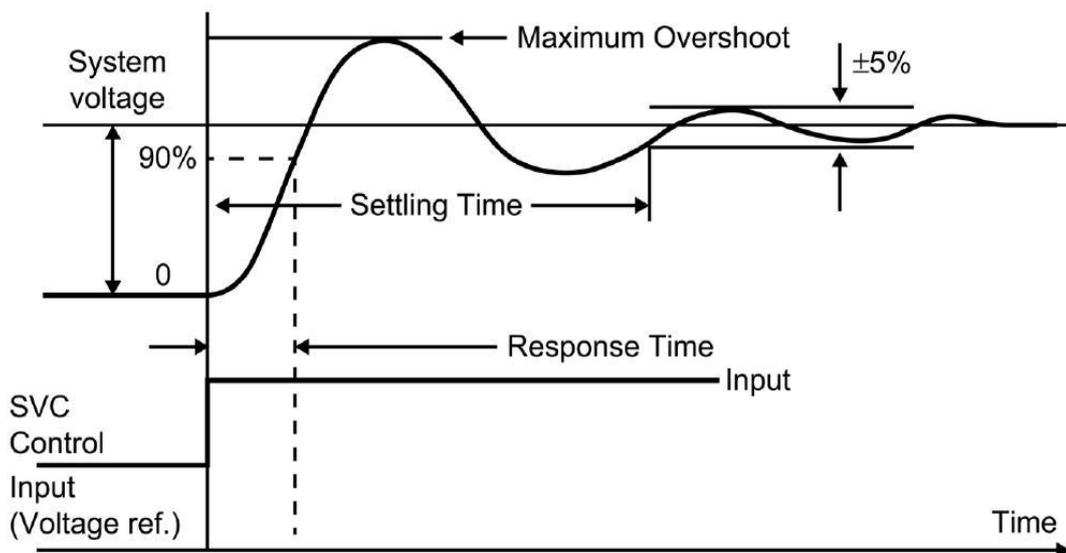


Figure-4 Response and Settling time

C.6.3 Harmonic performance and AC harmonic filter design

It is likely that with multi-level VSC based technology, no filters or only a small high-pass filter will be needed. The STATCOM shall be operable without AC filters. The STATCOM Station should be designed to eliminate the effects of any harmonic resonance between its MSRs, MSCs banks, filter branches, and the AC system. To limit the harmonic distortion imposed on the 400 kV transmission system, the additional contribution of harmonic distortion from the STATCOM Station to 400 kV system (PCC) should not exceed 1% for the total and 0.5% for any specific harmonic.

C.6.3.1 Filter performance

The distortion levels as specified should be met for the following:

- a) The continuous range of all system and environmental conditions.
- b) Variation in total filter capacitance due to manufacturing tolerance, ambient temperature, aging, and changes in capacitance up to alarm level.
- c) Variation in tolerance for STATCOM parameters, such as transformer winding unbalances, valve firing variations MSC and MSR unequal reactor and capacitor reactance between phases.
- d) System frequency in the range of 48.5 Hz to 50.5 Hz. Calculation should take into account all possible combinations of STATCOMs, MSCs and MSRs.

C.6.3.2 Filter component rating

The harmonic filter components (and other STATCOM components) should be rated to carry continuously the harmonic currents caused by the background harmonic distortion of the system and the harmonic currents produced by the STATCOM itself. Unless otherwise specified, harmonic currents from the system and the STATCOM of the same order should be added arithmetically. All filter harmonic currents of different order should be added quadratically (root sum of squares).

The rated voltage of capacitors should be derived from the largest arithmetic sum of the power-frequency and individual harmonic voltages obtained from stress calculations in continuous operating conditions (Note: Maximum fundamental voltage and maximum harmonic contributions may not exist at the same time for STATCOM configurations including MSRs or MSCs).

For filter capacitor voltage rating, the loss of capacitor unit or elements should be considered up to the trip level.

The rated voltage of so-called "low voltage" capacitors (e.g. in double or triple tuned filters) should be chosen such as to also withstand imposed transient stresses from faults, energization, or other switching events.

C.6.3.3 Harmonic at PCC

The STATCOM Station's contribution to the harmonic distortion levels at the STATCOM Station connection point (PCC) to the transmission system shall not exceed the limits defined in IEEE-2800 standard.

C.6.3.4 Harmonic calculation:

Chapter 7.3 of CIGRE Publication 139 together with information in PSSE network files given shall be used for the Network harmonic impedance.

C.6.4 MV Switchyard

- Medium Voltage (MV) delta bus shall be grounded through a Grounding Transformer (i.e. zig-zag winding Transformer) along with a suitable resistor in the neutral.
- MV Switchyard of different STATCOM Station branches shall be fenced with a fence height of three (3) meter. To minimize the probability of electrical fault suitable arrangement i.e. electrified fence shall be done to prevent the encroachment of unwanted animals or other to minimize the probability of electrical faults (Ph-E, Ph-Ph). Further bus bar arrangements shall be made in a way to minimize the probability of electrical faults.
- Secondary side of the Coupling Transformer shall be provided with suitable surge capacitors to mitigate transfer surges.
- For MV bus bar, an Aluminum conductor (Tube, Rectangular Hollow Section or C Section) may be used, however, a suitable bus bar end cover/cap shall be provided to avoid any animal/bird entering the hollow space.

C.6.5 Broadband Interference

C.6.5.1 Radio Interference

The TSP shall take necessary precautions in the form of shielding of valve hall and building or Containers to meet its own requirement together with any requirements that may be specified in Section-Project. Further, the following requirements shall also be met:

- a) With the STATCOM Station operating at any load upto rated value and within the design range of firing angle, the radio interference level from electromagnetic or electrostatic inductions generated by the STATCOM station shall not exceed 100 micro-volts/m, under fair weather conditions, at 500 m away from STATCOM fence or boundary of the substation whichever is higher . The Radio Interference Level (RIL) criteria shall be achieved at all frequencies within the range of 150 kHz to 300 MHz and with the STATCOM operation at any level up to and including rated value, the design shall provide correcting measures, in case the specified design not

being realized in the final installation. In case of any third-party complaints about the radio interference, suitable measures shall be implemented by the TSP.

- b) Measurements of actual RI at STATCOM Station shall be made by the TSP, at points along the above defined contour and at other critical points.
- c) RIV (Radio Interference voltage) measured at a phase to ground voltage (266 kV rms) in accordance to NEMA-107 shall not be more than 500 microvolts for 400 kV system. For other system voltages, IEC/NEMA in the order of preference shall be applicable.

C.6.5.2 Interference with Power Line carrier and open wire carrier system

The TSP shall take the necessary precautions in the form of noise suppression techniques and filtering devices to prevent harmful interferences from STATCOM Station to the power line carrier communication (PLCC) system operating on connected AC transmission network.

The frequency spectra to be protected are:

System	Frequency spectrum
Power Line Carrier	30 kHz to 500 kHz
Open Wire Carrier	5 kHz to 30 kHz

C.6.6 Audible Noise

The TSP shall limit the audible noise in various areas of the STATCOM Station buildings and containers to the following values.

Valve hall (Inside)	90 dBA
Mechanical equipment areas indoor (measured at 2 meter distance)	75 dBA
Mechanical equipment outdoor (Measured at 15 m distance)	75 dBA
Control Room Building*	60 dBA
At the limits of the STATCOM STATION perimeter fence	80 dBA

**This is the background noise from the ventilation system in adjacent rooms, control cubicles etc. Printers, recorders may be switched off during the measurement.*

C.6.7 Loss Requirements

- C.6.7.1** The TSP must guarantee the total losses of STATCOM Station, be less than 1% of the reactive power output individually at its inductive limit (STATCOM+MSRs) and capacitive limit (STATCOM+MSCs) for the cumulative highest reactive power output of STATCOM Station at PCC with the worse combination of manufacturing tolerances for the Option-1 to 2 as provided in clause C.3. In case of Option-3 as provided in clause C.3 i.e. +550/-300 MVAR STATCOM without MSC and MSR, the TSP must guarantee the total losses of

STATCOM Station will be less than 1.5% of the reactive power output individually at its inductive limit and capacitive limit for the cumulative highest reactive power output of STATCOM Station at PCC with the worse combination of manufacturing tolerances. For the purpose of total loss measurements, it should be assumed that the ambient temperature is 20 °C, the PCC voltage is 1 per unit, and the slope setting is 1%. The STATCOM system may not operate under these conditions, but they provide a common base.

- C.6.7.2** The total losses shall include all components, as well as different parts or subsystems of the complete STATCOM Station such as coupling transformer, All VSC systems and components, MSC and MSR, Control and protection systems, including ancillary devices such as HMI, fault recorders, and SCADA, Auxiliary Power supply systems, cooling systems, Building ancillary services such as lighting, air conditioning, heating, and ventilation. It may be noted that for the redundant VSC valve levels and dual/redundant control and protection systems, the losses of redundant VSC valve levels and dual control and protection systems shall be considered during loss measurement.
- C.6.7.3** For the dual or redundant systems design of STATCOM Station, such as dual pumps or redundant fans, dual systems losses are to be excluded, if the dual system is not in service during the normal operation of the STATCOM Station. However, dual systems should be included if they are required to be in service under the defined operating conditions. The same methodology shall be applied for HVAC (heating ventilation and air conditioning systems).
- C.6.7.4** The TSP is required to prepare documentation for the detailed calculation of total losses based on measurement during Factory Acceptance Tests of major equipment and systems mentioned above as per relevant IS/IEC/IEEE standards and the same shall be preserved and to be submitted to CEA/CTU/GRID-INDIA, as per their requirement. Further for equipment/systems, whose loss measurement cannot be done during Factory Acceptance Test, the same can be measured at the site, and a combination of calculation and measurement shall be used to derive the total losses as specified above. During Loss measurement, all fans, and pumps; valve room and control room air-conditioning system shall be switched on. However, redundant fans, pumps and air-conditioners shall be kept off during loss measurement.
- C.6.7.5** During the factory tests the losses for the following equipment shall be measured/ assessed as detailed below:

Coupling transformer:

Losses shall be measured at factory/lab at the maximum rating, at power frequency as per relevant IEC/IS under below mentioned conditions:

- i. No load loss (Iron loss) at rated voltage and fundamental frequency.

- ii. Load loss (copper loss) at rating corresponding to maximum continuous current and at 75 °C.
- iii. Transformer cooling equipment's loss (Auxiliary loss) at rated voltage and fundamental frequency.

Reactors:

The losses shall be measured at the factory/lab at the maximum rating at power frequency as per relevant IEC/IS.

VSC Valves:

Converter losses comprise the losses in power electronic switches [insulated gate bipolar transistor (IGBT) or equivalent], made up of conduction and switching losses, and the losses in DC capacitors, resistors, and inductors used within the converter system. Refer IEEE-1052 for calculating VSC losses.

Capacitor:

The capacitor losses shall be measured at the manufacturer's works at power frequency as well as calculated to obtain the losses in the complete bank on the basis of factory measurement.

Auxiliary System:

Auxiliary, power losses shall be calculated from the kW and efficiency of all motors (name plate rating) of the cooling system, air conditioning, ventilation etc. The higher of the total losses for the entire auxiliary systems occurring at full capacitive capacity MVar or full Inductive MVar as the case may be shall be considered for arriving at the total losses.

Harmonic Filters, if any:

The losses shall be calculated at the maximum STATCOM Station loading at 400 kV and 50 Hz.

The calculations shall be on the basis of the tested results of the components.

C.6.8 Selection of Insulation Levels

C.6.8.1 Arresters:

Protective levels of arresters connected to the 400 kV AC Bus Bars of the STATCOM Station shall be coordinated with the insulation and surge arrester Characteristics of the 400 kV AC systems to which the STATCOM Station is to be connected. The specification and characteristics of the surge arresters installed in 400 kV AC system is given in the Substation specifications. The front of wave (FWWL), lightning impulse (LIWL) and switching impulse withstand levels (SIWL) shall be determined by the following margins:

- a) A SIWL at least 1.15 times the switching impulse protection level.
- b) A LIWL which is an IEC standard level corresponding to the SIWL and shall be at least 1.25 times the lightning impulse protection level.
- c) A FWWL which is at least 1.25 times the front of wave protection level.

In addition to the above minimum basic requirement, the various insulation level of 400 kV equipment shall be as below. The STATCOM Station equipment, coupling transformers etc. shall be co-ordinated accordingly.

Description	SIWL	LIWL
All equipment including Transformer Bushing and winding	1050 kVp	1425 kVp

C.6.8.2 Valves

The requirement of insulation levels of the valves shall be as per the design requirement.

C.6.8.3 Air clearances

The air clearances shall be determined by the TSP based on the required withstand levels for all waveforms in order to limit the probability of flashover within the STATCOM Station to a target value of one flashover in 15 years.

C.6.8.4 Switchyard

The air clearances for switchyard equipment shall be equal to or greater than the minimum values as specified in IEC-60071. Altitude correction factor (if any) shall also be considered as per IEC.

C.6.8.5 Leakage distances

The Creepage/leakage distance across insulation shall be determined by the TSP and shall be adequate to ensure that under conditions of heavy pollution, the probability of a flashover of an insulator does not exceed one in 15 years. However, the leakage distance for all AC insulators for outdoor installation shall not be less than 31 mm/kV of the maximum operating phase to earth rms voltage at the insulator. The leakage distance of equipment connected to 400 kV systems shall not be less than 13020 mm.

Specific creepage distance for outdoor bushings, insulator strings and long rod insulators shall be a minimum 31 mm/kV.

C.6.9 STATCOM Station availability and reliability

The following definitions apply:

C.6.9.1 Outage terms:

a) Outage

The stage in which equipment is unavailable for normal operation due to an event directly related to the equipment which results in a reduction in STATCOM Station capacity.

b) Scheduled Outage

An outage that can be scheduled at least one week in advance.

c) Forced outage

The stage in which the equipment is unavailable for normal operation but is not in the scheduled outage stage and which results in a reduction in STATCOM Station capacity i.e. an outage which is not scheduled outage.

C.6.9.2 Capacity terms

Maximum Continuous Capacity (Pm)

The maximum STATCOM Station capacity (MVA_r) for which continuous operation under normal conditions is possible.

C.6.9.3 Outage duration terms

Actual outage duration (AOD)

The time elapsed in hours between the start and end of an outage.

C.6.9.4 Time Categories

a) The number of hours in the reporting period in a full year, the period year is 8760 hours. If the equipment is commissioned, part way through a year, the period hours will be proportionately less than 8760 hours.

b) Total Outage hour (TOH)

The sum of all outage duration within the reporting period. $TOH = AOD$

C.6.9.5 Availability and Reliability Terms

Unavailability:

Unavailability is the duration for which the STATCOM Station is not available with a specified rating due to forced outages per year. If part of the station is unavailable, then the unavailability duration shall be counted proportionally. However, if STATCOM is out then its duration shall count as a fully unavailable STATCOM Station. However, If the STATCOM unit is out then the STATCOM Station unavailability shall be counted proportionally to STATCOM capacity. STATCOM Station Control system outage shall count as full STATCOM Station unavailability.

'OF' is the Outage Frequency which will be the number of forced outages per

year.

The period basis for availability and reliability calculations shall be 12 months. The TSP shall ensure that the design will meet the specified guaranteed and design target value of availability and reliability.

Outage times for repair, maintenance and replacement of components shall be based on the premise that all items in the list of recommended spare parts are on hand, and that all maintenance schedules of recommended maintenance are adhered to. Reliability calculations shall be made and shall be presented as the expected frequency of unscheduled loss of STATCOM Station capacity. For simultaneous occurrence of events, for either of which a loss of capacity would result, the longer repair time shall be counted.

The facilities shall be assumed to be utilized 100% of the time at 100% load, regardless of the actual reactive power generated/absorbed by the STATCOM Station. Hence the availability and reliability assessment will be based on the capability of STATCOM Station to generate/absorb the rated reactive power regardless of whether, it is in service or not.

C.6.9.6 Availability Requirement

The calculated availability of the system considered on an annual basis shall be equal to or exceed the following target values.

Minimum availability requirement of each complete STATCOM Station

- Guaranteed for STATCOM Station - 98%

The outages of STATCOM Station capacity caused by the failure of equipment outside the scope of the TSP shall not be considered for the calculation of availability and reliability guarantee. However, such outages shall be restricted to

- 1) Complete loss to 400 kV supply (at PCC)
- 2) Human Error.

Circumstances causing curtailment of STATCOM Station capacity that will be included in reliability and availability assessment and which can lead to forced outages shall include but not be limited to the following:

- a) Failure of equipment
- b) Mal-operation of control and protection system
- c) Failure to start
- d) Reduction in capacity.

C.6.9.7 Reliability Requirement

a) Reliability

In the assessment of reliability, the following events shall also be considered to constitute a STATCOM Station outage:

- i) A STATCOM Station shut down.
- ii) A reduction of STATCOM Station capacity due to an outage of any component of STATCOM Station

The calculated reliability of the complete STATCOM Station shall be equal to or exceed the following design target values.

The average outage frequency per year for each STATCOM Station shall not exceed the following values:

	Design target for STATCOM Station	Max acceptable Guaranteed value for STATCOM Station
Total Number of Forced Outages	3 x Nos. of STATCOM Station	5 x Nos. of STATCOM Station

C.6.9.8 GUARANTEED FAILURE RATE OF Sub-modules. (Including all components and electronic). The maximum annual guaranteed failure rate of sub module (including all components and electronic) shall not exceed 1.0% per STATCOM. The failure rate shall not include failures directly attributable to operation and maintenance errors.

C.6.9.9 GUARANTEED VALUE OF FAILURE RATE OF AC POWER CAPACITOR

The maximum guaranteed annual capacitor failure rate shall not exceed 0.15% except for first unit failure. The capacitor shall be considered as failed if its Capacitance value varies more than $\pm 5\%$ of the (actually measured) name plate value. Leakage of oil from the capacitor and the deformation of the capacitor unit shall be considered as a failure even if the capacitance value is within the tolerance limits.

C.7 Design Principles

The objective for the design of the STATCOM Station shall be to achieve a high level of availability and reliability as specified. Special attention shall be given to designing the STATCOM Station to avoid forced outages. The TSP shall conduct thorough design reviews to ensure the minimum risk of such outages. The TSP shall give careful attention to related factors affecting STATCOM Station performance such as subsystem and system testing, protective relays co-ordination and proper setting of relays.

Except where greater reliability requirements are specified in these specifications, the design basis for STATCOM Station shall be such that no

single contingency downstream from the medium voltage bus shall cause a total outage of the STATCOM Station. The following general criteria shall be followed for the design of the control system:

- a) Use of components similar to those whose reliability has already been proved in use.
- b) Use of good design practices, surge protection, filtering, and interference buffers to assure immunity to sensitive components and circuits against damage and interference by induced voltages and currents in the external cabling and cubicle wiring.
- c) Use of fail-safe and self-checking design features.
- d) Use of component and equipment redundancy, by means of either duplication or triplication with automatic transfer facilities wherever necessary to meet the requirement of these specifications.
- e) Design which in the event of component failures, provides for transfer to a less complex operating mode.
- f) Provision of alarm, fault diagnosis and indication

C.8 STATCOM Station Main Components

C.8.1 STATCOM Unit

The main electrical data of the STATCOM Units are the following:

- Rated voltage 20 kV Minimum
- Rated frequency 50 Hz
- Redundancy (Sub Module) 2 Nos. or 5% whichever is higher
- Rated Power of each STATCOM unit/Branch ± 50 MVar Minimum
- Valve Cooling water Deionized/Demineralized

In general, the STATCOM units shall equally share the load however under contingency conditions it should be possible to run the units with unequal load. Charging of the DC capacitors of Sub module during the initial start-up shall be achieved by means of Resistors and bypass breaker arrangement. The charging resistor for DC capacitor of the STATCOM Sub module should be designed for three charges per hour followed by the appropriate cooling time. Power for the gate level control shall be derived internally from Sub module. The offered STATCOM Units with their Control system shall be suitably located inside the STATCOM Station Building.

C.8.1.1 STATCOM Valve

The valve shall be designed to meet the performance requirements described in this specification and as described below.

In order to ensure a modern low loss and reliable solution, the STATCOM valve assembly shall use the multi-module (including redundant sub-modules) approach.

The valves shall be designed to ensure satisfactory operation according to the overall performance requirements and include all necessary auxiliary equipment required for smooth and reliable operation. The valves shall be indoor air-insulated and cooled by de-mineralized water. The valves shall be of modular design and have removable Sub-Module for ease of maintenance. The valves shall be mounted to allow easy access for visual inspection, routine maintenance and replacement, and facilities shall be provided to enable easy access.

C.8.1.2 Semiconductor Switches

The electronic switches should be designed with the aim to achieve operation according to the overall performance requirements of the STATCOM Station. The valve shall be designed with individual semiconductor switches applied in a conservative manner with regard to their basic design parameters. The semiconductor switch shall meet the requirements of IEC 60747 except where otherwise specified herein.

The semiconductor switches shall be designed to withstand all stresses expected under steady state, transient and temporary overvoltage conditions. Basic semiconductor devices shall be of the Press Pack type, or packaged to provide short circuit means in case of device failure such that the STATCOM can continue to operate without interruption. The adjacent sub-module should be protected against the possible explosion of the semiconductor switch.

Under the restriction of redundancy (minimum two or 5% whichever is higher) i.e. the failure of any semiconductor switch or sub module or monitoring device etc shall not prevent continued system operation. In the event of any of the above failures, the STATCOM shall annunciate and identify the specific location of the failed device and continue operation until such time as repairs can be scheduled. During such time the next shutdown can be averted, the STATCOM must continue to operate without downgrading STATCOM capability.

The switching device's design should include an appropriate allowance for unequal voltage distribution across individual devices in the valve due to the stray capacitor and component tolerances.

Each switching device should be able to operate within component ratings, generally with at least two failed sub-module or levels. The number of possible failed sub-modules or levels as specified shall be consistent with the availability

requirements of the STATCOM system.

C.8.1.3 Sub module for Multi-Module Topology

The key element of the multi-module topology shall be the sub-module. By increasing the number of these sub-modules, it is possible to obtain high voltage with extremely low harmonic distortion and very low dv/dt using a low switching frequency that reduces power losses. Sub-module shall have the following characteristics:

VSC sub-modules should be protected against over voltages with appropriate strategies. A description of the failure mode of the switching device and the strategies used for failure should be provided.

In each fiber optic cable (having multiple fiber cores) used for control/communication purposes of sub-module at least two fiber cores shall remain available as spare for future use.

C.8.1.4 The STATCOM sub-module has DC capacitors that require a charge to allow full functionality and performance. At the startup of the STATCOM Station, the capacitors are discharged. During the energization sequence of the STATCOM, Capacitors are charged from the main power grid via resistor operated in series to the main connection circuits. Once the desired charging voltages are reached, the charging resistor circuit is bypassed using a bypass switch/breaker.

The Type and Rating of the charging resistor and associated bypass switch shall be designed with the aim to achieve operation according to the overall performance requirements of the STATCOM Station and shall conform to the relevant Standard.

C.8.1.5 STATCOM Valve Cooling system

A closed-loop recirculating system shall be provided with full heat rejection capacity with redundancy for pumps, heat exchangers, and fans, appropriate to the STATCOM Station availability requirements. The cooling system should be able to maintain full capacity at maximum ambient temperature and maximum STATCOM reactive power output. The cooling system should be able to operate at the lowest ambient temperature and zero output specified. The Valve cooling system shall have black start capability and necessary Uninterruptible Power Supply (UPS)/ Uninterruptible Motor Drives (UMD) shall be provided separately for each STATCOM Unit.

The valve cooling system shall be designed to meet the performance requirements described in this specification and as described below.

- a) Each STATCOM Unit shall have its own de-ionized water valve cooling system with redundant pumps.

- b) For cooling the STATCOM valves, a deionized re-circulating (closed loop) water system shall be used.
- c) Water to air heat exchanger shall be used for cooling of this de-ionized water. Water to water heat exchanger shall not be employed.
- d) System shall be designed such that no shut down of STATCOM be resorted to for making up the deionized water in the system. The make-up water should comply with the recommended pH and purity.
- e) Cooling water shall have a constant flow rate irrespective of loading. The flow rate shall be decided on the basis of extreme operating conditions.
- f) The control system for the cooling system shall be redundant type including the provision of redundant control supply and main power supply. However, in place of the redundant control system for the cooling system, suitable alternate mode is also acceptable meeting the requirement of fulfilling cooling system operation even if failure of cooling control system.
- g) 2x100% pumps with one as standby shall be provided for the primary. In case a pump failure occur, the second pump shall automatically switch in without shutting down the STATCOM. An alarm shall be displayed at the control panel for the failure of the first pump and standby pump in operation.
- h) Each cooling system shall be provided with an independent/dedicated UMD supply however common battery for both UMD power supply may be accepted. An UMD system will provide an extended capability of the STATCOM Station to deliver reactive power without any interruption, adding a buffer against the system faults or during events such as delayed voltage recovery or Transient over Voltage (TOV).
- i) The secondary cooling system shall be a redundant type such that it shall be possible to take out 10% (minimum one number) of the cooler module (fan unit) of secondary cooling system without affecting the rated performance of STATCOM).
- j) Normally no make-up water shall be required however in case of expansion vessel level going low; the same shall be replenished automatically by means the of make-up water tank and make up water pump to be supplied with the system.
- k) TSP shall provide a water treatment plant of sufficient capacity. The purification (treatment) system shall be designed to maintain conductivity below 1 micro Siemens. A resistivity cell in the outgoing water from the deionizer should detect the depletion of ionized material. Filters and deionizers shall be designed to allow replacement during operation. Normal replacement shall not be required more than once every year.
- l) Filters and deionizer/deoxidizer material shall be designed to allow replacement within minutes without shutdown of the cooling unit. (Normal replacement should not be required more than once/year).

- m) Primary cooling system shall monitor its own operation and condition of cooling water.
- n) The protection system of the cooling cycle shall have minimum following alarms:
 - i) Depleted deionizing cell
 - ii) Low water resistivity
 - iii) High water temperature
 - iv) Primary pump stopped
 - v) Fan stopped
 - vi) Primary pump or fan interlock circuits faulty
 - vii) Primary cycle (Make-up water) tank level low
 - viii) Failure of control supply.
 - ix) UMD/UPS fault.
- o) Following shutdown alarms / TRIP shall be provided with cooling system protection. Excessive low water resistivity excessive high water temperature, complete loss of auxiliary supply to primary pumps, low flow, low pressure etc.
- p) The dissipative components of the converter are cooled with deionized water.
- q) The power losses are transferred to the external ambient by means of a deionized water /air heat exchanger. All the piping and other components shall be provided. Complete instrumentation set including following shall be mounted on board in order to check the status of the cooling system:
 - Conductivity gauge system.
 - Flow meter equipped with two set points (alarm and trip).
 - Pressure meter
 - Two thermometers for the inlet and two thermometers for the outlet (two set points for alarm and trip)
 - Thermostat
- r) The status of the cooling system shall be monitored by means of the control system.
- s) Replacement of certain cooling equipment (e.g. pumps, fans, cooler unit etc.), if defective, shall be possible while the cooling system still operates.

C.8.1.6 Tests on STATCOM Unit Valve

All applicable tests i.e. Operational Type Tests, Dielectric Type Tests and Test for valve insensitivity to electromagnetic disturbance and Production tests shall be done as per the latest edition of IEC 62927.

C.8.2 STATCOM Station Control equipment and operator interface

C.8.2.1 Control Equipment

The control systems should achieve the functional objectives given in 6.2. The accuracy of voltage should be within $\pm 1\%$ of the reference voltage. The accuracy of the gradient and linearity of the slope delivered by the STATCOM Station should be defined in relation to the current deviation from the theoretical slope defined in 3.1. The maximum deviation should be less than $\pm 5\%$ of the nominal current.

The control system design shall be based on a single fail criterion i.e. failure of any one component in the system should not result into outage of the complete system. As a minimum, a dual (hot standby) digital programmable controller shall be supplied for each STATCOM unit/branch and STATCOM Station to control the STATCOM, MSRs and MSCs completely including the functions listed as mentioned below:

- a. The controller shall have diagnostic and self-checking features for both itself and for valves, gate firing and drive circuits, interface hardware, and software. This is required to reduce outage times and to facilitate fault finding.
- b. The Controller shall be reprogrammable. The Owner shall have at least the following possibility for changing the following reference and limit values via HMI:
- c. Closed loop Controllers:

The STATCOM Station controller shall have the means to modify the reference set points. This refers to the functionality that will allow all the control parameters to be adjustable within selectable limits and is inclusive of, but not limited to following:

- o Voltage controller
 - o Q controller (reactive power controller).
 - o Supplementary VSC current controller.
 - o Other supplementary control functions.
- d. Sequence Controllers:

The sequence control and open-loop controllers shall include the control of all switchgears and associated control gear and external devices.
- e. The Controller shall have at least 10% excess I/O capacity to allow future program upgrades to satisfy the changing requirements of the power systems or future extensions to the STATCOM Stations. As a minimum, a control of up to 4 future HV shunt devices (reactors or capacitors) shall be included in the offer.
- f. All control signals available for remote control must also be available locally so as to ensure that a local operator can operate the STATCOM Station if the

communications link between STATCOM Station and remote control centers is lost.

- g. A changeover switch shall be provided for control of the selection of local or remote control.
- h. TSP shall provide the equipment necessary for the purpose of control, protection and interlocking of all equipment within the scope of supply.
- i. TSP shall be responsible for the design and coordination of control, protection and interlocking system and switching sequences within the STATCOM Station. All necessary interfacing required between AC switchyard equipment and STATCOM Station for the above purpose shall also be included in the scope of TSP.
- j. It is proposed to control STATCOM through a Supervisory Control and Monitoring System (SCADA). All the data shall be acquired through suitable means from the field and various components and control is executed through the redundant HMI. The local STATCOM Station Control system shall consist of a redundant STATCOM Station controller, redundant HMI workstation, Gateway, STATCOM Station Control System Engineering cum Disturbance Recorder (DR), PC which can also be used as standby HMI workstations in case of emergency with associated peripheral equipment such as color laser log Printers, Color laser jet fault record printer, GPS System, Inverter / UPS etc. all interconnected via redundant Ethernet based Station LAN Network. Each work-stations and PCs at STATCOM Station shall have at least 19" LED display.
- k. In addition to the above, HMI workstation (identical to HMI Workstation provided in the STATCOM Station control room) should also be provided in the control room of the main 400kV substation. This HMI workstation should be powered from an independent UPS system adequate enough to provide power to the HMI workstation for a minimum two hours in case of auxiliary power failure.
- l. The control equipment shall satisfy the reliability and availability requirements specified in this specification
- m. All necessary measures shall be taken to ensure satisfactory operation in the presence of harmonic current and voltage, noise and radio interference signals. The equipment shall be designed to operate in the environmental conditions specified in the specification.
- n. There should be a provision for independent operation of MSC/MSR after delinking it with STATCOM controls when STATCOM is out of service due to any reason.
- o. The threshold values for switching the MSC/MSR on/off shall be configurable in all modes of operation.

C.8.2.2 Operator Interface

- a) Each STATCOM Station shall have a SCADA consisting of an HMI which shall provide a Centralized (local) operator control of the STATCOM Station functions. All human interface operations necessary for the control and monitoring of the STATCOM shall be provided at this point.
- b) Any abnormal condition requiring operator action or intervention or maintenance on any of the STATCOM Station subsystems shall be annunciated at the STATCOM Station control room and the Substation control room.
- c) The local HMI shall include the following diagrams as different screens in the display system:
 - i. Complete STATCOM Units and STATCOM Station single line diagram including EHV and MV busses
 - ii. AC Auxiliary supply and distribution
 - iii. DC Auxiliary supply and distribution
 - iv. STATCOM Valve cooling systems
 - v. Interlocking system.
- d) These diagrams shall indicate status, alarms, voltages, currents, etc. The HMI shall provide complete diagnostics on alarm and trip indications as required and discussed in this specification, including SER information.
- e) A facility shall be provided whereby the local HMI features and functions shall be accessible from remote. A remote user shall be able to view screens and change STATCOM Station parameter settings.
- f) As the substation where STATCOM Station shall be installed, will be equipped with Sub-station Automation System (SAS) conforming to IEC 61850, it is required that STATCOM Station control and monitoring shall be integrated with SAS at the main Sub-station by the TSP. It is proposed to connect STATCOM Station's SCADA with SAS through a Gateway and the database, configuration etc of the main substation SAS shall be upgraded to incorporate STATCOM Station events, alarms, Controls (both switchgear and control functions of STATCOM Station like the setting of parameters etc.) so that STATCOM Station can be effectively monitored and controlled from main substation SAS and shall be monitored from Load Dispatch Center (RLDC).

C.8.3 STATCOM Station Protection System

C.8.3.1 Protection system Design

- a) To ensure that faults are cleared within stability critical clearing time, to minimize damage to the plant, and to avoid voltage collapse, loss of load, or load limitations, TSP shall provide a high speed main protection scheme.

An independent (having a separate measurement system) back-up protection scheme shall be provided in the event of the main protection scheme failing or taken out for maintenance.

- b) The STATCOM Station shall be completely self-protecting (unit protection). STATCOM Station shall be protected from damage for all conditions of over-current, overvoltage, excessive reactive power loading, unbalance due to loss of capacitor elements, phase-to-phase and phase-to-ground faults, three phase faults, loss of cooling, semiconductor valve or control malfunction, faults (STATCOM, MV system) in individual primary connected components of the STATCOM, HV system faults, etc. The STATCOM Station shall withstand the maximum fault current for a period of the maximum fault clearing time as specified, considering second contingency cases due to the previously mentioned conditions.
- c) All protection equipment and systems should be properly co-ordinated to prevent incorrect operations of the protection equipment or systems during normal STATCOM Station operation, including anticipated abnormal conditions on the transmission system, as specified. Fail-safe principles should be applied throughout.

C.8.3.2 The basic principle and order of precedence for the control and protection shall be, to take care of the following:

- Correctly identify a fault, problem or error condition,
- Only if necessary, isolate the minimum number of components, subsystems whenever possible,
- Utilize degraded modes to the maximum extent possible either directly (no interruption of the STATCOM Station operation) or indirectly (by tripping the STATCOM Station momentarily in order to isolate the branch and re-energization of the STATCOM Station).
- Trip STATCOM Station and Block.
 - a) Failure of the STATCOM Station Interface (SCADA interface) shall not result in a Protection trip of the STATCOM Station. A fail-safe philosophy shall be implemented to allow the STATCOM Station to operate safely and independently from the STATCOM Station Interface (SCADA interface).
 - b) Protection equipment shall be designed and applied to provide maximum discrimination between faulty and healthy circuits.
 - c) The Protection shall be sufficiently sensitive to cater to the full range from maximum to minimum fault level conditions. The Protection shall also be suitable for a system fault level equal to the maximum short circuit capacity of the substation. All current transformer designs shall be based on these fault levels.

- d) All required protective, control devices, etc including auxiliary instrument transformers and panels, relays, cabling, wiring, indication, and all other associated plant and material necessary for the effective operation of the protection systems shall be supplied and installed by TSP.
- e) The protective relays shall be microprocessor based. Relays shall have approved characteristics and be mounted in dust and moisture-proof cases. The protective relays shall be provided with visual indications for starting, tripping and failure of the protective function. The LEDs shall be reset without opening the covers. The protection relays shall also be equipped with HMI facilities suitable for manual parameter settings and viewing of the settings. Relays with provision for manual operation from outside the case, other than for resetting, are not acceptable. Relay settings shall be visible and readable without having to remove the relay cover. Relays shall be of approved construction and shall be arranged so that adjustments, testing and replacement can be effected with the minimum of time and labor. Auxiliary Relays of the hand reset type, if provided shall be capable of being reset without opening the case. Electrically reset tripping relays shall be provided as necessitated by the system of control, such as for those circuits subject to remote supervisory control.
- f) Relay contacts shall be suitable for making and breaking the maximum currents which, they may be required to control in normal service but where contacts of the protective relays are unable to deal directly with the tripping currents, approved Auxiliary tripping relays shall be provided. In such cases, the number of auxiliary tripping relays operating in tandem shall be kept to a minimum in order to achieve fast and reliable fault clearance times. Separate contacts shall be provided for alarm and tripping functions. Relay contacts shall make firmly without bounce and the whole of the relay mechanisms shall be as far as possible unaffected by vibration or external magnetic fields.
- g) Steps shall be taken to protect the circuitry from externally impressed transient voltages which could reach the circuitry via connections to instrument transformers or the station battery. The routing of cables should be such as to limit interference to a minimum. Any auxiliary supplies necessary to power solid-state circuits shall be derived from the main station battery and not from batteries internal to the protection.
- h) **Relay communication**

The Relays shall also have a communication port provided on the front of the relay for configuration and parameter settings as well as downloading of data. A direct port suitable for remote communication shall also be provided at the back of the Relay. This port shall conform

to IEC - 61850.

i) **Tripping schemes**

- Tripping of MV circuit breakers shall be done by means of two-separated trip signals.
- Duplicate high security tripping circuits for MV Circuit Breaker shall comprise two independent high speed (less than 10 ms) high burden (greater than 150 W) tripping relays for each circuit, each with its own independent DC supply. The trip circuits for all circuit breakers need to be equipped with a “lockout” function and it shall be possible for this to be reset manually and remotely by the operator.

j) The protection for the power system is based on a normal switching state and an occurrence of a single fault. This means that faults resulting from maintenance as well as the simultaneous occurrence of two or more faults are not taken into account.

k) The input circuits of the digital protections shall be monitored by means of a plausibility check. If any incorrect information is found, the protection function shall be blocked by the protection system. All protection relays shall have facilities for monitoring trip circuits. Detection of an interruption in the case of a switched on circuit breaker shall be signaled.

l) **Test facilities**

- It shall be possible to test the protective device during operation without causing trips. Links shall be provided for the isolation of individual protection trip circuits and the common protection trip circuit to each circuit breaker trip coil.
- Separate test facilities shall be provided for each current and voltage transformer secondary circuit so as to give access for testing of protection relays and associated circuits. The Test facility to be supplied shall have two selectable positions, a Service and a Test position. In the service Position, the test switch connects CTs and VTs signals to the Relays and trip commands to the circuit breaker trip coils. In the Test Position, the test switch applies a short-circuit to the Current Transformer (CT) secondary windings and open circuits the VT secondary cores and allow injection of secondary current and voltage into the relay. At the same time, the Trip commands to the Circuit Breaker Trip Coils are isolated. The test switch supplied shall be to the Approval of the Owner.

m) The protection of the electrical system shall be designed and installed in such a way that the failed equipment is disconnected selectively and automatically. All equipment have to remain operative during transient phenomena, which may arise during switching or other disturbances to the system.

n) **Auxiliary DC Supplies**

- The protection concept has to be designed in a way so that back-up protection is provided at all times. All protection relays shall be configured in a way that failure of one Auxiliary DC system will not affect the relay. If all DC supplies to the controllers are lost, the STATCOM Station breaker must be tripped via the protection panel.

o) **Electromagnetic Compatibility**

- Electronic Relays and other electronic devices and the ancillary circuits connected to them, such as power supplies, current and voltage transformer secondaries, status or tripping or alarm circuits shall be designed to ensure that they are compatible for use in the hostile electrical environment found in an MV or HV substation.
- Adequate steps by means of suitable design, shall be taken to prevent Electromagnetic Interference (EMI), (generated by sources such as circuit breakers, disconnectors, lightning, radio or radar emissions, switching contactors in DC circuits etc) or Electrostatic Discharges (ESD) from affecting relay performance or causing damage to components.
- All relays offered shall therefore have been type-tested to meet the current requirements of IEC Standards with respect to High Frequency disturbance, Fast Transients, Electrostatic Discharge, Radio Frequency Interference testing etc.

p) List of Protection functions for STATCOM Station

Coupling Transformer Protection:

- i) Biased Differential protection (87T)
- ii) REF protection (64T)
- iii) Overcurrent protection (50, 51)
- iv) Ground Overcurrent (51N)
- v) Over flux protection (HV and MV)
- vi) Transformer mechanical trips

STATCOM MV Bus Protection:

- i) Bus Differential protection (87)
- ii) Ground over current protection (51N), used with a neutral Grounding Transformer
- iii) Under / Over Voltage (59 Ph-Ph) protection
- iv) Over voltage (Open Delta) protection

STATCOM Branch Protection:

- i) Differential protection (87)
- ii) Overload protection (49)
- iii) Overcurrent protection inside delta (50, 51)
- iv) Negative phase sequence protection (46)

- v) STATCOM branch overcurrent protection (50, 51, 50N, 51N)

MSR Branch Protection:

- i) Differential protection (87)
- ii) Ground over current protection (51N)
- iii) Reactor branch unbalance protection (Negative Phase Sequence)
- iv) Thermal Overload protection

MSC Branch Protection:

- i) Ground over current protection (51N)
- ii) Capacitor Overvoltage (Using current signal) protection.
- iii) Capacitor unbalance protection (60C)
- iv) Over current protection (50, 51)

- The protection functions listed above are the minimum set of function to be provided, any additional protection required to fulfill the requirement of the protection system shall also be provided.
- Further protection functions of individual branch (STATCOM, MSC, MSR) shall trip the respective branch MV Circuit Breaker (CB).
- All CBs shall be provided with individual Breaker Failure protection relays. Breaker Failure relay shall have the logic based on the current signal or Circuit Breaker close open status.
- Any fault on MV bus will trip the 400 kV breaker. However, any branch fault shall be cleared by the respective MV branch Circuit Breaker
- Protection System for the STATCOM valve portion of the STATCOM station shall be provided in the redundant controllers to isolate the STACOM valve during internal overload/overvoltage, ground fault etc.

C.8.4 STATCOM Station Fault Recording System

An integrated Transient Fault Recording (TFR) System shall be supplied, installed and commissioned. This shall include trigger level settings for analog signal, etc subject to review and comment. Disturbance and event recording facilities are required for local monitoring of the STATCOM following a disturbance on the power system or the STATCOM System. The TFR shall be Global Positioning System (GPS)/NavIC synchronized.

The following inputs are required:

- All analog signals (output signals) including 3-ph and sequence values of voltage, control.
- All digital signals (control outputs, status indications, commands, alarms, and trip indications). Internal STATCOM Station control signals/variables to be selectable.
- The accuracy of the TFR for event inputs shall be at least 100 μ s (sampling rate of minimum 10 kHz).

- The TFR shall have provision for remote access and retrieval of recorded information onto a PC. For this purpose, a communication link to the substation LAN shall be implemented.
- The remote software application for data retrieval shall be included.
- There shall be multiple channels to view 3-ph and sequence values of voltage, current.
- TFR file shall be viewable in any open source software.

C.8.5 Mechanically Switched Reactor (MSR)

MSR is a fixed source of inductive reactive power connected in shunt to the MV bus of STATCOM Station and switched by means of a circuit breaker (with a control switching device) based on the command from the STATCOM Station control system. The rated capability of MSRs shall be at 400 kV (Referred to as “Point of Common Coupling” or PCC) and in the steady state frequency range of 48.5 Hz-50.5 Hz. However, the MSR Components shall be designed with the aim to achieve operation according to the overall performance requirements of the STATCOM Station. The individual components of MSR shall be able to withstand the onerous conditions imposed by system overvoltage and harmonics. The MSR consists of 3-ph Air Core Reactor, 3-ph MV Circuit breaker (SF6/Vacuum type), associated current transformer, 3-ph Disconnecter and associated safety grounding switch. The MSR area shall be fenced and a castle key interlock with safety grounding switch shall be provided for human safety.

Specifications for individual components like Air core reactors etc are provided in the subsequent clause.

C.8.6 Mechanically switched capacitor (MSC)

MSC is a switched 3-phase capacitor bank connected in shunt to the MV bus of STATCOM station and switched automatically by means of a circuit breaker (with control switching device) based on the command from STATCOM Station control system. The rated capability of MSCs shall be at 400 kV (Referred to as “Point of Common Coupling” or PCC) and in the steady state frequency range of 48.5 Hz-50.5 Hz. However, TSP will ensure the corresponding values at PCC (400 kV) for possible operating condition measured at PCC. The MSC Components shall be designed with the aim to achieve operation according to the overall performance requirements of the STATCOM Station. The individual components of MSC shall be able to withstand the onerous conditions imposed by system overvoltages and harmonics. The MSC consists of 3-ph AC power capacitor bank, a current limiting air core reactor as required, 3-ph MV Circuit breaker (SF6/Vacuum type), associated current transformer, 3-ph Disconnecter and associated safety grounding switch. The MSC area shall be fenced and a castle key interlock with safety grounding switch shall be provided for human safety. Specifications for individual components like Capacitors, Air core reactors etc are provided in the subsequent clauses.

C.8.7 Air Core Reactors

- a) Reactors shall be air core, dry type, be suitable for outdoor installation and there shall be no tapping on the reactors. The insulation level shall be adequate and TSP has to ensure proper insulation coordination.
- b) The insulation of the reactor shall be class F and hot spot temperature rise shall not exceed 105 °C above ambient temperature. Winding temperature rise shall not exceed 80 °C above ambient temperature.
- c) The reactor shall be designed to withstand thermal dynamic shocks and mechanical shocks while in service and during erection.
- d) The reactor shall fully conform to the relevant IEC standard.
- e) The reactor shall be designed to withstand overloading due to over voltage as specified and shall also be subjected to excitation by harmonics; the reactor must be able to withstand such events without deterioration in normal life.
- f) The reactors shall be subjected to type and routine tests in accordance with the latest issue of IEC-60076 as appropriate to the type of reactor provided.
- g) Tests on Reactors: The reactors shall be subjected to type and routine tests in accordance with the latest issue of IEC-60076 as appropriate to the type of reactor provided.

C.8.8 AC POWER CAPACITORS

i) General

- a) The capacitor banks shall comprise capacitor units, discharge devices, protection equipment, series reactor as required, earthing switches, suitably connected in series and parallel, mounted at ground level with protected fencing all around. The number, arrangement and connection of capacitor banks shall be designed to suit the requirement of the compensator as a whole. If convenient, the capacitor banks may be used in conjunction with reactors. In this event, the rating of the capacitor shall be adequate to cope up with the harmonic loading. The frequency variations shall also be considered. To limit the peak inrush current for switching in the capacitors, current limiting reactors with parallel connected damping resistors, if required shall be connected in series with shunt capacitor banks.
- b) The capacitors shall be provided with internal-type fuses. Alternatively, the fuseless capacitor is also acceptable.
- c) Fuses shall not melt nor shall deteriorate when subjected to the inrush current during the life of the capacitor bank.

- d) With the capacitor charged to a peak voltage, the fuses associated with the healthy elements shall not melt when carrying the discharge current resulting from a breakdown of an element or from an external short circuit.
- e) Fuses shall be capable of disconnecting a faulty element over a range of voltage across the unit terminals from 0.9 U_n to 2.0 U_n . In addition, if all the elements in the same row of an internally fused capacitor were to fail as a result of a cascading action, the last fuse element to melt shall be capable of successful disconnection with a voltage of not less than 1.5 times.
- f) After fuse operation the fuse assembly shall be able to withstand continuously at least 1.5 times the rated unit voltage U_n across the gap for 10 Seconds.
- g) Fuses shall preferably be of the current limiting type but fuse system shall in any event be designed to ensure that energy released into a faulty capacitor unit is less than the value that will cause rupture or bursting of the container.
- h) The capacitor units shall be the outdoor type. The container of the capacitor shall be of stainless steel.
- i) Each capacitor unit shall be readily accessible and replaceable without disturbing any other unit. The supporting frames shall be designed to provide adequate ventilation to the units.
- j) The dielectric fluid used in the capacitor unit shall be environmentally safe and bio-degradable, non-toxic. Polychlorinated Biphenyle (PCB) type dielectric or any of its derivatives shall not be acceptable.

ii) Construction and Design Requirement

- a) The capacitors shall conform to IEC-60871. The capacitors shall be provided with internally mounted discharge resistors with characteristics in accordance with IEC-60871.
- b) The current limiting reactors (as required) shall be dry type and connected in series with the capacitor bank. Suitable lifting lugs shall be provided.
- c) The capacitor enclosure shall have sufficient strength to withstand without damage or loss of life, mechanical load, both in operation and during erection. The loads shall include electromagnetic forces including those during faults external or internal to the capacitor bank, wind loading, forces due to expansion and contraction caused by ambient temperature and load variation, and seismic effects all as specified.
- d) The capacitor units shall be interchangeable in order to reduce the spare requirements and simplify maintenance procedures.
- e) The capacitor stack shall be vibration free. The stack shall have a fixed potential which is connected to one electrical point in the bank. The stack shall be of galvanized structural steel.

- f) The capacitor racks shall be supplied complete with all capacitor units, insulators, and connections and shall be equipped with lifting lugs/eyes to facilitate assembly into the stacks. The racks shall be constructed of galvanized structural steel. No drilling of galvanized steel shall be allowed. Each rack shall be labeled with the weight of the fully equipped racks, the phase, and the bank of which it forms a part. The maximum and minimum capacitor unit capacitance which may be substituted into the racks as spares shall be suitably identified. Suitable warning labels shall be affixed.
- g) The capacitor shall be specially designed to be suitable for intermittent duty.
- h) The capacitors should comply with the overload capacity as per NEMA Standard.
- i) The capacitor elements shall be vacuum dried inside the case prior to impregnation with dielectric fluid. After impregnation, the capacitor unit shall be sealed immediately upon removal of the impregnated reservoir.
- j) The discharge resistor shall discharge the unit from peak operating voltage to less than 75 Volts within 10 minutes.
- k) The capacitor case shall be made from type 409 stainless steel or equivalent stainless steel with all joints welded and tested for leaks.
- l) All racks and bus insulators as well as the insulators used to insulate each stack of capacitor from ground level shall be pincap or post type. The minimum voltage rating shall be 15 kV and low frequency wet withstand voltage of all insulators used to insulate within or between the capacitor rack of a stack shall not be less than three times the actual voltage stress across the insulators. The insulator shall be outdoor type manufactured from wet porcelain. The insulators shall be bolted to the top members of the frame to support electric-grade aluminum buses.
- m) The size and groupings of the individual capacitor units shall be such that a single blown fuse will not cause the voltage across the parallel group to rise by more than 10%.
- n) The redundancy to be provided, shall be as per the requirement specified regarding reliability and availability in the clause mentioned elsewhere.

iii) Capacitor Unit Failure Detection

The stages of capacitor units or element failure detection shall be provided as below:

- a) A three-step unbalanced current protection shall be provided in each capacitor bank to initially generate an alarm when the unbalance limit is reached and finally to trip the bank in case of the limit is exceeded.

- b) The first stage shall generate an alarm and the capacitor unit shall continue in service. It may be assumed that the bank shall be disconnected for maintenance within 2 weeks.
- c) The second stage shall generate a separate alarm and a delayed trip signal which will disconnect the bank after two hours.
- d) The third stage shall cause immediate disconnection of the Capacitor Bank.

iv) Tests on Capacitors

All the tests on capacitor units shall be in accordance with the latest issue of IEC 60871.

C.8.9 Coupling Transformer

The TSP shall provide single phase coupling transformers to operate as 3-phase bank with one unit as a common spare with necessary auxiliary arrangements for stepping down the voltage from 400kV system to a suitable medium voltage value as required for replacing any one of the faulty phase units without physically shifting the transformer. The Medium Voltage side of the coupling transformer to couple with the STATCOM shall not be less than 20 kV to ensure optimum power transformation.

The Coupling Transformer shall be designed with the aim to achieve operation according to the overall performance requirements of the STATCOM Station. The transformer should be designed and rated to carry complete capacitive and inductive reactive loading as specified for STATCOM Station including that of mechanically switched capacitors (MSC) and Reactors(MSR) etc.), as well as harmonic currents associated with the most onerous operating conditions of STATCOM Station, without loss of life.

The coupling transformer shall be designed in accordance with the most up-to-date experience in STATCOM application and shall incorporate the latest improvements of design currently employed in the industry. The Comprehensive design review of the Coupling Transformer of STATCOM Station shall be carried out by the TSP.

C.8.9.1 General Requirements

The coupling transformer shall be designed electrically and mechanically for operating conditions peculiar to STATCOM Station operation, which shall include, but not be limited to the following:

- a) Electrical insulation problems resulting from the transformer being subjected to voltages of distorted sinusoidal wave shape because of saturation, harmonics, trapped charges in capacitors etc.
- b) The cumulative effect of electro-dynamic forces produced during valve commutation or other short circuit conditions imposed by valve design limitation and valve group operation.

- c) Harmonic currents due to STATCOM operation, with reference to additional stray losses resulting from these harmonic currents.
- d) No generation of uncharacteristic harmonics by the transformers.
- e) Stresses due to normal control operation and other onerous operations such as blocking and de-blocking.
- f) Stress due to the fast response requirement of STATCOM for loading from 100% inductive to 100% capacitive and vice-versa.
- g) Overvoltage stresses for which STATCOM shall be designed as per specification would apply to the transformer also.
- h) All other stresses for which STATCOM Station shall be designed as per specification would apply to the transformer also.
- i) The transformer and all its accessories like Bushings, CTs etc shall be designed to withstand without damage, the thermal and mechanical effects of any external short circuit to earth and of a short circuit across the terminals of any winding for a period of 3 seconds. The short circuit level of the 400 kV system to which the transformer shall be connected, will be as per the maximum short circuit level of the main substation. Short Circuit level of the Coupling Transformer shall be as per the Short Circuit level of the respective Substation. Short circuit level for HV bushing shall be 63 kA for 1 Sec.
- j) The transformer shall be capable of being loaded in accordance with IEC 60076 or the overload conditions as specified whichever is the worst. There shall be no limitation imposed by bushings during its terminal fault.
- k) The transformer shall be capable of withstanding the mechanical stresses caused by symmetrical or asymmetrical faults on any winding.
- l) The transformer should be designed to carry a certain level of direct current consistent with the STATCOM design. To ensure minimum harmonics generation, the saturation flux density of the transformer should be higher than the maximum flux density reached over the full steady state (continuous operating) range; this margin shall be at least 10%. This maximum flux density (over the full steady-state range) is obtained at the highest secondary voltage during any reactive power generation, highest reference voltage, minimum slope, and minimum continuous frequency. The flux density at the highest secondary voltage shall lie in the linear portion of the BH curve of the core. Any harmonic generated by the transformer should be considered for the design of the STATCOM.
- m) All protection class Current Transformers in the coupling transformer shall be of PX/PS type. Other details of these Current Transformers shall be as per protection/metering requirements and shall be decided during detailed engineering. However, the parameters of the Winding Temperature Indicator (WTI) of Current Transformer for each winding shall be as per the Coupling Transformer manufacturer.

- n) Transformers shall be capable of operating under natural cooled conditions up to the specified load. The forced cooling equipment shall come into operation by pre-set contacts of winding temperature indicator and the transformer shall operate as a forced cooling unit initially as Oil Natural Air Forced (ONAF) up to a specified load and then as Oil Forced Air Forced (OFAF). Cooling shall be so designed that during total failure of power supply to cooling fans and oil pumps, the transformer shall be able to operate at full load for at least ten (10) minutes without the calculated winding hot spot temperature exceeding 140 ° (degree) Celsius. Transformers fitted with two coolers, each capable of dissipating 50 percent of the heat due to losses at the continuous maximum rating, shall be capable of operating for 20 minutes in the event of failure of the oil circulating pump or blowers associated with one cooler without the calculated winding hot spot temperature exceeding 140 ° (degree) Celsius at continuous maximum rating.
- o) The transformer shall be free from any electrostatic charging tendency (ECT) under all operating conditions when all oil circulation systems are in operation. In general, the oil flow speed shall not exceed 1.0 m/sec within winding in the oil flow system of the transformers. The manufacturer shall ensure that there is no electrostatic charging tendency in the design.

The Technical Parameters of the Transformer shall be as below

Sl. No.	Description	Unit	Technical Parameters
1.1	Rated Capacity		
	HV	MVA	To meet the performance requirement and ratings of STATCOM. The transformer shall be suitable for 100% reactive loading
	MV	MVA	
1.2	Voltage ratio (Line to Line)		400 / XX (*)
1.3	Single / Three Phase Design		Single phase
1.4	Applicable Standard		IEC 60076
1.5	Rated Frequency	Hz	50
1.6	Cooling and Percentage Rating at different coolings		ONAN/ONAF/(OFAF or ODAF): 60% / 80%/100% OR ONAN/ONAF1/ONAF2: 60% /80%/100% OR OFAF (with 5 x 25% unit cooler if required)
1.7	Impedance at 75 °C (in		

Sl. No.	Description	Unit	Technical Parameters
	percentage)		
	HV–MV		To suit the design requirements.
1.8	Tolerance on Impedance (HV-MV)	%	As per IEC
1.9	Service		Outdoor
1.10	Duty		Continuous Reactive loading
1.11	Overload Capacity		IEC-60076-7
1.12	Temperature rise over 50 °C ambient Temp		
i)	Top oil measured by thermometer	°C	50
ii)	Average winding measured by resistance Method	°C	55
1.13	Windings		
i)	System Fault level		
	HV	kA	63
	MV	kA	To suit the design requirements.
ii)	Lightning Impulse withstand Voltage		
	HV	kVp	1300
	MV	kVp	*
	Neutral	kVp	170
iii)	Switching Impulse withstand Voltage		
	HV	kVp	1050
iv)	One Minute Power Frequency withstand Voltage		
	HV	kVrms	570
	MV	kVrms	*
	Neutral	kVrms	70
v)	Neutral Grounding		Solidly grounded
vi)	Insulation		
	HV		Graded
	MV		Uniform
vii)	Tan delta of winding	%	< 0.5
1.14	Vector Group (3 – ph) (unless specified differently elsewhere)		YNd*
1.15	Tap Changer		Not Applicable

Sl. No.	Description	Unit	Technical Parameters
1.16	Bushing		
i)	Rated voltage		
	HV	kV	420
	MV	kV	*
	Neutral	kV	36
ii)	Rated current (Min.)		
	HV	A	*
	MV	A	*
	Neutral	A	*
iii)	Lightning Impulse withstand Voltage		
	HV	kVp	1425
	MV	kVp	*
	Neutral	kVp	170
iv)	Switching Impulse withstand Voltage		
	HV	kVp	1050
v)	One Minute Power Frequency withstand Voltage		
	HV	kVrms	695
	MV	kVrms	*
	Neutral	kVrms	77
vi)	Minimum total creepage distances		
	HV	mm/kV	31
	MV	mm/kV	31
	Neutral	mm/kV	31
vii)	Tan delta of bushings		
	HV	%	Refer Note 2
	MV	%	Refer Note 2
viii)	Max Partial discharge level at Um		
	HV	pC	10
	MV	pC	10
	Neutral		-
1.17	Max Partial discharge level at $1.58 * U_r / \sqrt{3}$	pC	100
1.18	Max Noise level at rated voltage and at principal tap at no load and all cooling Active	dB	80
1.19	Maximum Permissible		

Sl. No.	Description	Unit	Technical Parameters
	Losses of		
	Transformers		
i)	Max. No Load Loss at rated voltage and Frequency	kW	To suit the design requirements.
ii)	Max. Load Loss at maximum continuous current and at 75° C	kW	To suit the design requirements.
iii)	Max. Auxiliary Loss at rated voltage and Frequency	kW	To suit the design requirements.

Notes:

1. No external or internal Transformers / Reactors are to be used to achieve the specified HV/MV impedances.
2. The criteria for Transformer losses shall be “Copper Loss (Load Loss) > Iron Loss (No Load Loss) > Cooler Loss (Auxiliary Loss)”.
3. (*) marked parameters shall be decided based on STATCOM manufacturer’s requirement.

C.8.10 STATCOM Station MV Switchgear

The MV Switchgear shall be designed with the aim to achieve operation according to the overall performance requirements of the STATCOM Station.

C.8.10.1 MV Circuit Breaker

The MV Circuit Breaker shall comply with the relevant IEC standard and all other relevant Standards, and as specified in this specification. They shall satisfy the General Technical Requirements and shall be designed to operate in the environmental conditions specified in this specification.

The Circuit Breaker offered should be of SF6 type/Vacuum type only and of class C2, M2 as per IEC

- i) The circuit breaker shall be complete with terminal connectors, operating mechanism, control cabinets, piping, interpole cable, cable accessories like glands, terminal blocks, marking ferrules, lugs, pressure gauges, density monitors (with graduated scale), galvanised support structure for CB and control cabinets, their foundation bolts and all other circuit breaker accessories required for carrying out all the functions the CB is required to perform.
- ii) All necessary parts to provide a complete and operable circuit breaker installation such as main equipment, terminals, control parts, connectors and other devices whether specifically called for herein or not shall be provided.

- iii) The support structure of the circuit breaker shall be hot dip galvanized. Exposed hardware items shall be hot dip galvanized or Electro-galvanized.
- iv) MV Circuit Breaker shall be equipped with controlled switching with consequent optimization of switching behavior, when used in:
 - Switching of Capacitor Bank
 - Switching of shunt Reactor Bank
- v) Reactor Switching Duty test shall be conducted on MV Circuit Breaker in line with latest edition of IEC 62271-110.
- vi) Type Tested for Back-to-Back Capacitor Bank Switching as per latest edition of IEC 62271-100.
- vii) Routine tests as per IEC: 62271-100 shall be performed on all circuit breakers.
- viii) The medium voltage circuit breakers in any of the branches shall be designed to switch off metallic three phase short circuits only limited by the transformer impedance of the STATCOM System (Coupling transformer) with the initial short circuit current and DC component according to IEC 60909-0. Thereby the worst case time constant where the maximum short circuit peak and DC component occur shall be considered. The network shall be considered to deliver the maximum short circuit power of the substation.

C.8.10.2 MV Isolator and Earth Switch

The isolators and earth switches shall comply with the IEC and all other relevant Standards, and as specified in this specification. They shall satisfy the General Technical Requirements and shall be designed to operate in the environmental conditions specified in this specification.

- i) The isolators and accessories shall conform in general to IEC-62271 series as per relevance (or IS:9921) except to the extent explicitly modified in specification.
- ii) Earth switches shall be provided on isolators wherever called for.
- iii) Switches shall be motor operated with local and remote operation features and local manual operation features. Remote operation of Earth Switch is not required.
- iv) Disconnections and earth switches shall electrically and mechanically be interlocked. Castle Key interlocking facilities shall be provided to mechanically interlock the earth switch and Isolator to the doors of valve rooms.

C.8.10.3 Instrument Transformers for STATCOM Station

The instrument transformers shall comply with the relevant IEC Standards.

They shall satisfy the general Technical Requirement specified in the specification and shall be designed to operate in the environmental conditions specified in this Specification. The instrument transformers provided for control, metering and protective relaying functions shall have voltage and current ratings, accuracy ratings and burden capabilities adequate to provide their designated functions within the overall accuracy requirement of the systems.

Voltage Transformers

Voltage transformers shall comply with the relevant IEC standards IEC 61869 (Part-1, Part-3 and Part-5).

Current Transformers

Current transformers shall comply with IEC 61869 (Part-1 and Part-2). Type tests and routine tests as per relevant IEC.

C.8.10.4 Surge Arrester

TSP shall install the surge arresters necessary for the protection of the equipment associated with the STATCOM Station in accordance with the requirements as per the insulation coordination study. The surge arresters shall give consistent protection to their associated equipment against overvoltage produced by lightning or switching surges, internal or external station faults, and other system disturbances.

The surge arresters shall be rated such that they are able to discharge a specified maximum energy due to the application of lightning, switching surges, temporary over voltages and faults as determined by insulation coordination studies, without coming into the temperature region where thermal runaway could result upon subsequent application of maximum transient and steady state voltage conditions.

The arrester housing shall be porcelain/composite type. The end fittings shall be made of non-magnetic and corrosion proof material.

Internal components shall be designed to eliminate internal corona and also to ensure minimal capacitive coupling with any conducting layer of pollutant on the outside of the porcelain housing. Particular attention shall be given to the high discharge currents which some of the arresters may experience in service due to discharge of stored energy of the AC filter and reactive compensating equipment, tripping of STATCOM etc.

C.8.11 STATCOM Station Auxiliary Power Supply

The auxiliary supply of STATCOM Station shall conform with the system requirements relating to reliability, availability, and redundancy, performing continuously to help ensure that the complete STATCOM Station operates as per the requirements. STATCOM station Auxiliary supply including all necessary switchgear (viz. AC/DC, lighting boards etc.) shall be completely separate from the main 765/400/220 kV substation auxiliary supply, all loads of

STATCOM station shall be fed from this supply. The auxiliary supply provides power to the controllers, cooling system, station supplies, and various other essential and non-essential loads. With the exception of the cooling system, all other essential loads are also connected to the DC system of the STATCOM Station which is also to be provided separately from the DC system of the main 765/400/220 kV substation.

The auxiliary supply system shall be able to provide a stable supply for the STATCOM Station during system faults such as single-phase faults, phase-to-phase faults, and three-phase faults and LVRT (Low Voltage Ride Through) to allow continuous operation of the STATCOM Station during these transient events.

The auxiliary supply system of each STATCOM Station shall consist of two main incomers and one emergency incomer from DG set. The two main incomers shall be required to be paired to act redundantly to help ensure a certain degree of reliability and availability. One of the main incomers shall be supplied from 33 kV tertiary winding of 765/400/33 kV or 400/220/33 kV ICT at the main substation.

The other main incomer can be supplied from any one of the following three options:

- Supplied from Tertiary/Yoke winding of STATCOM coupling Transformer.
- Supplied from MV Bus Bar of STATCOM Station.
- Supplied from Power PT on HV side of coupling Transformer.

Wherever the Voltage variation on the incomer is very high, a solid state AVR (Automatic Voltage Regulator) shall be provided to control the auxiliary supply voltage.

All MV incomers shall be provided with suitable CB, disconnector, instrument Transformer etc along with necessary protection system.

C.8.12 Fire Protection System for STATCOM Station:

Necessary fire protection for STATCOM units, Coupling Transformer, MSC, MCR and Harmonic filter (if any) shall be required. The main features of these protections are as under.

Fire Detection and Alarm System:

Suitable fire detection system using smoke detectors and/or heat detectors shall be provided in STATCOM Station for all room and areas. These smoke fire detection systems shall be connected to a separate Fire annunciation system clearly identifying the zone.

Hydrant System:

The hydrant system shall be extended from fire fighting system of the substation in the yard. Suitable number of hydrants shall be provided for protection of STATCOM Station equipment in the yard namely Coupling Transformer, MSCs, MSRs and Harmonic Filter (if required) etc as applicable for the station. Further suitable number of hydrants shall also be provided for STATCOM Station building

HVW System:

HVW (High Velocity Water) Spray system shall be provided for coupling transformer. The tapping for HVW system shall be done from nearby transformer/Reactor or any other suitable point of the main substation fire-fighting line-

Fire protection system shall be provided in accordance with the Central Electricity Authority (Measures relating to Safety and Electric Supply) Regulations, 2023.

C.8.13 Air-conditioning and ventilation system for STATCOM station

The STATCOM Station shall be provided with Air conditioning system as per requirement.

1) AC System (Except Valve Hall):

Air condition system shall be provided for the following rooms in the STATCOM Building:

- a. Control and Relay room
- b. Battery room
- c. Conference Room
- d. Store cum workshop
- e. Cooling system room
- f. Lobby

Capacity and quantity of the AC units shall be decided based on heat load calculation and redundancy requirement.

2) Air-Conditioning System for Valve hall:

Air-Conditioning shall be provided for each Valve room for maintaining the following inside conditions round the year:

DBT - 35 °C (Maximum) Relative Humidity (RH) - 60% (Maximum)

The system shall be designed for an outside ambient temperature of 50 °C. Based on the above system design and parameters for valve room the AC

system shall comprise “AHU and Air-cooled DX Condensing units” with one Main and one Standby unit for each room. The system shall be designed for 24 Hours, 365 Days of the year operation to maintain the inside temperatures of the Valve Hall for proper operation of the critical equipment. The air-cooled condensing unit shall be designed for continuous duty.

C.9 Engineering studies

The TSP shall carry out studies as brought out in this section with a model of the STATCOM in PSSE and PSCAD and documentation of the same shall be preserved and to be submitted to CEA/CTU, as per their requirement. The objective of these studies is to verify the steady state requirement of reactive power under normal and contingent operating conditions for peak and light loads conditions in the network.

The studies shall have to be carried out for

- Peak Load
- Light Load
- Contingency Conditions

The load flow and dynamic file available with CTU shall be provided to the TSP in PSSE version 34 format. If data is not available typical data shall be assumed by TSP.

The studies should demonstrate that the STATCOM system meets all system and equipment specified performance criteria as per the specification. Engineering studies should include, but not be limited to, the studies described in subsequent subsections.

C.9.1 System dynamic performance studies

Dynamic performance studies should verify that the STATCOM system controls the system’s dynamic performance during system disturbances. Dynamic performance studies include the following:

- a. Studies verifying that the STATCOM provides adequate dynamic control to meet the system and STATCOM system performance criteria for the system conditions.
- b. Study of response time and of the STATCOM system’s behavior and contribution to the system’s recovery from faults.
- c. Studies to verify the operation of any supplementary controls designed to damp power oscillations following system disturbances.
- d. Studies to evaluate the interaction of the STATCOM controls with the other nearby control systems, including high-voltage direct current (HVDC) controls, generator controls, and controls of other flexible AC transmission systems (FACTS) devices

In addition to the above, relevant studies shall include the cases stated as

mentioned in Annexure-I

C.9.2 Harmonic performance

The studies should evaluate resultant maximum harmonic levels at the STATCOM system point of common coupling (PCC), and determine maximum stresses on all STATCOM system components. The study report should include the following:

- a. Evaluation of specified system and operating conditions (refer to Clause 5) under all possible STATCOM operating conditions.
- b. Evaluation within maximum ranges of STATCOM system component tolerances (worst performance values may not occur at detuning extremes).
- c. Evaluation with maximum system voltage unbalance (refers to item 8 and item 9 in Table 3 of Clause 5).
- d. Evaluation of the worst case resonance condition between STATCOM system and overall system.
- e. Evaluation of possible resonant over voltages.
- f. Transformer saturation induced harmonics for component rating calculation only.
- g. Evaluation of impact considering single phase auto reclose deadtime.

C.9.3 Electromagnetic transients, control performance, and overvoltage studies

Transient overvoltage studies should be performed with the actual control modeled to verify that the STATCOM system equipment is adequately protected against over voltages and over currents (including excessive valve recovery voltages) from power system transients resulting from switching, fault clearing events, and credible STATCOM system maloperations. Evaluation shall include the following:

- a. Study of start-up, including transformer energization, shutdown, switching coordination, and other local area network switching events
- b. Study of STATCOM system protection and protection coordination
- c. Faults on the high-voltage (HV) and MV bus (single line-to-ground, phase-to-phase, and three-phase)
- d. Faults across the VSC, capacitors, and other equipment if used.
- e. Control interaction

C.9.4 Insulation coordination study

Overall insulation coordination should be verified by considering the results of 8.4 (dynamic over voltages, and fault and switching transients), including the impacts of lightning surges on the STATCOM equipment. This study should

determine and verify insulation levels, clearances, and arrester placement and ratings.

C.9.5 Other Studies

- a) Grounding Study
- b) Protection coordination
- c) PLC/radio interference
- d) Magnetic field strength
- e) Other studies as applicable

C.9.6 Software simulation models

The TSP shall provide the latest following PSCAD and PSSE simulation model(s) and parameters to CEA/CTU/GRID-INDIA alongwith detailed documentation for the purpose of future simulation to adequately represent and model the proposed STATCOM system in the respective software:

- a. **Stability model.** TSP should provide a detailed STATCOM system dynamics model for use in (PSCAD and PSSE) power flow and stability simulation software. The model detail should be appropriate and complete for positive-sequence power system simulation and analysis that is typically performed with power flow and transient stability programs. All appropriate control features for such analysis will be modeled, and necessary documentation on the theory and use of model should be provided. Further, a generic model, benchmarked to detailed STATCOM stability model, shall also be furnished for distribution.
- b. **Transient model.** TSP should provide a detailed STATCOM transients model for use in PSCAD. The model detail should be appropriate and complete for the transient response calculation of the STATCOM system. All appropriate control features for such analysis will be modeled, and necessary documentation on the theory and use of model should be provided. Further, a generic model, benchmarked to detailed STATCOM transient model, shall also be furnished for distribution.

PSS/E files may be used for developing RTDS files/ models. For simulation of STATCOM in PSS/E file (load flow and dynamic) and PSCAD (Transient) model for STATCOM is required for study. TSP will share STATCOM models with CEA, CTU and Grid-India along with detailed documentation for above study purposes and simulations. For PSS/E, both Generic and User-defined models shall be shared by the TSP with the CEA, CTU and Grid-India. Generic model (**PSS/E**) response shall be benchmarked with user-defined model (**PSS/E and PSCAD**) to the extent possible by the TSP. Generic models can be shared by the CEA, CTU and Grid-India with the concerned stakeholders/external party(ies) e. g. STUs etc. on need basis. For User Defined model, confidentiality shall be maintained by the CEA, CTU and Grid-

India. For PSCAD, User Defined model shall be provided by the TSP for which confidentiality shall be maintained by the CEA, CTU and Grid-India.

Both UDM (PSCAD and PSS/E) and Generic model (PSSE) shall be provided by OEMs to CEA/CTU/GRID-INDIA without any NDA (Non-Disclosure Agreement)

C.9.7 Factory tests of controls

The integrated nature of the performance of the STATCOM in an electrical grid requires the following tests:

- a. The TSP should perform factory simulator system tests for integrated control and protection system to ensure the proper operation of the same. The control system should be connected to a digital simulator with adequate representation of the electrical network for various conditions. The STATCOM system controller needs to be representative of control functions, including basic controllers but inclusive of supplementary controls, firing controls, and protective functions integrated into the controllers. TSP shall submit the Factory Acceptance Test (FAT) reports of STATCOM controls to CTU/RLDC.
- b. The simulator should provide an accurate network representation including network harmonic behavior, as well as synchronous condensers, power stations, generators (with AVRs), and pump storage schemes, existing HVDC, SVCs and STATCOMs, future SVCs and STATCOMs, FSC (fixed series capacitors), and shunt reactors/capacitors/filters.

STATCOM system control function type tests on a simulator should include the following:

- Verification of each control function.
- Verification of control linearity.
- Verification of control redundancy.
- Verification of the monitoring system.
- Verification of the protection system with reference to integrated protective functions included in the Controllers and firing controllers.
- Verification of overall system performance for minor and major system disturbances.
- Verification of processor loading of all digital controllers.
- Verification of STATCOM system parallel operation with other controls in the system and control Stability.
- Verification of control equipment performance for auxiliary power supply voltage (AC and DC) and frequency variations (AC).

- Routine production tests of all control functions, and separately of all protection functions.

C.10.0 VISUAL MONITORING SYSTEM FOR WATCH AND WARD OF STATCOM STATION

Visual monitoring system (VMS) for effective watch and ward of STACOM station premises covering the areas of entire switchyard, STATCOM building, Coupling Transformer, Cooling Towers and main gate, shall be provided. The TSP shall design, supply, erect, test and commission the complete system including cameras, Digital video recorder system, mounting arrangement for cameras, cables, LAN Switches, UPS and any other items/accessories required to complete the system.

Features of VMS system shall be as those specified for main substation. The number of cameras and their locations shall be decided in such a way that any location covered in the area can be scanned. The cameras shall be located in such a way to monitor at least:

- a) Coupling Transformer, Mechanically Switched Reactors (MSRs) (if any) and Mechanically Switched Capacitors (MSCs) (if any), AC filter banks (if any).
- b) STATCOM Valve Hall, Cooling System, Electrical and Mechanical Auxiliary area.
- c) Entrance to STATCOM Station.
- d) All other Major Equipment (such as CB, CT, VT, SA etc.)

The cameras can be mounted on structures, buildings or any other suitable mounting arrangement.

C.11.0 Spares, Special Tools and Tackles

Considering STATCOM as high technology proprietary equipment of the OEM, the TSP shall ensure necessary spares are procured to maintain the necessary reliability and availability of STATCOM station. Further all necessary special tools and tackles required for erection, testing, commissioning, and maintenance of equipment shall also be taken.

Contingency Cases for STATCOM

A) N-1 Contingency

Contingency at 765 kV level

1. Three Phase Fault close to 765 kV bus of Tuticorin GH followed by tripping of one circuit of Tuticorin PS – Tuticorin (GH) 765 kV D/c line (fault persisted for 100 ms)
2. Single Phase to Ground Fault close to 765 kV bus of Tuticorin GH followed by single pole opening (100 ms) of the faulted phase and unsuccessful re-closure (dead time 1 second) followed by 3-pole opening (100 ms) of the faulted line i.e. tripping one circuit Tuticorin PS – Tuticorin (GH) 765 kV D/c line
3. Three Phase Fault close to 765 kV bus of Tuticorin GH followed by tripping of one circuit of Tuticorin PS – Dharmapuri 765 kV D/c line (fault persisted for 100 ms)
4. Single Phase to Ground Fault close to 765 kV bus of Tuticorin GH followed by single pole opening (100 ms) of the faulted phase and unsuccessful re-closure (dead time 1 second) followed by 3-pole opening (100 ms) of the faulted line i.e. tripping one circuit of Tuticorin PS – Dharmapuri 765 kV D/c line

Contingency at 400 kV level

5. Three Phase Fault close to 400 kV bus of Tuticorin GH followed by tripping of one 765/400kV ICT at Tuticorin GH (fault persisted for 100 ms)
6. Three Phase Fault close to 400 kV bus of Tuticorin GH followed by tripping of 1 GW load at Tuticorin GH (fault persisted for 100 ms) – ***Load Throwover case***

B) N-1-1 Contingency

Contingency at 765 kV level

7. Case 1 and 2 (consider as separate cases) + Single Phase Fault close to 765 kV bus of Tuticorin GH followed by single pole opening (100 ms) of the faulted phase (2nd ckt of Tuticorin PS – Tuticorin (GH) 765 kV D/c line) and successful re-closure (dead time 1 second)
8. Case 3 and 4 (consider as separate cases) + Single Phase Fault close to 765 kV bus of Tuticorin GH followed by single pole opening (100 ms) of the faulted phase (2nd ckt of Tuticorin PS – Dharmapuri 765 kV 765 kV D/c line) and successful re-closure (dead time 1 second)

SPECIFIC TECHNICAL REQUIREMENTS FOR COMMUNICATION

The communication requirement shall be in accordance to CEA (Technical Standards for Communication System in Power System Operations) Regulations, 2020, CEA (Technical Standards for Construction of Electrical Plants and Electric Lines) Regulations, 2022, CERC (Communication System for inter-State transmission of electricity) Regulations, 2017, CEA (Cyber Security in Power Sector) Guidelines, 2021, CERC Guidelines on “Interface Requirements” 2024 and all above documents as amended from time to time.

The communication services viz. SCADA, AGC (wherever applicable), VoIP, AMR and PMU have been identified as critical services and therefore shall be provisioned with 2+2 redundancy i.e. 2 channels for Main Control Centre and 2 channels for Backup Control Centre. In order to meet this requirement, suitable redundancy at port and card level need to be ensured by the TSP to avoid any single point of failure which may lead to interruption in real-time grid operation.

PMU to PDC communication (wherever required) shall be through 2 channels to the PDC (main) as there is no backup PDC at present.

Accordingly, all the hardware for communication services of station as stated above shall support dual redundancy for data transmission of station to respective main and backup RLDCs.

The complete ISTS communication system commissioned by TSP under the RFP shall be the asset of ISTS and shall be available for usage of ISTS requirements as suggested by CTU from time to time.

In order to meet the requirement for grid management and operation of substations, Transmission Service Provider (TSP) shall provide the following:

C.1.0 Establishment of 765/400 kV Tuticorin (GH) S/s

- (I) TSP shall supply, install and commission One or more FODP with minimum 144 Fiber capacity along with panel and approach Cable (48F each) with all associated hardware fittings from gantry tower to Control Room for all the incoming lines envisaged under the present scope.
- (II) TSP shall supply, install and commission One or more STM-16 (FOTE) equipment alongwith panel/s supporting minimum Three (3) directions with MSP (Multiplex Section Protection – 1+1). Communication Equipment shall be provided with the necessary interfaces to meet the voice and data communication requirement among Tuticorin PS and Tuticorin (GH). The suitable DC Power Supply and backup to be provided for communication equipment.
- (III) FODP and FOTE equipment with panels shall be provided in Control Room of Tuticorin (GH) S/s. FOTE and FODP Eq can be accommodated in same panel

to optimize space.

- (IV) TSP shall supply, install and commission Firewall in redundant mode (1+1) in line with the specification attached at **Annexure F.1**.
- (V) The maintenance of all the communication equipment and software thereof including FOTE, FODP, PMU, approach cable, DCPS alongwith Battery Bank and Firewall shall be the responsibility of TSP.

C.2.0 Tuticorin PS – Tuticorin (GH) 765 kV D/c line

- (I) On Tuticorin PS – Tuticorin (GH) 765 kV D/c line, TSP shall supply, install and commission One (1) no. OPGW cable containing 48 Fibres (48F) on one E/W peak and conventional earth wire on other E/W peak.
- (II) The TSP shall install this OPGW from gantry of Tuticorin (GH) up to the gantry of Tuticorin PS with all associated hardware including Vibration Dampers, mid-way and gantry Joint Boxes (called **OPGW Hardware** hereafter) and finally terminate in Joint Boxes at end Substations. The transmission line length is **50 kms (approx.)**, where repeater may not be required to meet the link budget requirement of Tuticorin PS – Tuticorin (GH) 765 kV D/c link.
- (III) Maintenance of OPGW Cable and OPGW Hardware shall be responsibility of TSP.

C.3.0 OPGW requirement for Termination of line due to change of Bay 400kV to 765kV at Tuticorin PS , Dharampuri (Salem New), Madhugiri

- (I) TSP shall supply, install and commission One (1) no. OPGW cable containing 24 Fibres (24F) on one E/W peak and conventional earth wire on other E/W peak on each end of following lines as per **Fig-F.1** for termination lines at 765kV bays from existing 400kV bays:
 - (i) Tuticorin PS - Dharampuri (Salem New) – 1-2 kms both side (2-4 kms. OPGW)
 - (ii) Dharampuri (Salem New)- Madhugiri – 1-2 kms both side (2-4 kms. OPGW)
- (II) The TSP shall install this OPGW with all associated hardware including Vibration Dampers, mid-way and gantry Joint Boxes (called **OPGW Hardware** hereafter) and finally terminate in Joint Boxes at end Substations.
- (III) TSP shall integrate this OPGW with existing OPGW on these lines and also terminate in the FODP in the control room of these stations e.g. Tuticorin PS , Dharampuri (Salem New), Madhugiri with proper splicing, testing and commissioning.
- (IV) Maintenance of OPGW Cable and OPGW Hardware shall be responsibility of TSP.

Note: Existing OPGW with 24 Fiber is available in one no. of 765kV S/c Dharampuri (Salem New)- Madhugiri line therefore on the sections mentioned above at (I) (i) and (ii) 24F OPGW has been considered.

C.4.0 FOTE requirement at Tuticorin PS

- (I) TSP shall supply, install and commission One or more no. FODP with minimum 144 Fiber capacity alongwith panel and required Approach Cable (24F/48F) as per OPGW fiber capacity with all associated hardware fittings from gantry tower to Bay Kiosk and from the Bay Kiosk to Control room
- (II) TSP shall supply, install and commission 1 no. STM-16 (FOTE) equipment alongwith panel/s supporting minimum Three (3) directions with MSP (Multiplex Section Protection – 1+1) with necessary interfaces to meet the voice and data communication requirement among Tuticorin PS, Tuticorin (GH) S/s and local patching with Control Room FOTE. The suitable DC Power Supply and backup to be provided for communication equipment.
- (III) FOTE/FODP panel shall be installed in the new Bay Kiosk (Switchyard Panel Room (SPR)). The FOTE under present scope shall be integrated by TSP with the existing FOTE at control room of **Tuticorin PS** which shall be communicating with respective control center. TSP to provide necessary FODP sub rack / Splice trays/ Patch cords etc. and optical interfaces/equipment in the existing FOTE/FODP panels in control room for integration with the existing FOTE for onwards data transmission.

In case spare optical direction is not available in the existing FOTE at the control room, the TSP shall coordinate with station owner to reconfigure the directions in existing FOTE at control room. Alternatively, The TSP may integrate the FOTE under the present scope with existing FOTE in the nearby Kiosk connected to the control room FOTE (if available with spare direction). For this purpose, TSP shall provide necessary FODP sub rack / Splice trays/ Patch cords etc. and suitable optical interfaces/ equipment in the existing FOTE/FODP panels in another Kiosk (SPR).

- (IV) FOTE and FODP can be accommodated in same panel to optimize space.
- (V) The maintenance of all the communication equipment and software thereof including FOTE, FODP, approach cable, PMU, DCPS alongwith Battery Bank shall be the responsibility of TSP.

C.5.0 FOTE/ Interfaces requirement for Bay upgradation work at Dharmapuri (Salem new) S/s

- (I) TSP shall supply, install and commission required Approach Cable (24F) with all associated hardware fittings from gantry tower to Control room.

- (II) TSP shall supply necessary optical interfaces to meet link budget requirement between **Dharmapuri (Salem new) – Tuticorin PS** in the existing FOTE of **Dharmapuri (Salem new) S/s** Control Room. TSP shall also provide necessary support and integration required for new interfaces in the existing FOTE.

C.6.0 FOTE/ Interfaces requirement for Bay upgradation work at Madhugiri S/s

- (I) TSP shall supply, install and commission required Approach Cable (24F) with all associated hardware fittings from gantry tower to Control room.
- (II) TSP shall supply necessary optical interfaces to meet link budget requirement between **Dharmapuri (Salem new) – Madhugiri** in the existing FOTE of **Madhugiri S/s** Control Room. TSP shall also provide necessary support and integration required for new interfaces in the existing FOTE

C.7.0 Specific Requirement for Phasor Measurement Units (PMUs)

TSP shall supply, install and commission required no. of Phasor Measurement Units (PMUs) at all the locations under the scope this RFP as per CEA (Technical Standards for Construction of Electrical Plants and Electric Lines) Regulations, 2022 (alongwith all amendments if any) and all the other applicable Regulations, Standards, Guidelines issued time to time. The signal list shall be as per the Annexure-I Part-B of CERC Guidelines on “Interface Requirements” 2024. PMUs also to be provided at **STATCOMs** locations. These PMUs shall be provided with GPS clock and LAN switch and shall connect with LAN switch of control room of respective substations/ generating stations with Fibre Optic cable. These PMUs shall be connected with the FOTE at Substation/ generating stations for onwards data transmission to the PDC (Phasor Data Concentrator) located at respective RLDC. Configuration work in existing PDC at RLDC for new PMU integration shall be done by respective RLDC, however all the necessary support in this regard shall be ensured by TSP. The maintenance of all the PMUs and associated equipment shall be the responsibility of TSP.

Note: Existing Station owner/s to provide necessary support to integrate different equipment and applications of new extended bays with the existing substation e.g. Communication (through FOTE), Voice etc. for smooth operation and monitoring of new added grid elements.

Proposed Communication for “Transmission system for proposed Green Hydrogen / Green Ammonia projects in Tuticorin area”

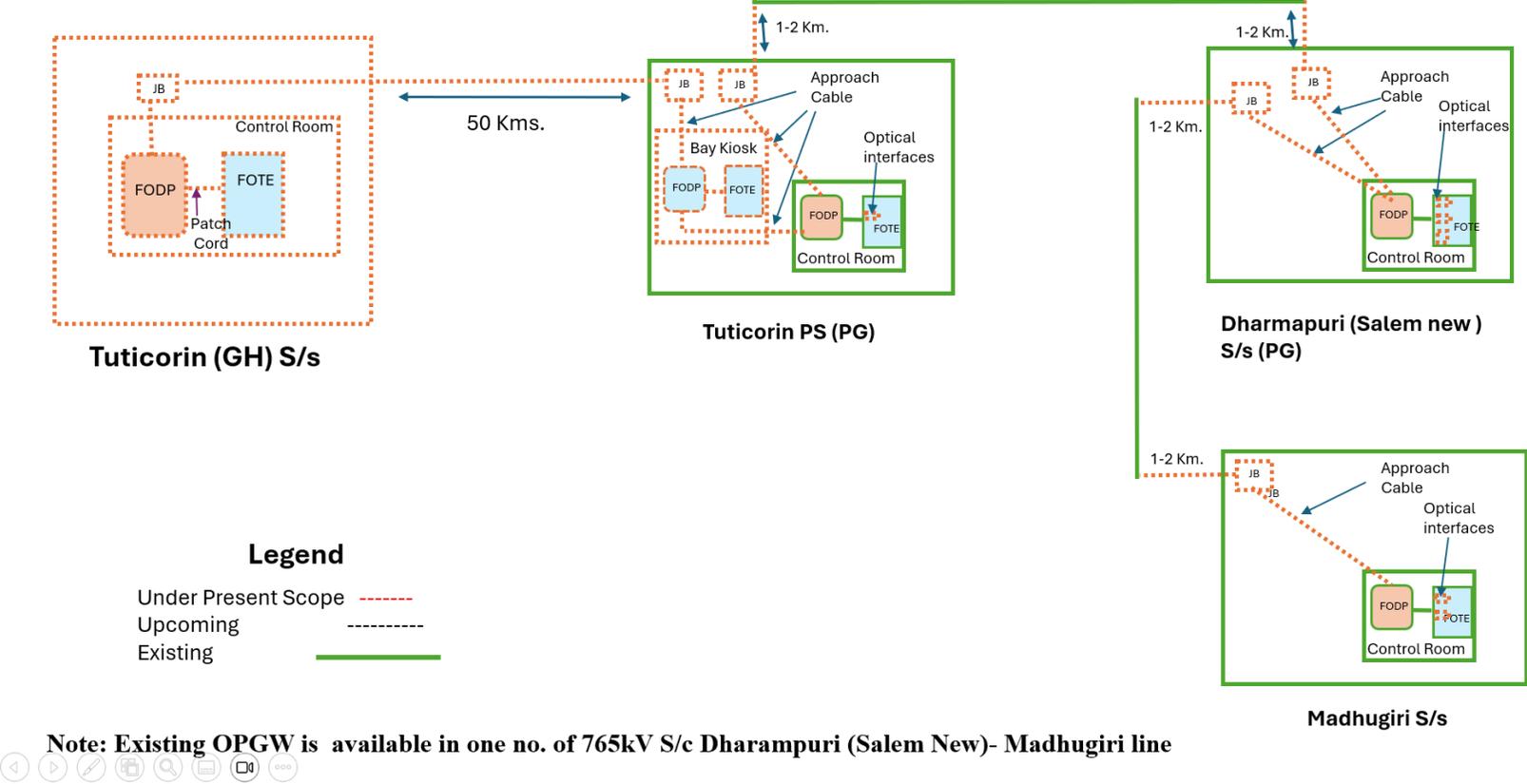


Figure F.1

Next Generation Firewall (NGFW)

TSP shall provide 2 NGFW one in Main and another in Standby mode having electrical ethernet interfaces/ports and placed between FOTE and SAS gateway/s at the substation. All ethernet based applications shall be terminated in the firewall ports directly (e.g. PMU, AMR, VOIP, SAS/SCADA etc.). Each port of firewall shall work as a separate zone. Firewall shall be hardware based with features of Block/Allow/drop and IPSec VPN (network encryption).

The number of ports/interfaces in each firewall (i.e. Main and Standby) shall be minimum 16 nos. TSP shall provide either single firewall or multiple firewalls to meet this interfaces requirement, each for main as well as standby firewall. Minimum throughput of firewall shall be 300 Mbps.

The Firewall shall be managed/ configured as standalone at present and shall also have compatibility to manage/configure through Centralized Management Console (CMC) remotely in future.

Firewall shall be tested and certified for ISO15408 Common Criteria for least EAL4+. Further, the OEM must certify that it conforms to Secure Product Development Life Cycle requirements as per IEC62443-4-1. The firewall shall generate reports for NERC-CIP Compliance.

The specifications for the firewalls are given at **Annexure-F.2** and schematic diagram showing firewall placement given at **Figure F.2**.

Specifications of Next Generation Firewall (NGFW)

1. NGFW shall have following features including but not limited to:
Encryption through IPSec VPN (Virtual Private Network), Deep Packet Inspection (DPI), Denial of service (DoS) and Distributed Denial of Service (DDoS) prevention, Port Block/ Allow, rules/ policies for block/allow, IP (Internet Protocol) and Media Access Control (MAC) spoofing protection, threat detection, Intrusion Prevention System (IPS), Anti-Virus, Anti-Spyware, Man In The Middle (MITM) attack prevention.
2. The proposed firewall shall be able to handle (alert, block or allow) unknown /unidentified applications e.g. unknown TCP and UDP packets. It shall have the provision to define application control list based on application group and/or list.
3. Firewall shall have feature and also have capability to update the definition/ Signatures of Anti-Virus online as well as offline. Firewall shall also be compatible to update the definitions/signatures through CMC. There shall be a defined process for security patching and firmware up-gradation. There shall be a feature to field validate firmware checksum. The same shall also be validated before using the OEM provided file/binary in the process of firmware up-gradation and security patching
4. Firewall shall have Management Console port to configure remotely.
5. Firewall shall be EMI/EMC compliant in Substation environment as per IEC 61850-3.
6. Firewall shall be rack mounted in existing standard equipment cabinets.
7. Firewall shall have support of SCADA applications (IEC-60870-5-104), ICCP, PMU (IEEE C37.118), Sub-Station Automation System (IEC 61850), Ethernet and other substation environment protocols.
8. Client based Encryption/ VPN must support different Operating System platforms e.g. Windows, Linux and Mac.
9. The solution must have content and comprehensive file detection policies, blocking the files as function of their types, protocols and directions.
10. Firewall shall have logging facility as per standard logs/events format. Firewall shall have features to export the generated/stored logs/events in csv (Comma Separated Value) and also any other standard formats for offline usage, analysis and compliance. Firewall shall have suitable memory architecture and solution to

store and be able to export all logs/events for a period of last 90 days at any given time.

11. Firewall shall have features and be compatible with local as well as central authentication system (RADIUS, LDAP, or TACACS+) for user account and access right management. It shall also have Role Based User management feature.
12. Firewall shall have the capability to configure sufficient number of VLANs.
13. Firewall shall have the capability to support sufficient number of sessions.
14. Firewall shall have provision to configure multiple IP Sec VPNs, at least 100 nos., (one-to-many or many-to-one). Shall support redundant operation with a similar router after creation of all the IP Sec VPN. IPsec VPN shall support encryption protocols as AES128, AES256 and hashing algorithms as MD5 and SHA1. IPsec VPN throughput shall support at least 300 Mbps
15. Firewall shall be capable of SNMP v3 for monitoring from Network Management system. It shall also have SNMPv3 encrypted authentication and access security
16. Firewall shall support in Active/Passive or Active-Active mode with High Availability features like load balancing, failover for firewall and IPsec VPN without losing the session connectivity.
17. Firewall should have integrated traffic shaping (bandwidth, allocation, prioritisation, etc.) functionality
18. Shall support simultaneous operation with both IPv4 and IPv6 traffic
19. Firewall shall be compatible with SNTP/NTP or any other standards for clock synchronization
20. Firewall shall have the features of port as well as MAC based security
21. Firewall shall support exporting of logs to a centralized log management system (e.g. syslog) for security event and information management.
22. Firewall time shall be kept synchronised to official Indian Timekeeping agency, time.nplindia.org.
23. Firewall product shall be provided with all applicable updates at least until 36 months since the applicable date of product shipping to the concerned utility.

Firewall Placement Diagram

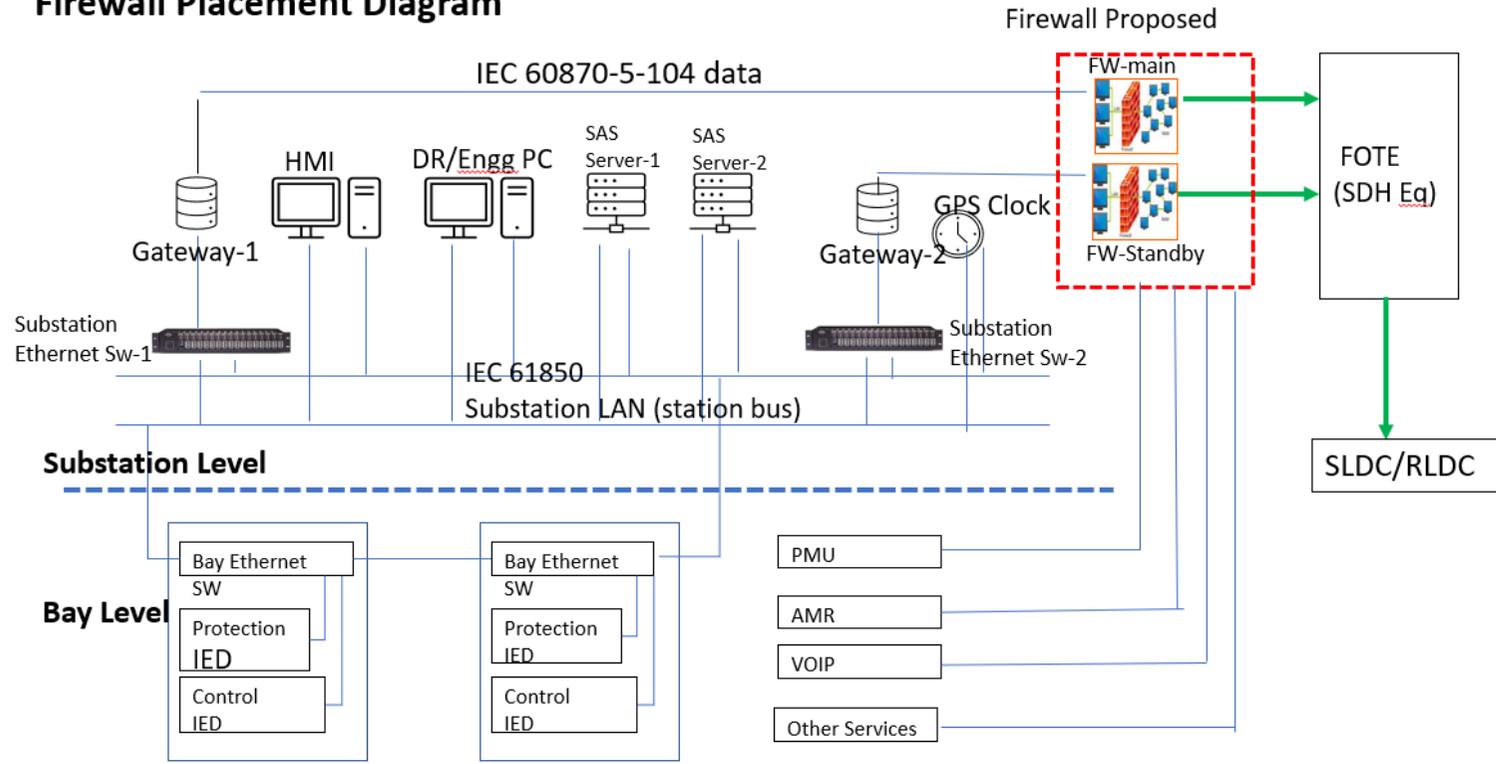


Figure F.2

C.8.0 PLCC and PABX:

Power line carrier communication (PLCC) equipment complete for speech, tele-protection commands and data channels shall be provided on each transmission line. The PLCC equipment shall in brief include the following: -

- Coupling device, Coupling filters line traps, carrier terminals, protection couplers, HF cables, PABX (if applicable) and maintenance and testing instruments.
- At new substation, a telephone exchange (PABX) of 24 lines shall be provided at as means of effective communication among various buildings of the substation, remote end substations and with control centres (RLDC/ SLDC) etc.
- Coupling devices shall be suitable for phase-to-phase coupling for 400 kV Transmission lines. The pass band of coupling devices shall have sufficient margin for adding communication channel in future if required. Necessary protection devices for safety of personnel and low voltage part against power frequency voltages and transient over voltage shall also be provided.
- The line traps shall be broad band tuned suitable for blocking the complete range of carrier frequencies. Line Trap shall have necessary protective devices such as lightning arresters for the protection of tuning device. Decoupling network consisting of line traps and coupling capacitors may also be required at certain substation in case of extreme frequency congestion.
- The carrier terminals shall be of single side-band (SSB) amplitude modulation (AM) type and shall have 4 kHz band width. PLCC Carrier terminals and Protection couplers shall be considered for both ends of the line.
- PLCC equipment for all the transmission lines covered under the scheme shall be provided by TSP. PLCC to be provided for following lines under present scope:

Sl. No	Line name	PLCC configuration
1	Tuticorin PS – Tuticorin (GH) 765 kV D/c line	1 set Analog PLCC + 1 set Digital Protection Coupler for each circuit at both ends.
2	Upgradation of Tuticorin PS - Dharmapuri (Salem New) 765kV D/c line (presently charged at 400kV level) at its rated 765kV voltage level	Existing PLCC/DPC may be utilized.
3	Upgradation of Dharmapuri (Salem New) – Madhugiri 765kV 2xS/c lines (presently charged at 400 kV) to its rated voltage at 765 kV	Existing PLCC/DPC may be utilized.

Further, CVT and Wave trap for all 765 kV line bays under present scope shall be provided by TSP.

- All other associated equipment like cabling, coupling device and HF cable shall also be provided by the TSP.
- Two (2) sets of 48 V battery banks for PLCC and communication equipment shall be provided at each new Substation with at least 10-hour battery backup and extended backup, if required.

Annexure – E

SPECIFIC TECHNICAL REQUIREMENTS FOR INTEGRATION OF COMMUNICATION EQUIPMENT WITH REGIONAL LEVEL NMS / REGIONAL UNMS:

The new communication equipment/ system for all the substations under the present scope shall be compatible for integration with existing regional level NMS system/ Centralized Supervision and Monitoring System (CSMS) i.e. Regional UNMS. The local configuration of the new communication equipment at the station end shall be the responsibility of TSP as per **Annexure E.1**. The configuration work in the existing centralized NMS/ CSMS at Control center end, for integration of new Communication equipment/ system shall be done by Regional ULDC Team/ NMT, however all the necessary support in this regard shall be ensured by TSP.

Annexure E.1

Requirement for integration of Communication Equipment with Regional UNMS:

1. TSP shall ensure that NMS/EMS/NE supplied by them is NBI compliant and all FCAPS functionality is supported in the NBI such as NE Inventory, Hardware Inventory – Shelf/Slot/Card/SFP/Port, Topology, Protections, Alarms, Performance- real time and periodic, Performance KPI parameters (E-1, STM, Ethernet) , Remote Configuration, Cross Connects, Trails and Circuits, Services Provisioning (NE), E-1 , STM, Ethernet , TX and RS Trace, loop back and details are published in the NBI guide for the configuration parameters.
2. TSP shall be obliged to provide/share all necessary documentations such as NBI Guide/MIB/IDL/WSDL/API files/ etc. for onward integration of their NMS/EMS/NE with regional UNMS.
3. The following support shall be provided by TSP for integration of their supplied equipment with regional UNMS:
 - Enabling and activating NBI license in their EMS/NMS and providing NBI login access along with User credentials
 - Assist in verifying NBI Connectivity with UNMS vendor for the successful communication and retrieval of data.
 - Assist in troubleshooting (if required) for NBI connectivity along with UNMS vendor for the communication and retrieval of data.
4. For standalone NE which is not integrated with any EMS/NMS, TSP shall provide modality of complete FCAPS data acquisition as above through industry standard programmatic methods and provide the CLI command manual.

Frequently Asked Queries:

1.0 Transmission Line:

- 1.1 Please clarify that whether shutdowns for crossing of existing transmission lines of POWERGRID/STUs/ Power Evacuation Lines from Generation Plants/ Any other Transmission Licensee will be given to TSP on chargeable basis or free of cost.

Reply: Shutdowns for crossing of existing transmission lines of POWERGRID/STUs/ Power Evacuation Lines from Generation Plants/ Any other Transmission Licensee will be given to TSP by the concerned owner of the lines as per their own terms and conditions. As far as shutdown of ISTS lines are concerned the same can be availed by approaching respective Regional Power Committee.

- 1.2 We understand that the suggested swing angle criteria are applicable for Suspension Insulator in Suspension Tower. Further, you are requested to provide similar swing angle and clearance criteria for Pilot Insulator with Jumper and Jumper.

Reply: It is clarified that the swing angle criteria (as mentioned in RFP) for transmission lines is applicable for Suspension Insulator in Suspension Tower. Further, as per Clause 3.0 of Specific Technical Requirements for transmission lines, Transmission service Provider (TSP) shall adopt any additional loading/design criteria for ensuring reliability of the line, if so desired and /or deemed necessary.

- 1.3 We request you to kindly allow that use of diamond configuration at Power line crossings and the existing owner of the lines may be directed to allow the same for the successful bidders.

Reply: Power line crossing including Diamond configuration is responsibility of the TSP. TSP shall formally submit the profile of the crossing section to the owner of the existing line suggesting proposed crossing alternatives. The crossing will have to be carried out as per approval of owner of the existing line.

- 1.4 It is requested you to kindly provide present status of Forest Clearances if any transmission line corridor area falling in wildlife forest / reserve forest/ mangroves

Reply: Based on the preliminary route survey, the process of initiation of forest clearance for the forest stretches, if any, enroute the proposed line alignment will be initiated by way of writing letters to the concerned authority (ies). However, it may be noted that it will be the responsibility of TSP for obtaining forest clearance for the forest stretches as provided in the survey report and also for any forest area encountered during detailed survey.

- 1.5 For transmission line, no special requirement is specified for type of Insulator and

creepage in RFP document. Hence it is understood that bidder can decide the type of insulator along with creepage requirement based on general CEA regulations and relevant standards. Kindly confirm.

Reply: The minimum specific creepage distances shall be decided for the pollution condition in the area of installation. It shall be as per CEA regulations and relevant standards.

2.0 Substation

2.1 We understand that space for storage of O&M spare shall be provided by existing owner within the station boundary without any cost. Kindly confirm.

Reply: Space for storage of O&M spares shall be arranged by TSP on its own.

2.2 We presume that the O&M for the end Termination bays will be in the scope of the TSP and TSP shall not be liable for any payment towards O&M to the existing owner of the substation. Kindly confirm.

Reply: Operation and maintenance of the bays is solely responsibility of the TSP. Further TSP shall follow CEA's "Operation and Maintenance (O&M) guidelines and Standard Format for Memorandum of Understanding between New TSP and Existing TSP" issued by CEA vide its letter No. I/28514/2023 dated 22.06.2023

2.3 With reference to subject scheme of existing sub-station, we assumed following scope of work:

- (a) We assumed internal road is available and need not to consider in the present scope of work.
- (b) Drainage is available and need not to consider in the present scope of work.
- (c) Cable trench extension in adjacent to Main cable trench only under present scope of work.
- (d) Levelled area being provided by developer for bay extension.

Reply: Regarding requirement of internal road, drainage, cable trench, leveling of the bay extension area, bidder is advised to visit site and acquaint themselves with the provisions/facilities available at substation.

2.4 Kindly provide the soil investigation report of soil parameters of existing substation.

Reply: Bidder is advised to visit the substation site and ascertain the requisite parameters.

2.5 Kindly confirm, energy accounting of aux. power consumption. Whether it will be on chargeable basis or part of transmission loss.

Reply: It will be on chargeable basis.

2.6 We understand that VMS requirement is for unmanned stations only. For Manned stations VMS is not compulsory.

Reply: VMS shall be provided in line with requirements of RfP document.

2.7 It is understood that Construction water and power shall be provided free of cost to TSP by respective substation owner for construction of new bays.

Reply: Arrangement of construction power and water is in the scope of TSP.

2.8 It is understood that existing fire hydrant system shall be extended by the TSP for bay extension.

Reply: Existing fire hydrant system shall be extended from existing system (if required)

2.9 Please clarify that Status of land acquisition for Substations. Whether the lands have been acquired by BPC and will be transferred to TSP.

Reply: The acquisition of land for substation is in the scope of TSP.

2.10 We understood that no any dedicated metering CT and CVT required for Line/feeders. Further, we understood that requisite Energy meters for various 765 kV, 400 kV and 220 kV Feeders shall be provided and installed by CTU free of cost to TSP.

Reply: Dedicated metering CT and CVT are not required for line/feeders. Metering core of existing CT/CVT can be used provided accuracy class is matching with metering requirement. Requisite Special Energy Meters shall be provided and installed by CTU at the cost of TSP in C&P panel subject to space availability, else, in separate metering panel (to be provided by TSP at its cost).

2.11 A draft copy of the Connection Agreement may be furnished. A draft copy of the Connection Agreement may be furnished.

Reply: Web page link https://www.ctuil.in/formats_gna_transition

2.12 Please clarify whether the spare 765 kV single phase Reactor unit for Bus reactor shall be provided with 1ph 765 kV CB.

Reply: As per RfP, the spare 1-Ph reactor unit shall be utilized for all the bus and switchable line reactor banks (including for future reactor banks). Hence, 1ph 765 kV CB shall also be provided with spare 1-Ph reactor for utilizing with bus reactor as well as switchable line reactor.

2.13 It is understood that existing busbar protection have provision for future bays and also PUs are available for future bays. BPC to confirm availability of CU and PU for bays under present scope of work at existing substations. BPC may kindly confirm availability of communication ports for integrating new PUs with the existing CUs at existing substations.

Reply: Bus Bar Protection with Central Unit (CU) is required for new bus section as specified in RfP. Peripheral Units (PUs) shall be provided by the respective bay owner. Further, augmentation/replacement of existing CU, if required, to meet the system requirement shall also be provided for proper functioning of bus bar protection.

- 2.14 For SCADA, it is understood that necessary process I/O shall be available for future bays and accordingly license for same. BPC to confirm.

Reply: Necessary process I/O along with license shall be in the scope of the successful bidder.

- 2.15 No separate FF system is envisaged under the present scope of work for existing substation. BPC to confirm.

Reply: Existing fire-fighting systems shall be extended to meet the additional requirements under present scope.

- 2.16 PLCC for 220 kV Lines are not under the scope of TSP. BPC to Confirm. It is requested to provide Type of Coupling for 220 kV Transmission Lines under present scope.

Reply: PLCC for 220 kV line is in the scope of developer of the line. Inter circuit coupling for 220 kV D/C and phase to phase coupling for 220 kV S/C shall be applicable for PLCC.

- 2.17 BPC is requested to confirm the availability of space in the existing control rooms at existing substation for execution of extension work under current project.

Reply: Switchyard Panel Rooms are generally required for AIS type substation and relay room are required for GIS type substation. Further, if needed, control room shall be augmented as per requirement.

3.0 Communication

- 3.1 What are the usage of OPGW, FOTE, PMU etc. under communication requirement of RFP?

Reply: User shall be responsible for providing compatible equipment along with appropriate interface for uninterrupted communication with the concerned control center and shall be responsible for successful integration with the communication system provided by CTU. Communication systems e.g. OPGW, FOTE etc. and PMU are required for grid operation through RLDC/SLDC, speech communication, tele-protection and tele-metering.

- 3.2 Is space for installation of communication panels are provided to TSP in existing Substations incase new bays are in the scope of TSP?

Reply: The space related issues are deliberated in the RfP itself. TSP to install

FOTE/FODP panels in the new Bay Kiosk (Switchyard Panel Room (SPR)) / Bay Kiosk/ Relay Panel Room (in case of GIS S/s). Further, TSP to connect and integrate the proposed FOTE with the existing FOTE in the control room to complete communication path upto RLDC.

In Case 132 kV Substation TSP shall accommodate the said panels either by extension of existing control room or other arrangements.

3.3 How is the OPGW laying done in case of LILO lines?

Reply: In case LILO lines are on same towers (e.g. both Line in and Line Out portion are on same towers, generally done LILO of S/C lines). Then 2x48F OPGW shall be required to install by TSP on both earthwire peak on 400 kV and 765 kV lines where two E/W peaks are available. On 220 and 132 kV lines where only one E/W peak is available TSP to install one no. 96F OPGW. In case LILO lines are on different towers (e.g. both Line In and Line Out portion are on different towers, generally done LILO of D/C lines). Then 1x48F OPGW shall be required to install by TSP on one earthwire peak and conventional earthwire on second earthwire peak, on both Line In and Line Out portion towers of 400 kV and 765 kV lines. On 220 and 132 kV lines where only one E/W peak is available TSP to install one no. 48F OPGW in place of conventional earthwire.

3.4 How is the OPGW laying done in case Multi circuit Towers?

Reply: In case two different lines are using common multi circuit portion for some distance (originating from different stations, may be terminating on same or on different stations). Two no. 48F OPGW to be installed on both E/W peaks for common M/C portion of 765 kV and 400 kV lines.

In case 220/132 kV lines using multi circuit portion where single E/W peak is available one no 96F may be installed for common multi circuit portion.

3.5 How PMUs are integrated for new bays at existing Substations?

Reply: PMU data of new bays to be provided in the ethernet port of switch at control room and thereafter to be connected with existing FOTE of existing substation to send data to PDC of RLDC by TSP. These PMUs shall be provided with GPS clock and LAN switch and shall connect with LAN switch of control room of respective substations with Fibre Optic cable

3.6 Is Spare direction available in existing FOTE for integration with new bay kiosk FOTE

Reply: The FOTE under present scope shall be integrated by TSP with the existing FOTE at control room of substation for onwards data transmission. In case spare optical direction is not available in the existing FOTE at the control room, the TSP shall coordinate with station owner to reconfigure the directions in existing FOTE at control room.

3.7 What is the distance from LILO point to proposed substation for feasibility of repeater station?

Reply: Tentative Location of LILO point shall be as per survey report of BPC however exact location to be ascertained after detailed survey by TSP.

3.8 What is the make and model of existing OPGW in case LILO of main line at new substation?

Reply: All OPGW(alongwith optical fibers) meet Central Electricity Authority (Technical Standards for Communication System in Power System Operations) Regulations, 2020 and bidder shall install OPGW accordingly.

3.9 In case of LILO of existing line at new substation who shall provide PMUs at existing substation bays?

Reply: TSP to provide PMUs for all bays under their scope of RFP.

4.0 Planning :

4.1 Whether the Project/ Elements are eligible for early commissioning incentive as per MoP, Gol order dated 15.07.2015.?

Reply: Commissioning is to be done as per the timeline mentioned in RfP. However, early commissioning shall be treated as per applicable CERC Regulations/orders.