TRANSMISSION SERVICE AGREEMENT

FOR

DEVELOPMENT AND OPERATION OF INTER-STATE TRANSMISSION SYSTEM

FOR TRANSMISSION OF ELECTRICITY THROUGH TARIFF BASED COMPETITIVE BIDDING FOR

TRANSMISSION SYSTEM FOR EVACUATION OF POWER FROM RAJASTHAN REZ PH-IV (PART-5: 6 GW) [BARMER COMPLEX] BARMER-II: 6 GW (SOLAR) (LCC CONFIGURATION)

BETWEEN THE

CENTRAL TRANSMISSION UTILITY OF INDIA LIMITED

(NODAL AGENCY)

AND

BARMER HVDC POWER TRANSMISSION LIMITED

.....

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THIS TRANSMISISON SERVICE AGREEMENT (hereinafter referred to as “TSA” or “Agreement” or "the Agreement” or “this Agreement") is made on the ……. [Insert day] of……. [Insert month] of Two Thousand and…… [Insert Year]

BETWEEN:

The ……..[Insert name and registered address of Nodal Agency for the project], acting as a Nodal Agency (referred to as the “Nodal Agency”), which expression shall unless repugnant to the context or meaning thereof include its successors, and permitted assigns) as Party of the one part;

AND

……. [Insert Name of the Transmission Service Provider], incorporated under the Companies Act, 1956/ Companies Act, 2013 (as the case may be), having its registered office at …….. (herein after referred to as “Transmission Service Provider” or “TSP” or “ISTS Licensee”, which expression shall unless repugnant to the context or meaning thereof include its successors, and permitted assigns) as Party of the other part;

(“Nodal Agency” and “TSP” are individually referred to as “Party” and collectively as the “Parties”)

AND WHEREAS:

A) In accordance with the Bidding Guidelines, the Bid Process Coordinator (hereinafter referred to as BPC) had initiated a competitive e-reverse bidding process through issue of RFP for selecting a Successful Bidder to build, own, operate and transfer the Project comprising of the Elements mentioned in Schedule 1 (hereinafter referred to as the Project)

B) Pursuant to the said e-reverse bidding process, the BPC has identified the Successful Bidder, who will be responsible to set up the Project on build, own, operate and transfer basis to provide Transmission Service in accordance with the terms of this Agreement and the Transmission License.

C) The Selected Bidder has submitted the Contract Performance Guarantee and acquired one hundred percent (100%) of the equity shareholding ofBarmer HVDC

Power Transmission Limited, along with all its related assets and liabilities in terms of the provisions of the Share Purchase Agreement.

D) The TSP has agreed to make an application for a Transmission License to the Commission for setting up the Project on build, own, operate and transfer basis.

E) The TSP has further agreed to make an application to the Commission for the adoption of the Transmission Charges under Section 63 of the Electricity Act, 2003, along with a certification from the Bid Evaluation Committee in accordance with the Bidding Guidelines issued by Ministry of Power, Government of India.

F) The TSP has agreed to execute the agreement(s) required, if any, under Sharing Regulations within fifteen (15) days from the date of grant of Transmission License from the Commission.

G) The TSP agrees to the terms and conditions laid down under Sharing Regulations, for making available the ISTS and charge the Transmission Charges in accordance with the terms and conditions of Sharing Regulations.

H) The billing, collection and disbursement of the Transmission Charges by the CTU to the ISTS Licensee shall be governed as per Sharing Regulations.

I) The terms and conditions stipulated in the Transmission License issued by the Commission to the TSP shall be applicable to this Agreement and the TSP agrees to comply with these terms and conditions. In case of inconsistency between the Transmission License terms & conditions and the conditions of this Agreement, the conditions stipulated in the Transmission License granted by the Commission shall prevail.

NOW, THEREFORE, IN CONSIDERATION OF THE PREMISES AND MUTUAL AGREEMENTS, COVENANTS AND CONDITIONS SET FORTH HEREIN, IT IS HEREBY AGREED BY AND BETWEEN THE PARTIES HERETO AS FOLLOWS:

ARTICLE: 1

1 DEFINITIONS AND INTERPRETATIONS

1.1 Definitions:

1.1.1 The words / expressions used in this Agreement, unless as defined below or repugnant to the context, shall have the same meaning as assigned to them by the Electricity Act, 2003 and the rules or regulations framed there under including those issued / framed by the Commission (as defined hereunder), as amended or re-enacted from time to time or the General Clauses Act, failing which it shall bear its ordinary English meaning.

The words/expressions when used in this Agreement shall have the respective meanings as specified below:

"Acquisition Price" shall have the same meaning as defined in the Share Purchase Agreement;

"Act" or **"Electricity Act"** or **"Electricity Act 2003"** shall mean the Electricity Act, 2003 and any amendments made to the same or any succeeding enactment thereof;

"Affiliate" shall mean a company that either directly or indirectly

i. controls or

ii. is controlled by or

iii. is under common control with

a Bidding Company (in the case of a single company) or a Member (in the case of a Consortium) and "**control**" means ownership by one entity of at least twenty six percent (26%) of the voting rights of the other entity;

"Availability" in relation to the Project or in relation to any Element of the Project, for a given period shall mean the time in hours during that period the Project is capable to transmit electricity at its Rated Voltage and shall be expressed in percentage of total hours in the given period and shall be calculated as per the procedure contained in Appendix –IV to Central Electricity Regulatory Commission (Terms and Conditions of Tariff) Regulations, 2024, attached herewith in Schedule 6;

"Bid" shall mean technical bid and financial bid submitted by the Bidder, in response to the RFP, in accordance with the terms and conditions of the RFP;

"Bid Deadline" shall mean the last date and time for submission of the Bid in response to RFP, as specified in the RFP;

"Bidding Company" shall refer to such single company that has made a Response to RFP for the Project;

"Bidding Consortium / Consortium" shall refer to a group of companies that has collectively made a Response to RFP for the Project;

"Bid Documents" or **"Bidding Documents"** shall mean the RFP, along with all attachments thereto or clarifications thereof;

"Bidding Guidelines" shall mean the "Tariff Based Competitive Bidding Guidelines for Transmission Service" and "Guidelines for Encouraging Competition in Development of Transmission Projects" issued by Government of India, Ministry of Power under Section – 63 of the Electricity Act as amended from time to time;

"Bid Process Coordinator" or **"BPC"** shall mean a person or its authorized representative as notified by the Government of India, responsible for carrying out the process for selection of Bidder who will acquire Transmission Service Provider;

"Bill" shall mean any bill raised by the CTU on the DICs to recover the Transmission Charges pursuant to the Sharing Regulations;

"Business Day" shall mean a day other than Sunday or a statutory holiday, on which the banks remain open for business in the State in which the Nodal Agency's registered office is located and the concerned TSP are located;

"CEA" shall mean the Central Electricity Authority constituted under Section -70 of the Electricity Act;

"Change in law" shall have the meaning ascribed thereto in Article 12;

"Commercial Operation Date" or **"COD"** shall mean the date as per Article 6.2;

"Commission" or **"CERC"** shall mean the Central Electricity Regulatory Commission referred to in sub-section (1) of Section 76 of the Electricity Act, 2003 or its successors and assigns;

"Competent Court of Law" shall mean the Supreme Court or any High Court, or any tribunal or any similar judicial or quasi-judicial body in India that has jurisdiction to adjudicate upon issues relating to the Project;

"Connection Agreement" shall mean the agreement between the CTU or STU or any other concerned parties and the TSP, setting out the terms relating to the connection of the Project to the Inter-connection Facilities and use of the Inter State Transmission System as per the provisions of the IEGC, as the case may be;

"Consultation Period" shall mean the period of sixty (60) days or such longer period as the Parties may agree, commencing from the date of issue of a TSP's Preliminary Notice or a Nodal Agency's Preliminary Termination Notice, as provided in Article 13 of this Agreement, for consultation between the Parties to mitigate the consequence of the relevant event having regard to all the circumstances;

"Consents, Clearances and Permits" shall mean all authorizations, licenses, approvals, registrations, permits, waivers, privileges, acknowledgements, agreements, or concessions required to be obtained from or provided by any concerned authority for the development, execution and operation of Project including without any limitation for the construction, ownership, operation and maintenance of the Transmission Lines and/or sub-stations;

"Construction Period" shall mean the period from (and including) the Effective Date of the Transmission Service Agreement up to (but not including) the COD of the Element of the Project in relation to an Element and up to (but not including) the COD of the Project in relation to the Project;

"Contractors" shall mean the engineering, procurement, construction, operation & maintenance contractors, surveyors, advisors, consultants, designers, suppliers to the TSP and each of their respective sub-contractors (and each of their respective successors and permitted assigns) in their respective capacities as such;

"Contract Performance Guarantee" shall mean the irrevocable unconditional bank guarantee, or insurance surety bond or Payment on Order Instrument submitted and to be submitted by the TSP or by the Selected Bidder on behalf of the TSP to the Nodal Agency from a bank mentioned in Annexure 17 of the RFP, in the form attached here to as Schedule 8 (for bank guarantee) or Schedule 8A (for insurance surety bond issued by any of the insurance companies authorized by Insurance Regulatory and Development Authority of India), or Schedule-8B (for Payment on Order Instrument issued by PFC/REC/IREDA, in accordance with Article 3 of this Agreement and which shall include the additional bank guarantee or insurance surety bond or Payment on Order Instrument furnished by the TSP under this Agreement;

"Contract Year", for the purpose of payment of Transmission Charges, shall mean the period beginning on the COD, and ending on the immediately succeeding March 31 and thereafter each period of 12 months beginning on April 1 and ending on March 31 provided that the last Contract Year shall end on the last day of the term of the TSA;

"CTU" or **"Central Transmission Utility"** shall have same meaning as defined in the Electricity Act, 2003;

"Day" shall mean a day starting at 0000 hours and ending at 2400 hours;

"D/C" shall mean Double Circuit;

"Designated ISTS Customers" or **"DICs"** shall have the meaning as ascribed in the Sharing Regulations;

"Dispute" shall mean any dispute or difference of any kind between the Parties, in connection with or arising out of this Agreement including any issue on the interpretation and scope of the terms of this Agreement as provided in Article 16;

"Effective Date" for the purposes of this Agreement, shall have the same meaning as per Article 2.1 of this Agreement;

"Electrical Inspector" shall mean a person appointed as such by the Government under sub-section (1) of Section 162 of the Electricity Act 2003 and also includes Chief Electrical Inspector;

"Electricity Rules 2005" shall mean the rules framed pursuant to the Electricity Act 2003 and as amended from time to time;

"Element" shall mean each Transmission Line or each circuit of the Transmission Lines (where there are more than one circuit) or each bay of Sub-station or switching station or HVDC terminal or inverter station of the Project, including ICTs, Reactors, SVC, FSC, etc. forming part of the ISTS, which will be owned, operated and maintained by the concerned ISTS Licensee, and which has a separate Scheduled COD as per Schedule 2 of this Agreement and has a separate percentage for recovery of Transmission Charges on achieving COD as per Schedule 5 of this Agreement;

"Event of Default" shall mean the events as defined in Article 13 of this Agreement;

"Expiry Date" shall be the date which is thirty five (35) years from the COD of the Project;

"Financial Closure" shall mean the first Business Day on which funds are made available to the TSP pursuant to the Financing Agreements;

"Financially Evaluated Entity" shall mean the company which has been evaluated for the satisfaction of the financial requirement set forth in the RFP;

"Financing Agreements" shall mean the agreements pursuant to which the TSP is to finance the Project including the loan agreements, security documents, notes, indentures, security agreements, letters of credit and other documents, as may be amended, modified, or replaced from time to time, but without in anyway increasing the liabilities of the Designated ISTS Customers / Nodal Agency;

"Financial Year" shall mean a period of twelve months at midnight Indian Standard Time (IST) between 1st April & 31st March;

"Force Majeure" and **"Force Majeure Event"** shall have the meaning assigned thereto in Article 11;

"GOI" shall mean Government of India;

"Grid Code" / "IEGC" shall mean the Grid Code specified by the Central Commission under Clause (h) of sub-section (1) of Section 79 of the Electricity Act;

"Independent Engineer" shall mean an agency/ company, appointed by Nodal Agency in accordance with the Guidelines for Encouraging Competition in Development of Transmission Projects.

"Indian Governmental Instrumentality" shall mean Government of India, Government of any State in India or any ministry, department, board, authority, agency, corporation, commission under the direct or indirect control of Government of India or any State Government or both, any political sub-division of any of them including any court or Commission or tribunal or judicial or quasi-judicial body in India but excluding the CTU, TSP and the Designated ISTS Customers;

"Insurances" shall mean the insurance cover to be obtained and maintained by the TSP in accordance with Article 9 of this Agreement;

"Interconnection Facilities" shall mean the facilities as may be set up for transmission of electricity through the use of the Project, on either one or both side of generating station's / CTU's / STU's / ISTS Licensee's / Designated ISTS Customer's substations (as the case may be) which shall

include, without limitation, all other transmission lines, gantries, sub-stations and associated equipment not forming part of the Project;

"ISTS Licensee" shall be the TSP under this Agreement, consequent to having been awarded a Transmission License by the CERC and shall be referred to as the TSP or the ISTS Licensee, as the context may require in this Agreement;

"Law" or "Laws" in relation to this Agreement, shall mean all laws including electricity laws in force in India and any statute, ordinance, rule, regulation, notification, order or code, or any interpretation of any of them by an Indian Governmental Instrumentality having force of law and shall include all rules, regulations, decisions and orders of the Commission;

"Lead Member of the Bidding Consortium" or "Lead Member" shall mean a company who commits at least 26% equity stake in the Project, meets the technical requirement as specified in the RFP and so designated by other Member(s) in Bidding Consortium;

"Lenders" means the banks, financial institutions, multilateral funding agencies, non-banking financial companies registered with the Reserve Bank of India (RBI), insurance companies registered with the Insurance Regulatory & Development Authority (IRDA), pension funds regulated by the Pension Fund Regulatory & Development Authority (PFRDA),mutual funds registered with Securities & Exchange Board of India (SEBI), etc., including their successors and assigns, who have agreed on or before COD of the Project to provide the TSP with the debt financing described in the capital structure schedule, and any successor banks or financial institutions to whom their interests under the Financing Agreements may be transferred or assigned;

Provided that, such assignment or transfer shall not relieve the TSP of its obligations to the Nodal Agency under this Agreement in any manner and shall also does not lead to an increase in the liability of the Nodal Agency;

"Lenders Representative" shall mean the person notified by the Lender(s) in writing as being the representative of the Lender(s) or the Security Trustee and such person may from time to time be replaced by the Lender(s) pursuant to the Financing Agreements by written notice to the TSP;

"Letter of Intent" or **"LOI"** shall have the same meaning as in the RFP;

"Member in a Bidding Consortium / Member" shall mean each company in the Bidding Consortium;

“Month” shall mean a period of thirty (30) days from (and excluding) the date of the event;

“Monthly Transmission Charges” for any Element of the Project, after COD of the Element till COD of the Project, and for the Project after COD of the Project, shall mean the amount of Transmission Charges as specified in Schedule 5 of this Agreement multiplied by no. of days in the relevant month and divided by no. of days in the year;

“National Load Despatch Centre” shall mean the centre established as per sub-section (1) of Section 26 of the Electricity Act 2003;

“**Nodal Agency**” shall mean CTU, which shall execute and implement the Transmission Service Agreement (TSA);

Provided that while taking major decisions, CTU shall consult CEA on technical matters and any other matter it feels necessary.

“Notification” shall mean any notification, issued in the Gazette of India;

“Operating Period” for any Element of the Project shall mean the period from (and including) the COD of such Element of the Project, up to (and including) the Expiry Date and for the Project, shall mean the period from (and including) the COD of the Project, up to (and including) the Expiry Date;

“Parent Company” shall mean an entity that holds at least twenty six percent (26%) of the paid - up equity capital directly or indirectly in the Bidding Company or in the Member in a Bidding Consortium, as the case may be;

"Payment on Order Instrument" shall mean Letter of Undertaking from Indian Renewable Energy Development Agency Limited (IREDA) or Power Finance Corporation Limited (PFC) or REC Limited (REC) [the three non-banking financial institutions under Ministry of New & Renewable Energy (MNRE)/ Ministry of Power (MoP)], to pay in case situation of default of Transmission Service Provider (TSP) in terms of tender conditions/ Power Purchase Agreement (PPA) arises. Such Letter(s) will have same effect as that of a Bank Guarantee issued by any public sector bank. Such "Payment on Order instrument" would have terms and conditions similar to that of any Bank Guarantee given by any public sector bank and would promise to pay the Nodal Agency on demand within stipulated time. TSPs can seek such Letter(s) by offering due security to the above-mentioned three non-banking financial institutions mentioned above (IREDA, PFC & REC). Nodal Agency shall not accept the instrument of 'Letter of Undertaking' as

described above or in any other form, from any other non-banking financial institutions or bank, except IREDA, PFC & REC;

"Preliminary Termination Notice" shall mean a Nodal Agency's Preliminary Termination Notice as defined in Article 13 of this Agreement;

"Project" shall mean **Transmission system for evacuation of power from Rajasthan REZ Ph-IV (Part-5: 6 GW) [Barmer Complex] Barmer-II: 6 GW (Solar) (LCC Configuration)**, as detailed in Schedule 1 of this Agreement;

"**Project Assets**" shall mean all physical and other assets relating to and forming part of the Project including:

(a) rights over the Site for substations, ROW for transmission lines;

(b) tangible & intangible assets such as civil works and equipment including foundations, embankments, pavements, electrical systems, communication systems, relief centres, administrative offices, Sub-stations, software, tower and sub-stations designs etc;

(c) project facilities situated on the Site;

(d) all rights of the TSP under the project agreements;

(e) financial assets, such as receivables, security deposits etc;

(f) insurance proceeds; and

(g) Applicable Permits and authorisations relating to or in respect of the Transmission System;"

"Project Execution Plan" shall mean the plan referred to in Article 3.1.3(c) hereof;

"Prudent Utility Practices" shall mean the practices, methods and standards that are generally accepted internationally from time to time by electric transmission utilities for the purpose of ensuring the safe, efficient and economic design, construction, commissioning, operation, repair and maintenance of the Project and which practices, methods and standards shall be adjusted as necessary, to take account of:

(i) operation, repair and maintenance guidelines given by the manufacturers to be incorporated in the Project,

(ii) the requirements of Law, and

(iii) the physical conditions at the Site;

(iv) the safety of operating personnel and human beings;

"Rated Voltage" shall mean voltage at which the Transmission System is designed to operate or such lower voltage at which the line is charged, for the time being, in consultation with the Central Transmission Utility;

"Rebate" shall have the meaning as ascribed to in Article 10.3 of this Agreement;

"RFP" shall mean Request for Proposal dated 28.01.2026 along with all schedules, annexures and RFP Project Documents attached thereto, issued by the BPC for tariff based competitive bidding process for selection of Bidder as TSP to execute the Project, including any modifications, amendments or alterations thereto;

"RFP Project Documents" shall mean the following documents to be entered into in respect of the Project, by the Parties to the respective agreements:

a. Transmission Service Agreement,

b. Share Purchase Agreement,

c. Agreement(s) required under Sharing Regulations and

d. Any other agreement as may be required;

"RLDC" shall mean the relevant Regional Load Dispatch Centre as defined in the Electricity Act, 2003, in the region(s) in which the Project is located;

"RPC" shall mean the relevant Regional Power Committee established by the Government of India for the specific Region(s) in accordance with the Electricity Act, 2003 for facilitating integrated operation of the Power System in that Region;

"Scheduled COD" in relation to an Element(s) shall mean the date(s) as mentioned in Schedule 2 as against such Element(s) and in relation to the Project, shall mean the date as mentioned in Schedule 2 as against such Project, subject to the provisions of Article 4.4 of this Agreement, or such date as may be mutually agreed among the Parties;

"Scheduled Outage" shall mean the final outage plan as approved by the RPC as per the provisions of the Grid Code;

"Selected Bid" shall mean the technical Bid and the Final Offer of the Selected Bidder submitted during e-reverse bidding, which shall be downloaded and attached in Schedule 7 on or prior to the Effective Date;

"Share Purchase Agreement" shall mean the agreement amongst REC Power Development and Consultancy Limited,Barmer HVDC Power Transmission Limited and the Successful Bidder for the purchase of one hundred (100%) per cent of the shareholding of theBarmer HVDC Power Transmission Limited for the Acquisition Price, by the Successful Bidder on the terms and conditions as contained therein;

"Sharing Regulations" shall mean the Central Electricity Regulatory Commission (Sharing of Inter-State Transmission Charges and Losses) Regulations, 2020 and as amended from time to time;

"Site" in relation to a substation, switching station or HVDC terminal or inverter station, shall mean the land and other places upon which such station / terminal is to be established;

"SLDC" shall mean the State Load Despatch Centre established as per sub-section (1) of Section 31 of the Electricity Act 2003;

"STU" or **"State Transmission Utility"** shall be the Board or the Government company, specified as such by the State Government under sub-section (1) of Section 39 of the Electricity Act 2003;

"Successful Bidder" or **"Selected Bidder"** shall mean the Bidder selected pursuant to the RFP and who has to acquire one hundred percent (100%) equity shares ofBarmer HVDC Power Transmission Limited, along with all its related assets and liabilities, which will be responsible as the TSP to establish the Project on build, own, operate and transfer basis as per the terms of the TSA and other RFP Project Documents;

"TSP's Preliminary Notice" shall mean a notice issued by the TSP in pursuant to the provisions of Article 13.3 of this Agreement;

"Target Availability" shall have the meaning as ascribed hereto in Article 8.2 of this Agreement;

"Technically Evaluated Entity" shall mean the company which has been evaluated for the satisfaction of the technical requirement set forth in RFP;

"Termination Notice" shall mean a Nodal Agency's Termination Notice given by the Nodal Agency to the TSP pursuant to the provisions of Articles

3.3.2, 3.3.4, 4.4.2, 5.8, 13.2 and 13.3 of this Agreement for the termination of this Agreement;

"Term of Agreement" for the purposes of this Agreement shall have the meaning ascribed thereto in Article 2.2 of this Agreement;

"Transmission Charges" shall mean the Final Offer of the Selected Bidder during the e-reverse bidding and adopted by the Commission, payable to the TSP as per Sharing Regulations;

"Transmission License" shall mean the license granted by the Commission in terms of the relevant regulations for grant of such license issued under the Electricity Act;

"Transmission Service" shall mean making the Project available as per the terms and conditions of this Agreement and Sharing Regulations;

"Unscheduled Outage" shall mean an interruption resulting in reduction of the Availability of the Element(s) / Project (as the case may be) that is not a result of a Scheduled Outage or a Force Majeure Event.

"Ultimate Parent Company" shall mean an entity which owns at least twenty six percent (26%) equity in the Bidding Company or Member of a Consortium, (as the case may be) and in the Technically Evaluated Entity and / or Financially Evaluated Entity (as the case may be) and such Bidding Company or Member of a Consortium, (as the case may be) and the Technically Evaluated Entity and / or Financially Evaluated Entity (as the case may be) shall be under the direct control or indirectly under the common control of such entity;

1.2 Interpretation:

Save where the contrary is indicated, any reference in this Agreement to:

"Agreement" shall be construed as including a reference to its Schedules, Appendices and Annexures;

"Rupee", **"Rupees"** and **"Rs."** shall denote lawful currency of India;

"crore" shall mean a reference to ten million (10,000,000) and a **"lakh"** shall mean a reference to one tenth of a million (1,00,000);

"encumbrance" shall be construed as a reference to a mortgage, charge, pledge, lien or other encumbrance securing any obligation of any person or any other type of preferential arrangement (including, without limitation, title transfer and retention arrangements) having a similar effect;

"holding company" of a company or corporation shall be construed as a reference to any company or corporation of which the other company or corporation is a subsidiary;

"indebtedness" shall be construed so as to include any obligation (whether incurred as principal or surety) for the payment or repayment of money, whether present or future, actual or contingent;

"person" shall have the meaning as defined in Section 2 (49) of the Act;

"subsidiary" of a company or corporation (the holding company) shall be construed as a reference to any company or corporation:

(i) which is controlled, directly or indirectly, by the holding company, or

(ii) more than half of the issued share capital of which is beneficially owned, directly or indirectly, by the holding company, or

(iii) which is a subsidiary of another subsidiary of the holding company,

for these purposes, a company or corporation shall be treated as being controlled by another if that other company or corporation is able to direct its affairs and/or to control the composition of its board of directors or equivalent body;

"winding-up", **"dissolution"**, **"insolvency"**, or **"reorganization"** in the context of a company or corporation shall have the same meaning as defined in the Companies Act, 1956/ Companies Act, 2013 (as the case may be).

1.2.1 Words importing the singular shall include the plural and vice versa.

1.2.2 This Agreement itself or any other agreement or document shall be construed as a reference to this or to such other agreement or document as it may have been, or may from time to time be, amended, varied, novated, replaced or supplemented.

1.2.3 A Law shall be construed as a reference to such Law including its amendments or re-enactments from time to time.

1.2.4 A time of day shall, save as otherwise provided in any agreement or document be construed as a reference to Indian Standard Time.

1.2.5 Different parts of this Agreement are to be taken as mutually explanatory and supplementary to each other and if there is any inconsistency between or among the parts of this Agreement, they shall be interpreted in a harmonious manner so as to give effect to each part.

1.2.6 The tables of contents and any headings or sub-headings in this Agreement have been inserted for ease of reference only and shall not affect the interpretation of this Agreement.

1.2.7 All interest payable under this Agreement shall accrue from day to day and be calculated on the basis of a year of three hundred and sixty five (365) days.

1.2.8 The words “hereof” or “herein”, if and when used in this Agreement shall mean a reference to this Agreement.

1.2.9 The contents of Schedule 7 shall be referred to for ascertaining accuracy and correctness of the representations made by the Selected Bidder in Article 17.2.1 hereof.

ARTICLE: 2

2 EFFECTIVENESS AND TERM OF AGREEMENT

2.1 Effective Date:

This Agreement shall be effective from later of the dates of the following events:

a. The Selected Bidder, on behalf of the TSP, has provided the Contract Performance Guarantee, as per terms of Article 3.1 of this Agreement; and

b. The Selected Bidder has acquired for the Acquisition Price, one hundred percent (100%) of the equity shareholding of REC Power Development and Consultancy Limited inBarmer HVDC Power Transmission Limited along with all its related assets and liabilities as per the provisions of the Share Purchase Agreement. and

c. The Agreement is executed and delivered by the Parties;

2.2 Term and Termination:

2.2.1 Subject to Article 2.2.3 and Article 2.4, this Agreement shall continue to be effective in relation to the Project until the Expiry Date, when it shall automatically terminate.

2.2.2 Post the Expiry Date of this Agreement, the TSP shall ensure transfer of Project Assets to CTU or its successors or an agency as decided by the Central Government at zero cost and free from any encumbrance and liability. The transfer shall be completed within 90 days of expiry of this Agreement failing which CTU shall be entitled to take over the Project Assets Suo moto.

2.2.3 This Agreement shall terminate before the Expiry Date in accordance with Article 13 or Article 3.3.2 or Article 3.3.4.

2.3 Conditions prior to the expiry of the Transmission License

2.3.1 In order to continue the Project beyond the expiry of the Transmission License, the TSP shall be obligated to make an application to the Commission at least two (2) years before the date of expiry of the Transmission License, seeking the Commission's approval for the extension of the term of the Transmission License up to the Expiry Date.

2.3.2 The TSP shall timely comply with all the requirements that may be laid down by the Commission for extension of the term of the Transmission License beyond the initial term of twenty-five (25) years & upto the Expiry Date and the TSP shall keep the Nodal Agency fully informed about the progress on its application for extension of the term of the Transmission License.

2.4 Survival:

The expiry or termination of this Agreement shall not affect any accrued rights, obligations/ roles and liabilities of the Parties under this Agreement, including the right to receive liquidated damages as per the terms of this Agreement, nor shall it effect the survival of any continuing obligations/ roles for which this Agreement provides, either expressly or by necessary implication, which are to survive after the Expiry Date or termination including those under Articles 3.3.3, 3.3.5, Article 9.3 (Application of Insurance Proceeds), Article 11 (Force Majeure), Article 13 (Events of Default and Termination), Article 14 (Liability & Indemnification), Article 16 (Governing Law & Dispute Resolution), Article 19 (Miscellaneous).

2.5 Applicability of the provisions of this Agreement

2.5.1 For the purpose of Availability, Target Availability and the computation of Availability, Incentive, Penalty, the provisions provided in this Agreement shall apply and any future modifications in the relevant Rules and Regulations shall not be applicable for this Project.

2.5.2 For the purposes of this Agreement for ISTS systems developed under the tariff based competitive bidding framework, the provisions relating to the definitions (Availability and COD), Article 3 (Contract Performance Guarantee and Conditions Subsequent), Article 5 (Construction of the Project), Article 6 (Connection and Commissioning of the Project), Article 8 (Target Availability and calculation of Availability), Article 11 (Force Majeure), Article 12 (Change in Law), Article 13 (Event of Default), Article 14 (Indemnification), Article 15 (Assignment and Charges), Articles 16.1, 16.2 and 16.4 (Governing Laws and Dispute Resolution) and Article 17 (representation and warranties of the ISTS Licensee) of this agreement shall supersede the corresponding provisions under Sharing Regulations.

ARTICLE: 3

3 CONDITIONS SUBSEQUENT

3.1 Satisfaction of conditions subsequent by the TSP

3.1.1 Within ten (10) days from the date of issue of Letter of Intent, the Selected Bidder, shall:

a. Provide the Contract Performance Guarantee, and

b. Acquire, for the Acquisition Price, one hundred percent (100%) equity shareholding ofBarmer HVDC Power Transmission Limited from REC Power Development and Consultancy Limited, who shall sell to the Selected Bidder, the equity shareholding ofBarmer HVDC Power Transmission Limited, along with all its related assets and liabilities.

c. Execute this Agreement;

The TSP shall, within five (5) working days from the date of acquisition of SPV by the Selected Bidder, undertake to apply to the Commission for the grant of Transmission License and for the adoption of tariff as required under section-63 of the Electricity Act.

The Selected Bidder, on behalf of the TSP, will provide to the Central Transmission Utility of India Limited (being the Nodal Agency) the Contract Performance Guarantee for an amount of Rs. 716 Crore (Rupees Seven Hundred and Sixteen Crore Only).

3.1.2 The Contract Performance Guarantee shall be initially valid for a period up to three (3) months after the Scheduled COD of the Project and shall be extended from time to time to be valid for a period up to three (3) months after the COD of the Project. In case the validity of the Contract Performance Guarantee is expiring before the validity specified in this Article, the TSP shall, at least thirty (30) days before the expiry of the Contract Performance Guarantee, replace the Contract Performance Guarantee with another Contract Performance Guarantee or extend the validity of the existing Contract Performance Guarantee until the validity period specified in this Article.

3.1.3 The TSP agrees and undertakes to duly perform and complete the following activities within six (6) months from the Effective Date (except for c) below), unless such completion is affected due to any Force Majeure Event, or if any of the activities is specifically waived in writing by the Nodal

Agency:

a. To obtain the Transmission License for the Project from the Commission;

b. To obtain the order for adoption of Transmission Charges by the Commission, as required under Section 63 of the Electricity Act 2003;

c. To submit to the Nodal Agency, CEA & Independent Engineer, the Project Execution Plan, immediately after award of contract(s) and maximum within one hundred and twenty (120) days from the Effective Date. Also, an approved copy each of Manufacturing Quality Plan (MQP) and Field Quality Plan (FQP) would be submitted to Independent Engineer & Nodal Agency in the same time period. The TSP's Project Execution Plan should be in conformity with the Scheduled COD as specified in Schedule 2 of this Agreement, and shall bring out clearly the organization structure, time plan and methodology for executing the Project, award of major contracts, designing, engineering, procurement, shipping, construction, testing and commissioning to commercial operation;

d. To submit to the Nodal Agency, CEA & Independent Engineer a detailed bar (GANTT) chart of the Project outlining each activity (taking longer than one Month), linkages as well as durations;

e. To submit to the Nodal Agency, CEA & Independent Engineer detailed specifications of conductor meeting the functional specifications specified in RFP;

f. To achieve Financial Closure;

g. To provide an irrevocable letter to the Lenders duly accepting and acknowledging the rights provided to the Lenders under the provisions of Article 15.3 of this Agreement and all other RFP Project Documents;

h. To award the Engineering, Procurement and Construction contract ("EPC contract") for the design and construction of the Project and shall have given to such Contractor an irrevocable notice to proceed; and

i. To sign the Agreement(s) required, if any, under Sharing Regulations.

3.2 Recognition of Lenders' Rights by the Nodal Agency

3.2.1 The Nodal Agency hereby accepts and acknowledges the rights provided to the Lenders as per Article 15.3 of this Agreement and all other RFP

Project Documents.

3.3 Consequences of non-fulfilment of conditions subsequent

3.3.1 If any of the conditions specified in Article 3.1.3 is not duly fulfilled by the TSP even within three (3) Months after the time specified therein, then on and from the expiry of such period and until the TSP has satisfied all the conditions specified in Article 3.1.3, the TSP shall, on a monthly basis, be liable to furnish to Central Transmission Utility of India Limited (being the Nodal Agency) additional Contract Performance Guarantee of Rupees Seventy One Crore Sixty Lakh Only (Rs. 71.60 Crore) within two (2) Business Days of expiry of every such Month. Such additional Contract Performance Guarantee shall be provided to Central Transmission Utility of India Limited (being the Nodal Agency) in the manner provided in Article 3.1.1 and shall become part of the Contract Performance Guarantee and all the provisions of this Agreement shall be construed accordingly. Central Transmission Utility of India Limited (being the Nodal Agency) shall be entitled to hold and / or invoke the Contract Performance Guarantee, including such additional Contract Performance Guarantee, in accordance with the provisions of this Agreement.

3.3.2 Subject to Article 3.3.4, if:

(i) the fulfilment of any of the conditions specified in Article 3.1.3 is delayed beyond nine (9) Months from the Effective Date and the TSP fails to furnish additional Contract Performance Guarantee to the Nodal Agency in accordance with Article 3.3.1 hereof; or

(ii) the TSP furnishes additional Performance Guarantee to the Nodal Agency in accordance with Article 3.3.1 hereof but fails to fulfil the conditions specified in Article 3.1.3 within a period of twelve (12) months from the Effective Date,

the Nodal Agency shall have the right to terminate this Agreement, by giving a Termination Notice to the TSP, in writing, of at least seven (7) days, with a copy to CEA and the Lenders' Representative in order to enable the Lenders to exercise right of substitution in accordance with Article 15.3 of this Agreement.

3.3.3 If the Nodal Agency elects to terminate this Agreement as per the provisions of Article 3.3.2, the TSP shall be liable to pay to the Nodal Agency an amount of Rs. 716 Crore (Rupees Seven Hundred and Sixteen Crore Only) as liquidated damages. The Nodal Agency shall be entitled to

recover this amount of damages by invoking the Contract Performance Guarantee to the extent of liquidated damages, which shall be required by the Nodal Agency, and the balance shall be returned to TSP, if any.

It is clarified for removal of doubt that this Article shall survive the termination of this Agreement.

3.3.4 In case of inability of the TSP to fulfil the conditions specified in Article 3.1.3 due to any Force Majeure Event, the time period for fulfilment of the condition subsequent as mentioned in Article 3.1.3, may be extended for a period of such Force Majeure Event. Alternatively, if deemed necessary, this Agreement may be terminated by the Nodal Agency by giving a Termination Notice to the TSP, in writing, of at least seven (7) days, with a copy to CEA and the Lenders' Representative in order to enable the Lenders to exercise right of substitution in accordance with Article 15.3 of this Agreement and the Contract Performance Guarantee shall be returned as per the provisions of Article 6.5.1.

Provided, that due to the provisions of this Article 3.3.4, any increase in the time period for completion of conditions subsequent mentioned under Article 3.1.3, shall lead to an equal increase in the time period for the Scheduled COD. If the Scheduled COD is extended beyond a period of one hundred eighty (180) days due to the provisions of this Article 3.3.4, the TSP will be allowed to recover the interest cost during construction corresponding to the period exceeding one hundred eighty (180) days by adjustment in the Transmission Charges in accordance with Schedule 9.

3.3.5 Upon termination of this Agreement as per Articles 3.3.2 and 3.3.4, the Nodal Agency may take steps to bid out the Project again.

3.3.6 The Nodal agency, on the failure of the TSP to fulfil its obligations, if it considers that there are sufficient grounds for so doing, apart from invoking the Contract Performance Guarantee under para 3.3.3 may also initiate proceedings for blacklisting the TSP as per provisions of Article 13.2 of TSA.

3.4 Progress Reports

The TSP shall notify the Nodal Agency and CEA in writing at least once a Month on the progress made in satisfying the conditions subsequent in Articles 3.1.3.

ARTICLE: 4

4 DEVELOPMENT OF THE PROJECT

4.1 TSP's obligations in development of the Project:

Subject to the terms and conditions of this Agreement, the TSP at its own cost and expense shall observe, comply with, perform, undertake and be responsible:

a. for procuring and maintaining in full force and effect all Consents, Clearances and Permits, required in accordance with Law for development of the Project;

b. for financing, constructing, owning and commissioning each of the Element of the Project for the scope of work set out in Schedule 1 of this Agreement in accordance with:

i. the Electricity Act and the Rules made thereof;

ii. the Grid Code;

iii. the CEA Regulations applicable, and as amended from time to time, for Transmission Lines and sub-stations:

- the Central Electricity Authority (Technical Standards for Connectivity to the Grid) Regulations, 2007;
- Central Electricity Authority (Technical Standards for construction of Electrical Plants and Electric Lines) Regulation, 2010;
- Central Electricity Authority (Grid Standard) Regulations, 2010;
- Central Electricity Authority (Safety requirements for construction, operation and maintenance of Electrical Plants and Electrical Lines) Regulation, 2011;
- Central Electricity Authority (Measures relating to Safety and Electricity Supply) Regulation, 2010;
- Central Electricity Authority (Technical Standards for Communication System in Power System Operation) Regulations, 2020.

iv. Safety/ security Guidelines laid down by the Government;

v. Prudent Utility Practices, relevant Indian Standards and the Law;

not later than the Scheduled COD as per Schedule 2 of this Agreement;

c. for entering into a Connection Agreement with the concerned parties in accordance with the Grid Code.

d. for owning the Project throughout the term of this Agreement free and clear of any encumbrances except those expressly permitted under Article 15 of this Agreement;

e. to co-ordinate and liaise with concerned agencies and provide on a timely basis relevant information with regard to the specifications of the Project that may be required for interconnecting the Project with the Interconnection Facilities;

f. for providing all assistance to the Arbitrators as they may require for the performance of their duties and responsibilities;

g. to provide to the Nodal Agency and CEA, on a monthly basis, progress reports with regard to the Project and its execution (in accordance with prescribed form) to enable the CEA to monitor and co-ordinate the development of the Project matching with the Interconnection Facilities;

h. to comply with Ministry of Power order no. 25-11/6/2018 – PG dated 02.07.2020 as well as other Guidelines issued by Govt. of India pertaining to this;

i. to procure the products associated with the Transmission System as per provisions of Public Procurement (Preference to Make in India) orders issued by Ministry of Power vide orders No. A-1/2021- FSC- Part(5) dated 16.11.2021 and No.: P45021/2/2017-PP (BE-II)-Part-4 Vol.II dated 19.07.2024 issued by Ministry of Power for transmission sector, as amended from time to time read with Department for Promotion of Industry and Internal Trade (DPIIT) orders in this regard (Procuring Entity as defined in above orders shall deemed to have included Selected Bidder and/ or TSP).

Also, to comply with Department of Expenditure, Ministry of Finance vide Order (Public Procurement No 1) bearing File No.

6/18/2019-PPD dated 23.07.2020, Order (Public Procurement No 2) bearing File No. 6/18/2019-PPD dated 23.07.2020 and Order (Public Procurement No. 3) bearing File No. 6/18/2019-PPD, dated 24.07.2020, Office Memorandum (OM) No. F.18/37/2020-PPD dated 08.02.2021, OM No. F.12/1/2021-PPD(Pt.) dated 02.03.2021, OM No. F.7/10/2021-PPD dated 08.06.2021 and Order (Public Procurement No 4) bearing File No. F.7/10/2021- PPD dated 23.02.2023, as amended from time to time, regarding public procurement from a bidder of a country, which shares land border with India;

j. to submit to Nodal Agency information in the prescribed format [To be devised by Nodal Agency] for ensuring compliance to Article 4.1 i) above.

k. to comply with all its obligations undertaken in this Agreement.

4.2 Roles of the Nodal Agency in implementation of the Project:

4.2.1 Subject to the terms and conditions of this Agreement, the Nodal Agency shall be the holder and administrator of this Agreement and shall inter alia:

a. appoint an Independent Engineer within 90 days of the Effective Date

b. provide letters of recommendation to the concerned Indian Governmental Instrumentality, as may be requested by the TSP from time to time, for obtaining the Consents, Clearances and Permits required for the Project;

c. coordinate among TSP and upstream/downstream entities in respect of Interconnection Facilities; and

d. monitor the implementation of the Agreement and take appropriate action for breach thereof including revocation of guarantees, cancellation of Agreement, blacklisting etc

e. provide all assistance to the Arbitrators as required for the performance of their duties and responsibilities; and

f. perform any other responsibility (ies) as specified in this Agreement.

4.3 Time for Commencement and Completion:

a. The TSP shall take all necessary steps to commence work on the Project from the Effective Date of the Agreement and shall achieve

Scheduled COD of the Project in accordance with the time schedule specified in Schedule 2 of this Agreement;

b. The COD of each Element of the Project shall occur no later than the Scheduled COD or within such extended time to which the TSP shall be entitled under Article 4.4 hereto.

4.4 Extension of time:

4.4.1 In the event that the TSP is unable to perform its obligations for the reasons solely attributable to the Nodal Agency, the Scheduled COD shall be extended, by a 'day to day' basis, subject to the provisions of Article 13.

4.4.2 In the event that an Element or the Project cannot be commissioned by its Scheduled COD on account of any Force Majeure Event as per Article 11, the Scheduled COD shall be extended, by a 'day to day' basis for a period of such Force Majeure Event. Alternatively, if deemed necessary, the Nodal Agency may terminate the Agreement as per the provisions of Article 13.4 by giving a Termination Notice to the TSP, in writing, of at least seven (7) days, with a copy to CEA and the Lenders' Representative in order to enable the Lenders to exercise right of substitution in accordance with Article 15.3 of this Agreement.

4.4.3 If the Parties have not agreed, within thirty (30) days after the affected Party's performance has ceased to be affected by the relevant circumstance, on how long the Scheduled COD should be deferred by, any Party may raise the Dispute to be resolved in accordance with Article 16.

4.5 Metering Arrangements:

4.5.1 The TSP shall comply with all the provisions of the IEGC and the Central Electricity Authority (Installation and Operation of Meters) Regulations, 2006 as amended from time to time, with regard to the metering arrangements for the Project. The TSP shall fully cooperate with the CTU / STU / RLDC and extend all necessary assistance in taking meter readings.

4.6 Interconnection Facilities:

4.6.1 Subject to the terms and conditions of this Agreement, the TSP shall be responsible for connecting the Project with the interconnection point(s) specified in Schedule 1 of this Agreement. The Interconnection Facilities shall be developed as per the scope of work and responsibilities assigned in Schedule 1 of this Agreement. The Nodal Agency shall be responsible for coordinating to make available the Interconnection Facilities.

4.6.2 In order to remove any doubts, it is made clear that the obligation of the TSP within the scope of the project is to construct the Project as per Schedule-1 of this Agreement and in particular to connect it to the Interconnection Facilities as specified in this Agreement.

ARTICLE: 5

5 CONSTRUCTION OF THE PROJECT

5.1 TSP's Construction Responsibilities:

5.1.1 The TSP, at its own cost and expense, shall be responsible for designing, constructing, erecting, testing and commissioning each Element of the Project by the Scheduled COD in accordance with the Regulations and other applicable Laws specified in Article 4.1 of this Agreement.

5.1.2 The TSP acknowledges and agrees that it shall not be relieved from any of its obligations under this Agreement or be entitled to any extension of time or any compensation whatsoever by reason of the unsuitability of the Site or Transmission Line route(s).

5.1.3 The TSP shall be responsible for obtaining all Consents, Clearances and Permits related but not limited to road / rail / river / canal / power line / crossings, Power and Telecom Coordination Committee (PTCC), defence, civil aviation, right of way / way-leaves and environmental & forest clearances from relevant authorities required for developing, financing, constructing, maintaining/ renewing all such Consents, Clearances and Permits in order to carry out its obligations under this Agreement in general and shall furnish to the Nodal Agency such copy/ies of each Consents, Clearances and Permits, on demand. Nodal Agency shall provide letters of recommendation to the concerned Indian Governmental Instrumentality, as may be requested by the TSP from time to time for obtaining the Consents, Clearances and Permits required for the Project.

5.1.4 The TSP shall be responsible for:

(a) acquisition of land for location specific substations, switching stations or HVDC terminal or inverter stations. Also, the actual location of Greenfield substations (Switching Stations or HVDC Terminal or Inverter Stations) for a generation pooling substation and for load serving substations in the scope of TSP;

- For a Generation Pooling Substation shall not be beyond 3 Km radius of the location proposed by the BPC in their Survey Report.
- For Load Serving Substation within the scope of TSP shall not be beyond 5 Km radius of the location proposed by the BPC in their Survey Report

- For an intermediate Substation shall not be beyond 10 Km radius of the location proposed by the BPC in their Survey Report.

(b) final selection of Site including its geo-technical investigation;

(c) survey and geo-technical investigation of line route in order to determine the final route of the Transmission Lines;

(d) seeking access to the Site and other places where the Project is being executed, at its own risk and costs, including payment of any crop, tree compensation or any other compensation as may be required.

5.1.5 In case the Project involves any resettlement and rehabilitation, the resettlement and rehabilitation package will be implemented by the State Government authorities, for which the costs is to be borne by the TSP and no changes would be allowed in the Transmission Charges on account of any variation in the resettlement and rehabilitation cost. The TSP shall provide assistance on best endeavour basis, in implementation of the resettlement and rehabilitation package, if execution of such package is in the interest of expeditious implementation of the Project and is beneficial to the Project affected persons.

5.2 Appointing Contractors:

5.2.1 The TSP shall conform to the requirements as provided in this Agreement while appointing Contractor(s) for procurement of goods & services.

5.2.2 The appointment of such Contractor(s) shall neither relieve the TSP of any of its obligations under this Agreement nor make the Nodal Agency liable for the performance of such Contractor(s).

5.3 Monthly Progress Reporting:

The TSP shall provide to the CEA, Nodal Agency & Independent Engineer, on a monthly basis, progress reports along with likely completion date of each Element with regard to the Project and its execution (in accordance with prescribed form). The Nodal Agency/ CEA shall monitor the development of the Project for its timely completion for improving and augmenting the electricity system as a part of its statutory responsibility.

5.4 Quality of Workmanship:

The TSP shall ensure that the Project is designed, built and completed in a good workmanship using sound engineering and construction practices,

and using only materials and equipment that are new and manufactured as per the MQP and following approved FQP for erection, testing & commissioning and complying with Indian /International Standards such that, the useful life of the Project will be at least thirty five (35) years from the COD of the Project.

The TSP shall ensure that all major substation equipment / component (e.g. transformers, reactors, Circuit Breakers, Instrument Transformers (IT), Surge Arresters (SA), Protection relays, clamps & connectors etc.), equipment in terminal stations of HVDC installations including Thyristor/ IGBT valves, Converter Transformers, smoothing reactors, Transformer bushings and wall bushings, GIS bus ducts, towers and gantry structures and transmission towers or poles and line materials (conductors, earthwire, OPGW, insulator, accessories for conductors, OPGW & earthwires, hardware fittings for insulators, aviation lights etc), facilities and system shall be designed, constructed and tested (Type test, Routine tests, Factory Acceptance Test (FAT)) in accordance with relevant CEA Regulations and Indian Standards. In case Indian Standards for any particular equipment/ system/ process is not available, IEC/ IEEE or equivalent International Standards and Codes shall be followed.

5.5 Progress Monitoring & Quality Assurance:

5.5.1 The Project Execution Plan submitted by the TSP in accordance with Article 3.1.3 c) shall comprise of detailed schedule of all the equipments/items /materials required for the Project, right from procurement of raw material till the dispatch from works and receipt at the site. Further, it should also include various stages of the construction schedule up to the commissioning of the Project.

5.5.2 Nodal Agency, CEA & Independent Engineer shall have access at all reasonable times to the Site and to the Manufacturer's works and to all such places where the Project is being executed.

5.5.3 Independent Engineer shall ensure conformity of the conductor specifications with the functional specifications specified in RFP.

5.5.4 The Independent Engineer shall monitor the following during construction of the Project:

a) Quality of equipments, material, foundation, structures and workmanship etc. as laid down in Article 5.4 and 6.1.4 of the TSA. Specifically, quality of Sub-station equipments, transmission line material and workmanship etc. would be checked in accordance with the Article 5.4.

b) Progress in the activities specified in Condition Subsequent

c) Verification of readiness of the elements including the statutory clearances & completion of civil works, fixing of all components and finalisation of punch points (if any) prior to charging of the elements

d) Progress of construction of substation and Transmission Lines

5.5.5 The progress shall be reviewed by the Independent Engineer against the Project Execution Plan. The Independent Engineer shall prepare its report on monthly basis and submit the same to Nodal Agency highlighting the progress achieved till the end of respective month vis-à-vis milestone activities, areas of concern, if any, which may result in delay in the timely completion of the Project. Based on the progress, Nodal Agency and/ or CEA shall issue written instructions to the TSP to take corrective measures, as may be prudent for the timely completion of the Project. In case of any deficiency, the Nodal Agency would be at liberty to take action in accordance with the procedure of this Agreement.

5.5.6 For any delay in commissioning any critical Element(s), as identified in Schedule 1 & Schedule 2 of this Agreement, beyond a period of 45 days shall lead to a sequestration of 10% of the Contract Performance Guarantee.

5.6 Site regulations and Construction Documents

The TSP shall abide by the Safety Rules and Procedures as mentioned in Schedule 3 of this Agreement

The TSP shall retain at the Site and make available for inspection at all reasonable times, copies of the Consents, Clearances and Permits, construction drawings and other documents related to construction.

5.7 Supervision of work:

The TSP shall provide all necessary superintendence for execution of the Project and its supervisory personnel shall be available to provide full-time superintendence for execution of the Project. The TSP shall provide skilled personnel who are experienced in their respective fields.

5.8 Remedial Measures:

The TSP shall take all necessary actions for remedying the shortfall in achievement of timely progress in execution of the Project, if any, as intimated by the Independent Engineer and/ or CEA and/ or the Nodal Agency. However, such intimation by the Independent Engineer and/ or CEA and/ or the Nodal Agency and the subsequent effect of such remedial

measures carried out by the TSP shall not relieve the TSP of its obligations in the Agreement. Independent Engineer and/ or CEA and/ or the Nodal Agency may carry out random inspections during the Project execution, as and when deemed necessary by it. If the shortfalls as intimated to the TSP are not remedied to the satisfaction of the CEA and/ or the Nodal Agency, this Agreement may be terminated by the Nodal Agency by giving a Termination Notice to the TSP, in writing, of at least seven (7) days, with a copy to CEA and the Lenders' Representative in order to enable the Lenders to exercise right of substitution in accordance with Article 15.3 of this Agreement.

ARTICLE: 6

6 CONNECTION AND COMMISSIONING OF THE PROJECT

6.1 Connection with the Inter-Connection Facilities:

6.1.1 The TSP shall give the RLDC(s), CTU, / STU, as the case may be, and any other agencies as required, at least sixty (60) days advance written notice of the date on which it intends to connect an Element of the Project, which date shall not be earlier than its Scheduled COD or Schedule COD extended as per Article 4.4.1 & 4.4.2 of this Agreement, unless mutually agreed to by Parties. Further, any preponing of COD of any element prior to Scheduled COD must be approved by the Nodal Agency.

6.1.2 The RLDC / SLDC (as the case may be) or the CTU / STU (as the case may be), for reasonable cause, including non-availability of Interconnection Facilities as per Article 4.2, can defer the connection for up to fifteen (15) days from the date notified by the TSP pursuant to Article 6.1.1, if it notifies to the TSP in writing, before the date of connection, of the reason for the deferral and when the connection is to be rescheduled. However, no such deferment on one or more occasions would be for more than an aggregate period of thirty (30) days. Further, the Scheduled COD would be extended as required, for all such deferments on “day to day” basis.

6.1.3 Subject to Articles 6.1.1 and 6.1.2, any Element of Project may be connected with the Interconnection Facilities when:

a. it has been completed in accordance with this Agreement and the Connection Agreement;

b. it meets the Grid Code, Central Electricity Authority (Technical Standards for Connectivity to the Grid) Regulations, 2007 as amended from time to time and all other Indian legal requirements, and

c. The TSP has obtained the approval in writing of the Electrical Inspector certifying that the Element is ready from the point of view of safety of supply and can be connected with the Interconnection Facilities.

d. It has satisfactorily met all the testing requirements as per Articles 6.1.4

6.1.4 Site Acceptance Test (SAT)/ pre-commissioning tests of all major substation equipment, component, system, facilities shall be successfully

carried out before commissioning. The Type tests, FAT and SAT reports should be available at the substation / terminal station of HVDC installations for ready reference of operation and maintenance staff and has to be made available to the Independent Engineer appointed for quality monitoring or their authorised representatives, as and when they wish to examine the same.

6.2 Commercial Operation:

6.2.1 An Element of the Project shall be declared to have achieved COD twenty four (24) hours following the connection of the Element with the Interconnection Facilities pursuant to Article 6.1 or seven (7) days after the date on which it is declared by the TSP to be ready for charging but is not able to be charged for reasons not attributable to the TSP subject to Article 6.1.2.

Provided that an Element shall be declared to have achieved COD only after all the Element(s), if any, which are pre-required to have achieved COD as defined in Schedule 2 of this Agreement, have been declared to have achieved their respective COD.

6.2.2 Once any Element of the Project has been declared to have achieved deemed COD as per Article 6.2.1 above, such Element of the Project shall be deemed to have Availability equal to the Target Availability till the actual charging of the Element and to this extent, TSP shall be eligible for the Monthly Transmission Charges applicable for such Element

6.3 Compensation for Direct Non Natural Force Majeure Event or Indirect Non Natural Force Majeure Event or Natural Force Majeure Event (affecting the Nodal Agency)

6.3.1 If the TSP is otherwise ready to connect the Element(s) of the Project and has given due notice, as per provisions of Article 6.1.1, to the concerned agencies of the date of intention to connect the Element(s) of the Project, where such date is not before the Scheduled COD, but is not able to connect the Element(s) of the Project by the said date specified in the notice, due to Direct Non Natural Force Majeure Event or Indirect Non Natural Force Majeure Event or Natural Force Majeure Event affecting the Nodal Agency, provided such Direct Non Natural Force Majeure Event or Indirect Non Natural Force Majeure Event or Natural Force Majeure Event affecting the Nodal Agency has continued for a period of more than three (3) continuous or non-continuous Months, the TSP shall, until the effects of the Direct Non Natural Force Majeure Event or of Indirect Non Natural Force Majeure Event or Natural Force Majeure Event affecting the Nodal Agency no longer prevent the TSP from connecting the Element(s) of the

Project, be deemed to have achieved COD relevant to that date and to this extent, be deemed to have been providing Transmission Service with effect from the date notified, and shall be treated as follows:

a. In case of delay due to Direct Non Natural Force Majeure Event, TSP is entitled for Transmission Charges calculated on Target Availability for the period of such events in excess of three (3) continuous or non continuous Months in the manner provided in (c) below.

b. In case of delay due to Indirect Non Natural Force Majeure Event or Natural Force Majeure Event affecting the Nodal Agency, TSP is entitled for payment for debt service which is due under the Financing Agreements, subject to a maximum of Transmission Charges calculated on Target Availability, for the period of such events in excess of three (3) continuous or non continuous Months in the manner provided in (c) below.

c. In case of delay due to Direct Non Natural Force Majeure Event or Indirect Non Natural Force Majeure Event or Natural Force Majeure Event affecting the Nodal Agency, the TSP is entitled for payments mentioned in (a) and (b) above, after commencement of Transmission Service, in the form of an increase in Transmission Charges. These amounts shall be paid from the date, being the later of a) the date of cessation of such Indirect Non Natural Force Majeure Event or Natural Force Majeure Event affecting the Nodal Agency and b) the completion of sixty (60) days from the receipt of the Financing Agreements by the Nodal Agency from the TSP.

Provided such increase in Transmission Charges shall be so as to put the TSP in the same economic position as the TSP would have been in case the TSP had been paid amounts mentioned in (a) and (b) above in a situation where the Force Majeure Event had not occurred.

For the avoidance of doubt, it is clarified that the charges payable under this Article 6.3.1 shall be recovered as per Sharing Regulations.

6.4 Liquidated Damages for Delay in achieving COD of Project:

6.4.1 If the TSP fails to achieve COD of any Element of the Project or the Project, by the Element's / Project's Scheduled COD or such Scheduled COD as extended under Articles 4.4.1 and 4.4.3, then the TSP shall pay to the Nodal Agency, a sum equivalent to 3.33% of Monthly Transmission Charges applicable for the Element of the Project [in case where no Elements have been defined, to be on the Project as a whole] / Project,

for each day of delay up to sixty (60) days of delay and beyond that time limit, at the rate of five percent (5%) of the Monthly Transmission Charges applicable to such Element / Project, as liquidated damages for such delay and not as penalty, without prejudice to any rights of the Nodal Agency under the Agreement.

6.4.2 The TSP's maximum liability under this Article 6.4 shall be limited to the amount of liquidated damages calculated in accordance with Article 6.4.1 for and up to six (6) months of delay for the Element or the Project.

Provided that, in case of failure of the TSP to achieve COD of the Element of the Project even after the expiry of six (6) months from its Scheduled COD, the provisions of Article 13 shall apply.

6.4.3 The TSP shall make payment to the Nodal Agency of the liquidated damages calculated pursuant to Article 6.4.1 within ten (10) days of the earlier of:

a. the date on which the applicable Element achieves COD; or

b. the date of termination of this Agreement.

The payment of such damages shall not relieve the TSP from its obligations to complete the Project or from any other obligation and liabilities under the Agreement.

6.4.4 If the TSP fails to pay the amount of liquidated damages to the Nodal Agency within the said period of ten (10) days, the Nodal Agency shall be entitled to recover the said amount of the liquidated damages by invoking the Contract Performance Guarantee. If the then existing Contract Performance Guarantee is for an amount which is less than the amount of the liquidated damages payable by the TSP to the Nodal Agency under this Article 6.3 and the TSP fails to make payment of the balance amount of the liquidated damages not covered by the Contract Performance Guarantee, then such balance amount shall be deducted from the Transmission Charges payable to the TSP. The right of the Nodal Agency to encash the Contract Performance Guarantee is without prejudice to the other rights of the Nodal Agency under this Agreement.

6.4.5 For avoidance of doubt, it is clarified that amount payable by TSP under this Article is over and above the penalty payable by TSP under Article 5.5.6 of this Agreement.

6.5 Return of Contract Performance Guarantee

6.5.1 The Contract Performance Guarantee as submitted by TSP in accordance

with Article 3.1.1 shall be released by the Nodal Agency within three (3) months from the COD of the Project. In the event of delay in achieving Scheduled COD of any of the Elements by the TSP (otherwise than due to reasons as mentioned in Article 3.1.3 or Article 11) and consequent part invocation of the Contract Performance Guarantee by the Nodal Agency, Nodal Agency shall release the Contract Performance Guarantee, if any remaining unadjusted, after the satisfactory completion by the TSP of all the requirements regarding achieving the Scheduled COD of the remaining Elements of the Project. It is clarified that the Nodal Agency shall also return / release the Contract Performance Guarantee in the event of (i) applicability of Article 3.3.2 to the extent the Contract Performance Guarantee is valid for an amount in excess of Rs. 716 Crore (Rupees Seven Hundred and Sixteen Crore Only), or (ii) termination of this Agreement by the Nodal Agency as mentioned under Article 3.3.4 of this Agreement.

6.5.2 The release of the Contract Performance Guarantee shall be without prejudice to other rights of the Nodal Agency under this Agreement.

ARTICLE: 7

7 OPERATION AND MAINTENANCE OF THE PROJECT

7.1 Operation and Maintenance of the Project:

The TSP shall be responsible for ensuring that the Project is operated and maintained in accordance with the regulations made by the Commission and CEA from time to time and provisions of the Act.

ARTICLE: 8

8 AVAILABILITY OF THE PROJECT

8.1 Calculation of Availability of the Project:

Calculation of Availability for the Elements and for the Project, as the case may be, shall be as per Appendix –IV to Central Electricity Regulatory Commission (Terms and Conditions of Tariff) Regulations, 2024, as applicable on the Bid Deadline and as appended in Schedule 6 of this Agreement.

8.2 Target Availability:

The Target Availability of each Element and the Project shall be 98%.

Payment of monthly Transmission charges based on actual availability will be calculated as per para 1.2 of Schedule 4 of this Agreement.

If the availability of any Element or the Project is below the Target Availability, for six consecutive months in a Contract Year, the DIC(s) or the Nodal Agency may issue a show cause notice to the TSP, asking them to show cause as to why the Transmission Service Agreement be not terminated, and if no satisfactory cause is shown it may terminate the Agreement. If the Nodal Agency is of the opinion that the transmission system is of critical importance, it may carry out or cause to carry the operation and maintenance of transmission system at the risk and cost of TSP.

ARTICLE: 9

9 INSURANCES

9.1 Insurance:

9.1.1 The TSP shall effect and maintain or cause to be effected and maintained during the Construction Period and the Operating Period, adequate Insurances against such risks, with such deductibles including but not limited to any third party liability and endorsements and co-beneficiary/insured, as may be necessary under

a. any of the Financing Agreements,

b. the Laws, and

c. in accordance with Prudent Utility Practices.

The Insurances shall be taken effective from a date prior to the date of the Financial Closure till the Expiry Date.

9.2 Evidence of Insurance cover:

9.2.1 The TSP shall furnish to the Nodal Agency copies of certificates and policies of the Insurances, as and when the Nodal Agency may seek from the TSP as per the terms of Article 9.1

9.3 Application of Insurance Proceeds:

9.3.1 Save as expressly provided in this Agreement, the policies of Insurances and the Financing Agreements, the proceeds of any insurance claim made due to loss or damage to the Project or any part of the Project shall be first applied to reinstatement, replacement or renewal of such loss or damage.

9.3.2 If a Natural Force Majeure Event renders the Project no longer economically and technically viable and the insurers under the Insurances make payment on a “total loss” or equivalent basis, the portion of the proceeds of such Insurance available to the TSP (after making admissible payments to the Lenders as per the Financing Agreements) shall be allocated only to the TSP. Nodal Agency and / or concerned Designated ISTS Customers shall have no claim on such proceeds of the Insurance.

9.3.3 Subject to the requirements of the Lenders under the Financing Agreements, any dispute or difference between the Parties as to whether the Project is no longer economically and technically viable due to a Force Majeure Event or whether that event was adequately covered in accordance with this Agreement by the Insurances shall be determined in

accordance with Article 16.

9.4 Effect on liability of the Nodal Agency / Designated ISTS Customers

9.4.1 The Nodal Agency and / or the Designated ISTS Customers shall have no financial obligations or liability whatsoever towards the TSP in respect of this Article 9.

ARTICLE: 10

10 BILLING AND PAYMENT OF TRANSMISSION CHARGES

10.1 Subject to provisions of this Article 10, the Monthly Transmission Charges shall be paid to the TSP, in Indian Rupees, on monthly basis as per the provisions of the Sharing Regulations, from the date on which an Element(s) has achieved COD until the Expiry Date of this Agreement, unless terminated earlier and in line with the provisions of Schedule 4 of this Agreement.

10.2 Calculation of Monthly Transmission Charges:

The Monthly Transmission Charges for each Contract Year including Incentive & Penalty payment shall be calculated in accordance with the provisions of Schedule 4 of this Agreement.

10.3 Rebate & Late Payment Surcharge:

The rebate and late payment surcharge shall be governed as per Sharing Regulations.

10.4 Disputed Bills, Default in payment by the Designated ISTS Customers & Annual Reconciliation:

Any Disputed Bill, Default in payment by the Designated ISTS Customers & Annual Reconciliation shall be governed as per Sharing Regulations.

ARTICLE: 11

11 FORCE MAJEURE

11.1 Definitions

11.1.1 The following terms shall have the meanings given hereunder.

11.2 Affected Party

11.2.1 An Affected Party means any Party whose performance has been affected by an event of Force Majeure.

11.2.2 Any event of Force Majeure shall be deemed to be an event of Force Majeure affecting the TSP only if the Force Majeure event affects and results in, late delivery of machinery and equipment for the Project or construction, completion, commissioning of the Project by Scheduled COD and/or operation thereafter;

11.3 Force Majeure

A 'Force Majeure' means any event or circumstance or combination of events and circumstances including those stated below that wholly or partly prevents or unavoidably delays an Affected Party in the performance of its obligations/ roles under this Agreement, but only if and to the extent that such events or circumstances are not within the reasonable control, directly or indirectly, of the Affected Party and could not have been avoided if the Affected Party had taken reasonable care or complied with Prudent Utility Practices:

(a) **Natural Force Majeure Events:**

i. act of God, including, but not limited to drought, fire and explosion (to the extent originating from a source external to the Site), earthquake, volcanic eruption, landslide, flood, cyclone, typhoon, tornado, or exceptionally adverse weather conditions, which are in excess of the statistical measures for the last hundred (100) years; and

ii. epidemic/ pandemic notified by Indian Governmental Instrumentality.

(b) **Non-Natural Force Majeure Events :**

i. Direct Non–Natural Force Majeure Events

- Nationalization or compulsory acquisition by any Indian

Governmental Instrumentality of any material assets or rights of the Affected Party; or

- the unlawful, unreasonable or discriminatory revocation of, or refusal to renew, any Consents, Clearances and Permits required by the Affected Party to perform their obligations/ roles under the RFP Project Documents or any unlawful, unreasonable or discriminatory refusal to grant any other Consents, Clearances and Permits required for the development/ operation of the Project, provided that a Competent Court of Law declares the revocation or refusal to be unlawful, unreasonable and discriminatory and strikes the same down; or

- any other unlawful, unreasonable or discriminatory action on the part of an Indian Governmental Instrumentality which is directed against the Project, provided that a Competent Court of Law declares the action to be unlawful, unreasonable and discriminatory and strikes the same down.

ii. Indirect Non - Natural Force Majeure Events

- act of war (whether declared or undeclared), invasion, armed conflict or act of foreign enemy, blockade, embargo, revolution, riot, insurrection, terrorist or military action; or

- radio active contamination or ionising radiation originating from a source in India or resulting from any other Indirect Non Natural Force Majeure Event mentioned above, excluding circumstances where the source or cause of contamination or radiation is brought or has been brought into or near the Site by the Affected Party or those employed or engaged by the Affected Party; or

- industry-wide strikes and labour disturbances, having a nationwide impact in India.

11.4 Force Majeure Exclusions

11.4.1 Force Majeure shall not include (i) any event or circumstance which is within the reasonable control of the Parties and (ii) the following conditions, except to the extent that they are consequences of an event of Force Majeure:

(a) Unavailability, late delivery, or changes in cost of the machinery,

equipment, materials, spare parts etc. for the Project;

(b) Delay in the performance of any Contractors or their agents;

(c) Non-performance resulting from normal wear and tear typically experienced in transmission materials and equipment;

(d) Strikes or labour disturbance at the facilities of the Affected Party;

(e) Insufficiency of finances or funds or the Agreement becoming onerous to perform; and

(f) Non-performance caused by, or connected with, the Affected Party's:

i. negligent or intentional acts, errors or omissions;

ii. failure to comply with an Indian Law; or

iii. breach of, or default under this Agreement or any Project Documents.

(g) Any error or omission in the survey report provided by BPC during the bidding process.

11.5 Notification of Force Majeure Event

11.5.1 The Affected Party shall give notice to the other Party of any event of Force Majeure as soon as reasonably practicable, but not later than seven (7) days after the date on which such Party knew or should reasonably have known of the commencement of the event of Force Majeure. If an event of Force Majeure results in a breakdown of communications rendering it unreasonable to give notice within the applicable time limit specified herein, then the Party claiming Force Majeure shall give such notice as soon as reasonably practicable after reinstatement of communications, but not later than one (1) day after such reinstatement.

Provided that, such notice shall be a pre-condition to the Affected Party's entitlement to claim relief under this Agreement. Such notice shall include full particulars of the event of Force Majeure, its effects on the Party claiming relief and the remedial measures proposed. The Affected Party shall give the other Party regular reports on the progress of those remedial measures and such other information as the other Party may reasonably request about the Force Majeure.

11.5.2 The Affected Party shall give notice to the other Party of (i) the cessation

of the relevant event of Force Majeure; and (ii) the cessation of the effects of such event of Force Majeure on the performance of its rights or obligations/ roles under this Agreement, as soon as practicable after becoming aware of each of these cessations.

11.6 Duty to perform and duty to mitigate

To the extent not prevented by a Force Majeure Event, the Affected Party shall continue to perform its obligations/ roles as provided in this Agreement. The Affected Party shall use its reasonable efforts to mitigate the effect of any event of Force Majeure as soon as practicable.

11.7 Available Relief for a Force Majeure Event

Subject to this Article 11,

(a) no Party shall be in breach of its obligations/ roles pursuant to this Agreement to the extent that the performance of its obligations/ roles was prevented, hindered or delayed due to a Force Majeure Event;

(b) each Party shall be entitled to claim relief for a Force Majeure Event affecting its performance in relation to its obligations/ roles under Articles 3.3.4, 4.4.2 and 6.3.1 of this Agreement.

(c) For the avoidance of doubt, it is clarified that the computation of Availability of the Element(s) under outage due to Force Majeure Event, as per Article 11.3 affecting the TSP shall be as per Appendix –IV to Central Electricity Regulatory Commission (Terms and Conditions of Tariff) Regulations, 2024 as on Bid Deadline. For the event(s) for which the Element(s) is/are deemed to be available as per Appendix –IV to Central Electricity Regulatory Commission (Terms and Conditions of Tariff) Regulations, 2024, then the Transmission Charges, as applicable to such Element(s), shall be payable as per Schedule 4, for the duration of such event(s).

(d) For so long as the TSP is claiming relief due to any Force Majeure Event under this Agreement, the Nodal Agency may, if it so desires, from time to time on one (1) day notice, inspect the Project and the TSP shall provide the Nodal Agency's personnel with access to the Project to carry out such inspections.

(e) For avoidance of doubt, the TSP acknowledges that for extension of Scheduled COD a period up to one hundred eighty (180) days due to Force Majeure event, no compensation on the grounds such as interest cost, incident expenditure, opportunity cost will be made to the

TSP. However, if Scheduled COD is extended beyond a period of one hundred eighty (180) days due to Force Majeure event, the TSP will be allowed to recover the interest cost during construction corresponding to the period exceeding one hundred eighty (180) days by adjustment in the Transmission Charges in accordance with Schedule 9.

ARTICLE: 12

12 CHANGE IN LAW

12.1 Change in Law

12.1.1 Change in Law means the occurrence of any of the following after the Bid Deadline resulting into any additional recurring / non-recurring expenditure by the TSP or any savings of the TSP:

- the enactment, coming into effect, adoption, promulgation, amendment, modification or repeal (without re-enactment or consolidation) in India, of any Law, including rules and regulations framed pursuant to such Law, subject to the provisions under Article 12.1.2;
- a change in the interpretation or application of any Law by any Indian Governmental Instrumentality having the legal power to interpret or apply such Law, or any Competent Court of Law;
- the imposition of a requirement for obtaining any Consents, Clearances and Permits which was not required earlier;
- a change in the terms and conditions prescribed for obtaining any Consents, Clearances and Permits or the inclusion of any new terms or conditions for obtaining such Consents, Clearances and Permits;
- any change in the licensing regulations of the Commission, under which the Transmission License for the Project was granted if made applicable by such Commission to the TSP;
- change in wind zone; or
- any change in tax or introduction of any tax made applicable for providing Transmission Service by the TSP as per the terms of this Agreement.

12.1.2 Notwithstanding anything contained in this Agreement, Change in Law shall not cover any change:

a) Taxes on corporate income; and

b) Withholding tax on income or dividends distributed to the shareholders of the TSP.

12.2 Relief for Change in Law

12.2.1 During Construction Period, the impact of increase/decrease in the cost of the Project on the Transmission Charges shall be governed by the formula given in Schedule 9 of this Agreement.

12.2.2 During the Operation Period:

During the operation period, if as a result of Change in Law, the TSP suffers or is benefited from a change in costs or revenue, the aggregate financial effect of which exceeds 0.30% (zero point three percent) of the Annual Transmission Charges in aggregate for a Contract Year, the TSP may notify so to the Nodal Agency and propose amendments to this Agreement so as to place the TSP in the same financial position as it would have enjoyed had there been no such Change in Law resulting in change in costs or revenue as aforesaid.

12.2.3 For any claims made under Articles 12.2.1 and 12.2.2 above, the TSP shall provide to the Nodal Agency documentary proof of such increase / decrease in cost of the Project / revenue for establishing the impact of such Change in Law.

In cases where Change in Law results in decrease of cost and it comes to the notice of Nodal Agency that TSP has not informed Nodal Agency about such decrease in cost, Nodal Agency may initiate appropriate claim.

12.3 Notification of Change in Law:

12.3.1 If the TSP is affected by a Change in Law in accordance with Article 12.1 and wishes to claim relief for such Change in Law under this Article 12, it shall give notice to Nodal Agency of such Change in Law as soon as reasonably practicable after becoming aware of the same.

12.3.2 The TSP shall also be obliged to serve a notice to the Nodal Agency even when it is beneficially affected by a Change in Law.

12.3.3 Any notice served pursuant to Articles 12.3.1 and 12.3.2 shall provide, amongst other things, precise details of the Change in Law and its estimated impact on the TSP.

12.4 Payment on account of Change in Law

12.4.1 The payment for Change in Law shall be through a separate Bill. However, in case of any change in Monthly Transmission Charges by reason of

Change in Law, as determined in accordance with this Agreement, the Bills to be raised by the Nodal Agency after such change in Transmission Charges shall appropriately reflect the changed Monthly Transmission Charges.

ARTICLE: 13

13 EVENTS OF DEFAULT AND TERMINATION

13.1 TSP's Event of Default

The occurrence and continuation of any of the following events shall constitute a TSP Event of Default, unless any such TSP Event of Default occurs as a result of any non-fulfilment of its obligations as prescribed under this Agreement by the Nodal Agency or a Force Majeure Event:

a. After having taken up the construction of the Project, the abandonment by the TSP or the TSP's Contractors of the construction of the Project for a continuous period of two (2) months and such default is not rectified within thirty (30) days from the receipt of notice from the Nodal Agency in this regard;

b. The failure to commission any Element of the Project by the date falling six (6) months after its Scheduled COD unless extended by Nodal Agency as per provisions of this Agreement;

c. If the TSP:

i. assigns, mortgages or charges or purports to assign, mortgage or charge any of its assets or rights related to the Project in contravention of the provisions of this Agreement; or

ii. transfers or novates any of its obligations pursuant to this Agreement, in a manner contrary to the provisions of this Agreement;

Except where such transfer is in pursuance of a Law and

- it does not affect the ability of the transferee to perform, and such transferee has the financial and technical capability to perform, its obligations under this Agreement;
- is to a transferee who assumes such obligations under the Project and this Agreement remains effective with respect to the transferee;

d. If:

i. The TSP becomes voluntarily or involuntarily the subject of any bankruptcy or insolvency or winding up proceedings and such proceedings remain uncontested for a period of thirty (30) days; or

ii. any winding up or bankruptcy or insolvency order is passed against the TSP; or

iii. the TSP goes into liquidation or dissolution or a receiver or any similar officer is appointed over all or substantially all of its assets or official liquidator is appointed to manage its affairs, pursuant to Law,

Provided that a dissolution or liquidation of the TSP will not be a TSP's Event of Default, where such dissolution or liquidation of the TSP is for the purpose of a merger, consolidation or reorganization with the prior approval of the Commission as per the provisions of Central Electricity Regulatory Commission (Procedure, terms and Conditions for grant of Transmission License and other related matters) Regulations, 2006 or as amended from time to time; or

e. Failure on the part of the TSP to comply with the provisions of Article 19.1 of this Agreement; or

f. the TSP repudiates this Agreement and does not rectify such breach even within a period of thirty (30) days from a notice from the Nodal Agency in this regard; or

g. after Commercial Operation Date of the Project, the TSP fails to achieve monthly Target Availability of 98%, for a period of six (6) consecutive months or within a non-consecutive period of six (6) months within any continuous aggregate period of eighteen(18) months except where the Availability is affected by Force Majeure Events as per Article 11; or

h. any of the representations and warranties made by the TSP in Article 17 of this Agreement being found to be untrue or inaccurate. Further, in addition to the above, any of the undertakings submitted by the Selected Bidder at the time of submission of the Bid being found to be breached or inaccurate, including but not limited to undertakings from its Parent Company / Affiliates related to the minimum equity obligation; or

i. the TSP fails to complete / fulfil all the activities / conditions within the specified period as per Article 3; or

j. except for the reasons solely attributable to Nodal Agency, the TSP is in material breach of any of its obligations under this Agreement and such material breach is not rectified by the TSP within thirty (30) days of receipt of notice in this regard from the Nodal Agency; or

k. TSP fails to take the possession of the land required for location specific substations, switching stations or HVDC terminal or inverter stations and / or fails to pay the requisite price to the parties and / or any State Government authority from whom the land is acquired, within twelve (12) months from the Effective Date.

13.2 Termination Procedure for TSP Event of Default

a. Upon the occurrence and continuance of any TSP's Event of Default under Article 13.1 the Nodal Agency may serve notice on the TSP, with a copy to the CEA and the Lenders' Representative, of their intention to terminate this Agreement (a "Nodal Agency's Preliminary Termination Notice"), which shall specify in reasonable detail, the circumstances giving rise to such Nodal Agency's Preliminary Termination Notice.

b. Following the issue of a Nodal Agency's Preliminary Termination Notice, the Consultation Period shall apply and would be for the Parties to discuss as to what steps shall be taken with a view to mitigate the consequences of the relevant Event of Default having regard to all the circumstances.

c. During the Consultation Period, the Parties shall, save as otherwise provided in this Agreement, continue to perform their respective obligations/ roles under this Agreement, and the TSP shall not remove any material, equipment or any part of the Project, without prior consent of the Nodal Agency.

Following the expiry of the Consultation Period, unless the Parties shall have otherwise agreed to the contrary or the circumstances giving rise to Nodal Agency's Preliminary Termination Notice shall have ceased to exist or shall have been remedied, this Agreement may be terminated by the Nodal Agency by giving a Termination Notice to the TSP, in writing, of at least seven (7) days, with a copy to CEA and the Lenders' Representative in order to enable the

Lenders to exercise right of substitution in accordance with Article 15.3 of this Agreement.

Further, the Nodal Agency may also initiate proceedings to blacklist the TSP & its Affiliates from participation in any RFP issued by BPCs for a period of 5 years.

13.3 Procedure for Nodal Agency's non-fulfilment of Role

a. Upon the Nodal Agency not being able to fulfil its role under Article 4.2, the TSP may serve notice on the Nodal Agency, with a copy to CEA and the Lenders' Representative (a "TSP's Preliminary Notice"), which notice shall specify in reasonable detail the circumstances giving rise to such non-fulfilment of role by the Nodal Agency.

b. Following the issue of a TSP's Preliminary Notice, the Consultation Period shall apply.

c. The Consultation Period would be for the Parties to discuss as to what steps shall be taken with a view to mitigate the consequences of the relevant non-fulfilment of role by the Nodal Agency including giving time extension to TSP, having regard to all the circumstances.

d. During the Consultation Period, both Parties shall, save as otherwise provided in this Agreement, continue to perform their respective obligations/ roles under this Agreement.

13.4 Termination due to Force Majeure

13.4.1 In case the Parties could not reach an agreement pursuant to Articles 3.3.4 and 4.4.2 of this Agreement and the Force Majeure Event or its effects continue to be present, the Nodal Agency shall have the right to cause termination of the Agreement. In case of such termination, the Contract Performance Guarantee shall be returned to the TSP as per the provisions of Article 6.5.1.

13.4.2 In case of termination of this Agreement, the TSP shall provide to the Nodal Agency the full names and addresses of its Contractors as well as complete designs, design drawings, manufacturing drawings, material specifications and technical information, as required by the Nodal Agency within thirty (30) days of Termination Notice.

13.5 Termination or amendment due to non-requirement of any Element or Project during construction

13.5.1 In case any Element or Project, which is under construction, is no longer required due to any reason whatsoever, the Nodal Agency may issue a notice to this effect to the TSP.

13.5.2 Nodal agency may also issue notice to the TSP seeking their response to the proposed termination/ amendment (as the case may be) of the Agreement. The Nodal Agency shall issue copy of such notice to Lenders. In the notice, Nodal Agency shall also include an assessment of the physical progress made by TSP in the Element/ Project (as the case may be) that is no longer required.

13.5.3 The TSP shall neither carry out further investment nor carry out any work on the Element/ Project (as the case may be) that is no longer required after delivery of the notice.

13.5.4 After taking into account the comments of the TSP, the Nodal Agency may terminate the Agreement or amend it if both Parties agree to the amendment.

13.6 Revocation of the Transmission License

13.6.1 The Commission may, as per the provisions of the Electricity Act, 2003, revoke the Transmission License of the ISTS Licensee. Further, in such a case, the Agreement shall be deemed to have been terminated.

13.7 Termination Payment

13.7.1 If Agreement is terminated on account of Force Majeure Events, non-requirement of any Element or Project during Construction, Nodal Agency's non-fulfilment of Role & TSP's Event of Default, the TSP shall be entitled for Termination Payment equivalent to valuation of Project Assets. Upon payment, the Nodal Agency shall take over the Project Assets.

ARTICLE: 14

14 LIABILITY AND INDEMNIFICATION

14.1 Indemnity

14.1.1 The TSP shall indemnify, defend and hold the Nodal Agency harmless against:

(a) any and all third party claims, actions, suits or proceedings against the Nodal Agency for any loss of or damage to property of such third party, or death or injury to such third party, arising out of a breach by the TSP of any of its obligations under this Agreement, except to the extent that any such claim, action, suit or proceeding has arisen due to a negligent act or omission, breach of this Agreement or non-fulfilment of statutory duty on the part of Nodal Agency; and

(b) any and all losses, damages, costs and expenses including legal costs, fines, penalties and interest actually suffered or incurred by the Nodal Agency from third party claims arising by reason of:

i. a breach by the TSP of any of its obligations under this Agreement, (provided that this Article 14 shall not apply to such breaches by the TSP, for which specific remedies have been provided for under this Agreement) except to the extent that any such losses, damages, costs and expenses including legal costs, fines, penalties and interest (together to constitute “Indemnifiable Losses”) has arisen due to a negligent act or omission, breach of this Agreement or non-fulfilment of statutory duty on the part of the Nodal Agency, or

ii. any of the representations and warranties of the TSP under this Agreement being found to be inaccurate or untrue.

14.1.2 The Nodal Agency shall, in accordance with the Regulations framed by CERC in this regard, indemnify, defend and hold the TSP harmless against:

(a) any and all third party claims, actions, suits or proceedings against the TSP, for any loss of or damage to property of such third party, or death or injury to such third party, arising out of any material breach by the Nodal Agency of any of their roles under this Agreement, except to the extent that any such claim, action, suit or proceeding has arisen due to a negligent act or omission, breach of this Agreement or breach of statutory duty on the part of the TSP, its

Contractors, servants or agents; and

(b) any and all losses, damages, costs and expenses including legal costs, fines, penalties and interest ('Indemnifiable Losses') actually suffered or incurred by the TSP from third party claims arising by reason of:

i. any material breach by the Nodal Agency of any of its roles under this Agreement (provided that, this Article 14 shall not apply to such breaches by the Nodal Agency, for which specific remedies have been provided for under this Agreement), except to the extent that any such Indemnifiable Losses have arisen due to a negligent act or omission, breach of this Agreement or breach of statutory duty on the part of the TSP, its Contractors, servants or agents or

ii. any of the representations and warranties of the Nodal Agency under this Agreement being found to be inaccurate or untrue.

14.2 Patent Indemnity:

14.2.1

(a) The TSP shall, subject to the Nodal Agency's compliance with Article 14.2.1 (b), indemnify and hold harmless the Nodal Agency and its employees and officers from and against any and all suits, actions or administrative proceedings, claims, demands, losses, damages, costs, and expenses of whatsoever nature, including attorney's fees and expenses, which the Nodal Agency may suffer as a result of any infringement or alleged infringement of any patent, utility model, registered design, trademark, copyright or other intellectual property right registered or otherwise existing at the date of the Agreement by reason of the setting up of the Project by the TSP.

Such indemnity shall not cover any use of the Project or any part thereof other than for the purpose indicated by or to be reasonably inferred from the Agreement, any infringement resulting from the misuse of the Project or any part thereof, or any products produced in association or combination with any other equipment, plant or materials not supplied by the TSP, pursuant to the Agreement.

(b) If any proceedings are brought or any claim is made against the Nodal Agency arising out of the matters referred to in Article 14.2.1(a), the Nodal Agency shall promptly give the TSP a notice thereof, and the TSP shall at its own expense take necessary steps

and attend such proceedings or claim and any negotiations for the settlement of any such proceedings or claim. The TSP shall promptly notify the Nodal Agency of all actions taken in such proceedings or claims.

(c) If the TSP fails to notify the Nodal Agency within twenty-eight (28) days after receipt of such notice from the Nodal Agency under Article 14.2.1(b) above, that it intends to attend any such proceedings or claim, then the Nodal Agency shall be free to attend the same on their own behalf at the cost of the TSP. Unless the TSP has so failed to notify the Nodal Agency within the twenty eight (28) days period, the Nodal Agency shall make no admission that may be prejudicial to the defence of any such proceedings or claims.

(d) The Nodal Agency shall, at the TSP's request, afford all available assistance to the TSP in attending to such proceedings or claim, and shall be reimbursed by the TSP for all reasonable expenses incurred in so doing.

14.2.2

(a) The Nodal Agency, in accordance with the Regulations framed by CERC in this regard, subject to the TSP's compliance with Article 14.2.2(b) shall indemnify and hold harmless the TSP and its employees, officers from and against any and all suits, actions or administrative proceedings, claims, demands, losses, damages, costs and expenses of whatsoever nature, including attorney's fees and expenses, which the TSP may suffer as a result of any infringement or alleged infringement of any patent, utility model, registered design, trademark, copyright or other intellectual property right registered or otherwise existing at the date of the Agreement by reason of the setting up of the Project by the TSP.

(b) If any proceedings are brought or any claim is made against the TSP arising out of the matters referred to in Article 14.2.2 (a) the TSP shall promptly give the Nodal Agency a notice thereof, and the Nodal Agency shall at its own expense take necessary steps and attend such proceedings or claim and any negotiations for the settlement of any such proceedings or claim. The Nodal Agency shall promptly notify the TSP of all actions taken in such proceedings or claims.

(c) If the Nodal Agency fails to notify the TSP within twenty-eight (28) days after receipt of such notice from the TSP under Article 14.2.2(b) above, that it intends to attend any such proceedings or claim, then the TSP shall be free to attend the same on its own behalf at the cost

of the Nodal Agency. Unless the Nodal Agency has so failed to notify the TSP within the twenty (28) days period, the TSP shall make no admission that may be prejudicial to the defence of any such proceedings or claim.

(d) The TSP shall, at the Nodal Agency request, afford all available assistance to the Nodal Agency in attending to such proceedings or claim, and shall be reimbursed by the Nodal Agency for all reasonable expenses incurred in so doing.

14.3 Monetary Limitation of liability

14.3.1 A Party ("Indemnifying Party") shall be liable to indemnify the other Party ("Indemnified Party") under this Article 14 for any indemnity claims made in a Contract Year only up to an amount of Rupees Forty-Seven Crore Seventy-Four Lakhs Only (Rs. 47.74 Crore)**.**

14.4 Procedure for claiming indemnity

14.4.1 Where the Indemnified Party is entitled to indemnification from the Indemnifying Party pursuant to Articles 14.1 or 14.2 the Indemnified Party shall promptly notify the Indemnifying Party of such claim, proceeding, action or suit referred to in Articles 14.1 or 14.2 in respect of which it is entitled to be indemnified. Such notice shall be given as soon as reasonably practicable after the Indemnified Party becomes aware of such claim, proceeding, action or suit. The Indemnifying Party shall be liable to settle the indemnification claim within thirty (30) days of receipt of the above notice.

Provided however that, if:

i. the Parties choose to contest, defend or litigate such claim, action, suit or proceedings in accordance with Article 14.4.3 below; and

ii. the claim amount is not required to be paid/deposited to such third party pending the resolution of the Dispute,

the Indemnifying Party shall become liable to pay the claim amount to the Indemnified Party or to the third party, as the case may be, promptly following the resolution of the Dispute, if such Dispute is not settled in favour of the Indemnified Party.

14.4.2 The Indemnified Party may contest, defend and litigate a claim, action, suit or proceeding for which it is entitled to be indemnified under Articles 14.1 or 14.2 and the Indemnifying Party shall reimburse to the Indemnified Party all reasonable costs and expenses incurred by the Indemnified

Party. However, such Indemnified Party shall not settle or compromise such claim, action, suit or proceedings without first getting the consent of the Indemnifying Party, which consent shall not be unreasonably withheld or delayed.

14.4.3 An Indemnifying Party may, at its own expense, assume control of the defence of any proceedings brought against the Indemnified Party if it acknowledges its obligation to indemnify such Indemnified Party, gives such Indemnified Party prompt notice of its intention to assume control of the defence, and employs an independent legal counsel at its own cost that is reasonably satisfactory to the Indemnified Party.

14.5 Limitation on Liability

14.5.1 Except as expressly provided in this Agreement, neither the TSP nor the Nodal Agency nor their respective officers, directors, agents, employees or Affiliates (including, officers, directors, agents or employees of such Affiliates), shall be liable or responsible to the other Party or its Affiliates including its officers, directors, agents, employees, successors, insurers or permitted assigns for incidental, indirect or consequential, punitive or exemplary damages, connected with or resulting from performance or non-performance of this Agreement, or anything done in connection herewith, including claims in the nature of lost revenues, income or profits (other than payments expressly required and properly due under this Agreement), any increased expense of, reduction in or loss of transmission capacity or equipment used therefore, irrespective of whether such claims are based upon breach of warranty, tort (including negligence, whether of the Nodal Agency, the TSP or others), strict liability, contract, breach of statutory duty, operation of law or otherwise.

14.5.2 The Nodal Agency shall have no recourse against any officer, director or shareholder of the TSP or any Affiliate of the TSP or any of its officers, directors or shareholders for such claims excluded under this Article. The TSP shall also have no recourse against any officer, director or shareholder of the Nodal Agency, or any Affiliate of the Nodal Agency or any of its officers, directors or shareholders for such claims excluded under this Article.

14.6 Duty to Mitigate

The party entitled to the benefit of an indemnity under this Article 14 shall take all reasonable measures to mitigate any loss or damage which has occurred. If the Party fails to take such measures, the other Party's liabilities shall be correspondingly reduced.

ARTICLE: 15

15 ASSIGNMENTS AND CHARGES

15.1 Assignments:

15.1.1 This Agreement shall be binding upon, and inure to the benefit of the Parties and their respective successors and permitted assigns. This Agreement shall not be assigned by any Party, except as provided in Article 15.3.

15.2 Permitted Charges:

15.2.1 Neither Party shall create or permit to subsist any encumbrance over all or any of its rights and benefits under this Agreement.

15.2.2 However, the TSP may create any encumbrance over all or part of the receivables, or the Project Assets of the Project in favour of the Lenders or the Lenders' Representative on their behalf, as security for amounts payable under the Financing Agreements and any other amounts agreed by the Parties.

Provided that:

i. the Lenders or the Lenders' Representative on their behalf shall have entered into the Financing Agreements and agreed in writing to the provisions of this Agreement; and

ii. any encumbrance granted by the TSP in accordance with this Article 15.2.2 shall contain provisions pursuant to which the Lenders or the Lender's Representative on their behalf agrees unconditionally with the TSP to release from such encumbrances upon payment by the TSP to the Lenders of all amounts due under the Financing Agreements.

15.2.3 Article 15.2.1 does not apply to:

a. liens arising by operation of law (or by an agreement evidencing the same) in the ordinary course of the TSP developing and operating the Project;

b. pledges of goods, the related documents of title and / or other related documents, arising or created in the ordinary course of the TSP developing and operating the Project; or

c. security arising out of retention of title provisions in relation to goods acquired in the ordinary course of the TSP developing and operating the Project.

15.3 Substitution Rights of the Lenders

15.3.1 The TSP would need to operate and maintain the Project under the provisions of this Agreement and cannot assign the Transmission License or transfer the Project or part thereof to any person by sale, lease, exchange or otherwise, without the prior approval of the Nodal Agency.

15.3.2 However, in the case of default by the TSP in debt repayments or in the case of default by the TSP as per Article 13 of this Agreement during the debt repayments, the Commission may, on an application from the Lenders, assign the Transmission License to the nominee of the Lenders subject to the fulfilment of the qualification requirements and provisions of the Central Electricity Regulatory Commission (Procedure, terms and Conditions for grant of Transmission License and other related matters) Regulations, 2006 and as amended from time to time.

ARTICLE: 16

16 GOVERNING LAW AND DISPUTE RESOLUTION

16.1 Governing Law:

This Agreement shall be governed by and construed in accordance with the Laws of India. Any legal proceedings in respect of any matters, claims or disputes under this Agreement shall be under the jurisdiction of appropriate courts in Delhi.

16.2 Amicable Settlement:

16.2.1 Either Party is entitled to raise any claim, dispute or difference of whatever nature arising under, out of or in connection with this Agreement, including its existence or validity or termination or whether during the execution of the Project or after its completion and whether prior to or after the abandonment of the Project or termination or breach of the Agreement by giving a written notice to the other Party, which shall contain:

(i) a description of the Dispute;

(ii) the grounds for such Dispute; and

(iii) all written material in support of its claim.

16.2.2 The other Party shall, within thirty (30) days of issue of notice issued under Article 16.2.1, furnish:

(i) counter-claim and defences, if any, regarding the Dispute; and

(ii) all written material in support of its defences and counter-claim.

16.2.3 Within thirty (30) days of issue of notice by the Party pursuant to Article 16.2.1, if the other Party does not furnish any counter claim or defense under Article 16.2.2, or thirty (30) days from the date of furnishing counter claims or defence by the other Party, both the Parties to the Dispute shall meet to settle such Dispute amicably. If the Parties fail to resolve the Dispute amicably within thirty (30) days from the later of the dates mentioned in this Article 16.2.3, the Dispute shall be referred for dispute resolution in accordance with Article 16.3.

16.3 Dispute Resolution:

All Disputes shall be adjudicated by the Commission.

16.4 Parties to Perform Obligations:

Notwithstanding the existence of any Dispute and difference referred to the Commission as provided in Article 16.3 and save as the Commission may otherwise direct by a final or interim order, the Parties hereto shall continue to perform their respective obligations/ roles (which are not in dispute) under this Agreement.

ARTICLE: 17

17 REPRESENTATION AND WARRANTIES

17.1 Representation and warranties of the Nodal Agency

17.1.1 The Nodal Agency hereby represents and warrants to and agrees with the TSP as follows and acknowledges and confirms that the TSP is relying on such representations and warranties in connection with the transactions described in this Agreement:

a. It has all requisite powers and authority to execute and consummate this Agreement;

b. This Agreement is enforceable against the Nodal Agency in accordance with its terms;

c. The consummation of the transactions contemplated by this Agreement on the part of Nodal Agency will not violate any provision of nor constitute a default under, nor give rise to a power to cancel any charter, mortgage, deed of trust or lien, lease, agreement, license, permit, evidence of indebtedness, restriction, or other contract to which the Nodal Agency is a Party or to which the Nodal Agency is bound, which violation, default or power has not been waived;

17.2 Representation and Warranties of the TSP:

17.2.1 The TSP hereby represents and warrants to and agrees with the Nodal Agency as follows and acknowledges and confirms that the Nodal Agency is relying on such representations and warranties in connection with the transactions described in this Agreement:

a. It has all requisite powers and has been duly authorized to execute and consummate this Agreement;

b. This Agreement is enforceable against it, in accordance with its terms;

c. The consummation of the transactions contemplated by this Agreement on the part of the TSP will not violate any provision of nor constitute a default under, nor give rise to a power to cancel any charter, mortgage, deed of trust or lien, lease, agreement, license, permit, evidence of indebtedness, restriction, or other contract to which the TSP is a Party or to which the TSP is bound which violation, default or power has not been waived;

d. The TSP is not insolvent and no insolvency proceedings have been instituted, nor threatened or pending by or against the TSP;

e. There are no actions, suits, claims, proceedings or investigations pending or, to the best of the TSP's knowledge, threatened in writing against the TSP at law, in equity, or otherwise, and whether civil or criminal in nature, before or by, any court, commission, arbitrator or governmental agency or authority, and there are no outstanding judgments, decrees or orders of any such courts, commission, arbitrator or governmental agencies or authorities, which materially adversely affect its ability to execute the Project or to comply with its obligations under this Agreement.

17.2.2 The TSP makes all the representations and warranties above to be valid as on the Effective Date of this Agreement.

ARTICLE: 18

18 INDEPENDENT ENGINEER

18.1 Appointment of Independent Engineer

The Nodal Agency shall appoint an agency/ company as Independent Engineer as per framework provided in the Guidelines for Encouraging Competition in Development of Transmission Projects for selection of Independent Engineer.

18.2 Roles and functions of Independent Engineer

The role and functions of the Independent Engineer shall include the following:

a. Progress Monitoring as required under this Agreement;

b. Ensuring Quality as required under this Agreement;

c. determining, as required under the Agreement, the costs of any works or services and/or their reasonableness during construction phase;

d. determining, as required under the Agreement, the period or any extension thereof, for performing any duty or obligation during construction phase;

e. determining, as required under the Agreement, the valuation of the Project Assets.

f. Assisting the Parties in resolution of Disputes and

g. Undertaking all other duties and functions in accordance with the Agreement.

18.3 Remuneration of Independent Engineer

The fee and charges of the Independent Engineer shall be paid by the Nodal Agency as per terms & conditions of appointment.

18.4 Termination of appointment

18.4.1 The Nodal Agency may, in its discretion, terminate the appointment of the Independent Engineer at any time, but only after appointment of another Independent Engineer.

18.4.2 If the TSP has reason to believe that the Independent Engineer is not discharging its duties and functions in a fair, efficient and diligent manner, it may make a written representation to the Nodal Agency and seek termination of the appointment of the Independent Engineer. Upon receipt of such representation, the Nodal Agency shall hold a tripartite meeting with the TSP and Independent Engineer for an amicable resolution, and the decision of Nodal agency is final. In the event that the appointment of the Independent Engineer is terminated hereunder, the Nodal Agency shall appoint forthwith another Independent Engineer.

18.5 Authorised signatories

The Nodal Agency shall require the Independent Engineer to designate and notify to the Nodal Agency up to 2 (two) persons employed in its firm to sign for and on behalf of the Independent Engineer, and any communication or document required to be signed by the Independent Engineer shall be valid and effective only if signed by any of the designated persons; provided that the Independent Engineer may, by notice in writing, substitute any of the designated persons by any of its employees.

ARTICLE: 19

19 MISCELLANEOUS PROVISIONS

19.1 Equity Lock-in Commitment:

19.1.1 The aggregate equity share holding of the Selected Bidder in the issued and paid up equity share capital ofBarmer HVDC Power Transmission Limited shall not be less than Fifty one percent (51%) up to a period of one (1) year after COD of the Project.

Provided that, in case the Lead Member or Bidding Company is holding equity through Affiliate/s, Ultimate Parent Company or Parent Company, such restriction as specified above shall apply to such entities.

Provided further, that in case the Selected Bidder is a Bidding Consortium, the Lead Member shall continue to hold equity of at least twenty six percent (26%) upto a period of one (1) year after COD of the Project and any Member of such Bidding Consortium shall be allowed to divest its equity as long as the other remaining Members (which shall always include the Lead Member) hold the minimum equity specified above.

19.1.2 If equity is held by the Affiliates, Parent Company or Ultimate Parent Company of the Selected Bidder, then, subject to the second proviso to Article 19.1.1, such Affiliate, Parent Company or Ultimate Parent Company shall be eligible to transfer its shareholding inBarmer HVDC Power Transmission Limited to another Affiliate or to the Parent Company / Ultimate Parent Company of the Selected Bidder. If any such shareholding entity, qualifying as an Affiliate / Parent Company / Ultimate Parent Company, is likely to cease to meet the criteria to qualify as an Affiliate / Parent Company / Ultimate Parent Company, the shares held by such entity shall be transferred to another Affiliate / Parent Company / Ultimate Parent Company of the Selected Bidder.

19.1.3 Subject to Article 19.1.1, all transfer(s) of shareholding of Barmer HVDC Power Transmission Limited by any of the entities referred to in Article 19.1.1 and 19.1.2 above, shall be after prior written intimation to the Nodal Agency.

19.1.4 For computation of effective Equity holding, the Equity holding of the Selected Bidder or its Ultimate Parent Company in such Affiliate(s) or Parent Company and the equity holding of such Affiliate(s) or Ultimate Parent Company inBarmer HVDC Power Transmission Limited shall be computed in accordance with the example given below:

If the Parent Company or the Ultimate Parent Company of the Selected Bidder A directly holds thirty percent (30%) of the equity inBarmer HVDC Power Transmission Limited then holding of Selected Bidder A inBarmer HVDC Power Transmission Limited shall be thirty percent (30%);

If Selected Bidder A holds thirty percent (30%) equity of the Affiliate and the Affiliate holds fifty percent (50%) equity inBarmer HVDC Power Transmission Limited, then, for the purposes of ascertaining the minimum equity/equity lock-in requirements specified above, the effective holding of Bidder A inBarmer HVDC Power Transmission Limited shall be fifteen percent (15%), (i.e., 30% x 50%)

19.1.5 The provisions as contained in this Article 19.1 shall override the terms of the consortium agreement submitted as part of the Bid.

19.1.6 The TSP shall be responsible to report to Nodal Agency, within thirty (30) days from the occurrence of any event that would result in any change in its equity holding structure from that which existed as on the date of signing of the Share Purchase Agreement. In such cases, the Nodal Agency would reserve the right to ascertain the equity holding structure and to call for all such required documents / information / clarifications as may be required.

19.2 Commitment of maintaining Qualification Requirement

19.2.1 The Selected Bidder will be required to continue to maintain compliance with the Qualification Requirements, as stipulated in RFP Document, till the COD of the Project. Where the Technically Evaluated Entity and/or the Financially Evaluated Entity is not the Bidding Company or a Member in a Bidding Consortium, as the case may be, the Bidding Company or Member shall continue to be an Affiliate of the Technically Evaluated Entity and/or Financially Evaluated Entity till the COD of the Project.

19.2.2 Failure to comply with the aforesaid provisions shall be dealt in the same manner as TSP's Event of Default as under Article 13 of this Agreement.

19.3 Language:

19.3.1 All agreements, correspondence and communications between the Parties relating to this Agreement and all other documentation to be prepared and supplied under the Agreement shall be written in English, and the Agreement shall be construed and interpreted in accordance with English language.

19.3.2 If any of the agreements, correspondence, communications or documents

are prepared in any language other than English, the English translation of such agreements, correspondence, communications or documents shall prevail in matters of interpretation.

19.4 Affirmation

The TSP and the Nodal Agency, each affirm that:

1. neither it nor its respective directors, employees, or agents has paid or undertaken to pay or shall in the future pay any unlawful commission, bribe, pay-off or kick-back; and

2. it has not in any other manner paid any sums, whether in Indian currency or foreign currency and whether in India or abroad to the other Party to procure this Agreement, and the TSP and the Nodal Agency hereby undertake not to engage in any similar acts during the Term of Agreement.

19.5 Severability

The invalidity or enforceability, for any reason, of any part of this Agreement shall not prejudice or affect the validity or enforceability of the remainder of this Agreement, unless the part held invalid or unenforceable is fundamental to this Agreement.

19.6 Counterparts

This Agreement may be executed in one or more counterparts, each of which shall be deemed an original and all of which collectively shall be deemed one and the same Agreement.

19.7 Breach of Obligations/ Roles

The Parties acknowledge that a breach of any of the obligations/ roles contained herein would result in injuries. The Parties further acknowledge that the amount of the liquidated damages or the method of calculating the liquidated damages specified in this Agreement is a genuine and reasonable pre-estimate of the damages that may be suffered by the non-defaulting Party in each case specified under this Agreement.

19.8 Restriction of Shareholders / Owners Liability

19.8.1 Parties expressly agree and acknowledge that none of the shareholders of the Parties hereto shall be liable to the other Parties for any of the contractual obligations of the concerned Party under this Agreement.

19.8.2 Further, the financial liabilities of the shareholder(s) of each Party to this Agreement shall be restricted to the extent provided in the Indian Companies Act, 1956 / Companies Act, 2013 (as the case may be).

19.9 Taxes and Duties:

19.9.1 The TSP shall bear and promptly pay all statutory taxes, duties, levies and cess, assessed/levied on the TSP, its Contractors or their employees that are required to be paid by the TSP as per the Law in relation to the execution of the Project and for providing Transmission Service as per the terms of this Agreement.

19.9.2 The Nodal Agency shall be indemnified and held harmless by the TSP against any claims that may be made against the Nodal Agency in relation to the matters set out in Article 19.9.1.

19.9.3 The Nodal Agency shall not be liable for any payment of, taxes, duties, levies, cess whatsoever for discharging any obligation of the TSP by the Nodal Agency on behalf of TSP or its personnel, provided the TSP has consented in writing to the Nodal Agency for such work, for which consent shall not be unreasonably withheld.

19.10 No Consequential or Indirect Losses

The liability of the TSP shall be limited to that explicitly provided in this Agreement.

Provided that, notwithstanding anything contained in this Agreement, under no event shall the Nodal Agency or the TSP claim from one another any indirect or consequential losses or damages.

19.11 Discretion:

Except where this Agreement expressly requires a Party to act fairly or reasonably, a Party may exercise any discretion given to it under this Agreement in any way it deems fit.

19.12 Confidentiality

19.12.1 The Parties undertake to hold in confidence this Agreement and RFP Project Documents and not to disclose the terms and conditions of the transaction contemplated hereby to third parties, except:

(a) to their professional advisors;

(b) to their officers, contractors, employees, agents or representatives, financiers, who need to have access to such information for the

proper performance of their activities; or

(c) disclosures required under Law,

without the prior written consent of the other Parties.

Provided that, the TSP agrees and acknowledges that the Nodal Agency, may, at any time, disclose the terms and conditions of the Agreement and the RFP Project Documents to any person, to the extent stipulated under the Law and the Competitive Bidding Guidelines.

19.13 Order of priority in application:

Save as provided in Article 2.5, in case of inconsistencies between the terms and conditions stipulated in Transmission License issued by the Commission to the TSP, agreement(s) executed between the Parties, applicable Law including rules and regulations framed thereunder, the order of priority as between them shall be the order in which they are placed below:

- terms and conditions of Transmission License;
- applicable Law, rules and regulations framed thereunder;
- this Agreement;
- Agreement(s), if any, under Sharing Regulations.

19.14 Independent Entity:

19.14.1 The TSP shall be an independent entity performing its obligations pursuant to the Agreement.

19.14.2 Subject to the provisions of the Agreement, the TSP shall be solely responsible for the manner in which its obligations under this Agreement are to be performed. All employees and representatives of the TSP or Contractors engaged by the TSP in connection with the performance of the Agreement shall be under the complete control of the TSP and shall not be deemed to be employees, representatives, Contractors of the Nodal Agency and nothing contained in the Agreement or in any agreement or contract awarded by the TSP shall be construed to create any contractual relationship between any such employees, representatives or Contractors and the Nodal Agency.

19.15 Amendments:

19.15.1 This Agreement may only be amended or supplemented by a written

agreement between the Parties.

19.16 Waiver:

19.16.1 No waiver by either Party of any default or breach by the other Party in the performance of any of the provisions of this Agreement shall be effective unless in writing duly executed by an authorised representative of such Party.

19.16.2 Neither the failure by either Party to insist on any occasion upon the performance of the terms, conditions and provisions of this Agreement nor time or other indulgence granted by one Party to the other Parties shall act as a waiver of such breach or acceptance of any variation or the relinquishment of any such right or any other right under this Agreement, which shall remain in full force and effect.

19.17 Relationship of the Parties:

This Agreement shall not be interpreted or construed to create an association, joint venture, or partnership or agency or any such other relationship between the Parties or to impose any partnership obligation or liability upon either Party and neither Party shall have any right, power or authority to enter into any agreement or undertaking for, or act on behalf of, or to act as or be an agent or representative of, or to otherwise bind, the other Party.

19.18 Entirety:

19.18.1 This Agreement along with its sections, schedules and appendices is intended by the Parties as the final expression of their agreement and is intended also as a complete and exclusive statement of the terms of their agreement.

19.18.2 Except as provided in this Agreement, all prior written or oral understandings, offers or other communications of every kind pertaining to this Agreement or the provision of Transmission Service under this Agreement to the Nodal Agency by the TSP shall stand superseded and abrogated.

19.19 Notices:

19.19.1 All notices or other communications which are required to be given under this Agreement shall be in writing and in the English language

19.19.2 If to the TSP, all notices or communications must be delivered personally or by registered post or facsimile or any other mode duly acknowledged to

the addressee below:

Address :

Attention :

Email :

Fax. No. :

Telephone No. :

19.19.3 If to the Nodal Agency, all notices or communications must be delivered personally or by registered post or facsimile or any other mode duly acknowledged to the addresses below:

(i) …… [Insert Name of the Nodal Agency]

Address :
Attention
Email :
Fax. No. :
Telephone No. :

19.19.4 All notices or communications given by facsimile shall be confirmed by sending a copy of the same via post office in an envelope properly addressed to the appropriate Party for delivery by registered mail. All notices shall be deemed validly delivered upon receipt evidenced by an acknowledgement of the recipient, unless the Party delivering the notice can prove in case of delivery through the registered post that the recipient refused to acknowledge the receipt of the notice despite efforts of the postal authorities.

19.19.5 Any Party may by notice of at least fifteen (15) days to the other Party change the address and/or addresses to which such notices and communications to it are to be delivered or mailed.

19.20 Fraudulent and Corrupt Practices

19.20.1 The TSP and its respective officers, employees, agents and advisers shall observe the highest standard of ethics during the subsistence of this Agreement. Notwithstanding anything to the contrary contained in the Agreement, the Nodal Agency may terminate the Agreement without being liable in any manner whatsoever to the TSP, if it determines that the TSP has, directly or indirectly or through an agent, engaged in corrupt practice, fraudulent practice, coercive practice, undesirable practice or restrictive practice in the Bid process. In such an event, the Nodal Agency shall forfeit

the Contract Performance Guarantee of the TSP, without prejudice to any other right or remedy that may be available to the Nodal Agency hereunder or subsistence otherwise.

19.20.2 Without prejudice to the rights of the Nodal Agency under Clause 19.20.1 hereinabove and the rights and remedies which the Nodal Agency may have under this Agreement, if a TSP is found by the Nodal Agency to have directly or indirectly or through an agent, engaged or indulged in any corrupt practice, fraudulent practice, coercive practice, undesirable practice or restrictive practice during the Bid process, or after the issue of Letter of Intent (hereinafter referred to as LoI) or after the execution of the agreement(s) required under Sharing Regulations, the Nodal Agency may terminate the Agreement without being liable in any manner whatsoever to the TSP. Further, the TSP & its Affiliates shall not be eligible to participate in any tender or RFP issued by any BPC for an indefinite period from the date such TSP is found by the Nodal Agency to have directly or indirectly or through an agent, engaged or indulged in any corrupt practice, fraudulent practice, coercive practice, undesirable practice or restrictive practices, as the case may be.

19.20.3 For the purposes of this Clause 19.20, the following terms shall have the meaning hereinafter respectively assigned to them:

(a) **"corrupt practice"** means (i) the offering, giving, receiving, or soliciting, directly or indirectly, of anything of value to influence the actions of any person connected with the Bid process (for avoidance of doubt, offering of employment to or employing or engaging in any manner whatsoever, directly or indirectly, any official of the BPC who is or has been associated or dealt in any manner, directly or indirectly with the Bid process or the LoI or has dealt with matters concerning the RFP Project Documents or arising there from, before or after the execution thereof, at any time prior to the expiry of one year from the date such official resigns or retires from or otherwise ceases to be in the service of the BPC, shall be deemed to constitute influencing the actions of a person connected with the Bid Process); or (ii) engaging in any manner whatsoever, whether during the Bid Process or after the issue of the LoI or after the execution of the RFP Project Documents, as the case may be, any person in respect of any matter relating to the Project or the LoI or the RFP Project Documents, who at any time has been or is a legal, financial or technical adviser of the BPC in relation to any matter concerning the Project;

(b) "**fraudulent practice**" means a misrepresentation or omission of facts or suppression of facts or disclosure of incomplete facts, in order to influence the Bid process;

(c) "**coercive practice**" means impairing or harming, or threatening to impair or harm, directly or indirectly, any person or property to influence any person's participation or action in the Bid process;

(d) "**undesirable practice**" means (i) establishing contact with any person connected with or employed or engaged by the BPC with the objective of canvassing, lobbying or in any manner influencing or attempting to influence the Bid process; or (ii) having a Conflict of Interest; and

(e) "**restrictive practice**" means forming a cartel or arriving at any understanding or arrangement among Bidders with the objective of restricting or manipulating a full and fair competition in the Bid process;

19.21 Compliance with Law:

Despite anything contained in this Agreement but without prejudice to Article 12, if any provision of this Agreement shall be in deviation or inconsistent with or repugnant to the provisions contained in the Electricity Act, 2003, or any rules and regulations made there under, such provision shall be deemed to be amended to the extent required to bring it into compliance with the aforesaid relevant provisions as amended from time to time.

IN WITNESS WHEREOF, THE PARTIES HAVE CAUSED THIS AGREEMENT TO BE EXECUTED BY THEIR DULY AUTHORISED REPRESENTATIVES AS OF THE DATE AND PLACE SET FORTH ABOVE.

1. For and on behalf of TSP

……..

[Signature, Name, Designation and Address]

2. For and on behalf of .....[Insert name of the Nodal Agency]

……..

[Signature, Name, Designation and Address]

WITNESSES:

1. For and on behalf of

: BPC

……
[Signature]

.....
[Insert, Name, Designation and Address of the Witness]

2. For and on behalf of

: Nodal Agency

……
[Signature]

.....
[Insert Name, Designation and Address of the Witness]

SCHEDULES

Schedule: 1

Project Description and Scope of Project

Scope of the Project:

Sl. No.	Scope of the Transmission Scheme	Scheduled COD in months from Effective Date
1.	Establishment of 400/220 kV, 6x500 MVA S/s at suitable location near Barmer (Barmer-II Substation) along with 2x125 MVAr bus reactor <u>Barmer-II PS – AIS</u> • 400/220 kV 500 MVA ICTs- 6 Nos. • 400 kV ICT bays- 6 Nos. • 220 kV ICT bays - 6 Nos. • 125 MVAr Bus Reactor-2 Nos. • 400 kV Bus reactor bays- 2 Nos. • 400 kV line bays– 4 Nos. (for RE interconnection) • 220 KV line bays – 7 Nos. (for RE connectivity) • 220 kV Sectionalization bay: 1 set • 220 kV BC (2 Nos.) & TBC (2 Nos.) • 400 kV Sectionaliser bay- 1 Set **<u>Future provisions (excl. scope of present scheme):</u>** • 400 kV line bays along with switchable line reactor –6 • 400 kV line bays –4 Nos. • 400 kV Bus Reactor along with bays: 1 No. • 400/220 kV ICT along with bays-4 Nos. • 400 kV Sectionalization bays: 2 sets • 220 kV line bays for connectivity RE Applications -5 Nos. • 220 kV Sectionalization bay: 2 sets • 220 kV BC (2 Nos.) & TBC (2 Nos.) • 2 Nos. of Syncon units* at 400 kV level along with 2 Nos. of 400 kV bays • STATCOM (2x+300 MVAr, 4x125 MVAr MSC, 2x125 MVAr MSR) along with 400 kV bays (2 Nos.)	54 months from allocation of project (Bipole-1: 48 months, Bipole-2: 54 months)

Sl. No.	Scope of the Transmission Scheme	Scheduled COD in months from Effective Date
	*1 No. of SynCon unit comprises dynamic support of +300 MVAr/-200 MVAr (Minimum) & Short circuit contribution at PCC of 1200 MVA (Minimum))	
2.	LILO of both circuits of 400 kV Fatehgarh-IV PS - Barmer-I PS D/C line at Barmer-II PS • 400 kV line bays- 4 Nos. (at Barmer-II PS end)	
3.	Barmer-II PS - Barmer-I PS 400 kV D/C line (Quad) • 400 kV line bays at Barmer-II PS – 2 Nos. • 400 kV line bays at Barmer-I PS– 2 Nos.	
4.	Establishment of 6000 MW, ± 800 kV Barmer-II (HVDC) [LCC] terminal station (4x1500 MW) at a suitable location near Barmer-II substation • HVDC terminal station (± 800 kV, 3000 MW (Bipole configuration)- 2 Nos.) • 400/33 kV, 2x50 MVA transformers for exclusively supplying auxiliary power to HVDC terminal.	
5.	Establishment of 6000 MW, ± 800 kV South Kalamb S/s (HVDC) [LCC] terminal station (4x1500 MW) at a suitable location near South of Kalamb • HVDC terminal station (± 800 kV, 3000 MW (Bipole configuration)- 2 Nos.)	
6.	±800 kV HVDC Bipole line (Hexa lapwing) between Barmer-II (HVDC) & South Kalamb (HVDC) (with parallel Dedicated Metallic Return) (capable to evacuate 6000 MW) [with 100% reverse power capability]	
7.	Augmentation of South Kalamb S/s# by 4x1500 MVA, 765/400 kV ICTs (3 Nos. 400 kV & 765 kV Section-II & 1 No. on 400 kV & 765 kV Section-I) along with 2x330 MVAR, 765 kV bus reactor & 2x125 MVAr, 420 kV bus reactor on Section-II. The	

Sl. No.	Scope of the Transmission Scheme	Scheduled COD in months from Effective Date
	Section-II will be established under a different network expansion scheme in WR as per details given below[$] (2x1500 MW HVDC Bipole-I to be terminated on 400 kV Section-I & 2x1500 MW HVDC Bipole-II to be terminated on 400 kV Section-II of South Kalamb S/s & 765 kV bus sectionalizer to be kept normally closed & 400kV bus sectionalizer to be kept normally open) • 765/400 kV 1500 MVA ICTs- 4 Nos. • 765 kV ICT bays- 4 Nos. • 400 kV ICT bays- 4 Nos. • 330 MVAr Bus Reactor-2 Nos. (at bus section-II) • 765 kV Bus reactor bays- 2 Nos. (at bus section-II) • 125 MVAr Bus Reactor-2 Nos. (at bus section-II) • 400 kV Bus reactor bays- 2 Nos. (at bus section-II)	
8.	2 Nos. of Syncon units at 400 kV level of Barmer-II PS (1 No. of SynCon unit comprises dynamic support of +300MVAr/-200 MVAr (Minimum) & Short circuit contribution at PCC of 1200 MVA (Minimum)) • Syncon units – 2 Nos. 400 kV line bays – 2 Nos.	

#South Kalamb S/s establishment with 2x1500 MVA, 765/400 kV ICTs with 2x330 MVAr, 765 kV bus reactor and 2x125 MVAr, 420 kV bus reactor along with LILO of Pune-III – Boisar-II 765 kV D/C line (presently under construction by M/s WRNES TPTL, a subsidiary of Adani Energy Solutions Limited).

$ Network Expansion Scheme: Creation of New 765kV & 400kV Bus Sections-II & III through 765 kV Sectionalization bay: 2 sets & 400 kV Sectionalization bay: 2 sets alongwith 2x330 MVAr, 765 kV bus reactor & 2x125 MVAr, 420 kV bus reactor on Section-III is being proposed along with ICT augmentation (3x1500MVA, 765/400kV ICTs) at Bus Section -III at both 765kV & 400kV levels alongwith downstream 400kV lines at bus section-III from South Kalamb S/s with implementation timeframe of 24 months from effective date. [400kV Sectionaliser between Sections-I & II & between sections-II & III to be normally open. Further, 765kV sectionaliser between Sections-

I & II & between II & III shall be kept normally closed. The 400kV sectionalisers can be closed under contingency conditions.].

Project Description

The transmission scheme comprises of the transmission system for evacuation of RE (Solar) power from Barmer area in the state of Rajasthan (Rajasthan REZ Ph-IV Part-5: 6 GW).

This scheme is a part of transmission system for evacuation of RE power from 75 GW of Renewable Energy Zones (REZs) identified by MNRE/SECI in Rajasthan. Out of 75 GW, evacuation of 13 GW has been planned from Fatehgarh (5 GW) and Barmer (8 GW) complex. Transmission schemes for 9 GW injection at Fatehgarh-IV PS and Barmer-I PS under Rajasthan REZ Ph-IV (Part-2: 5.5 GW) and Rajasthan REZ Ph-IV (Part-4: 3.5 GW) are under implementation. At present connectivity of about 6 GW capacity is already granted at Barmer-II PS and the present transmission scheme has been planned for evacuation of 6 GW RE (Solar) injection at Barmer-II Pooling station.

This comprehensive transmission scheme includes the establishment of 400 kV Barmer-II PS in Rajasthan along with 400 kV Barmer-II – Barmer-I D/c line and LILO of both circuits of 400 kV Fatehgarh-IV – Barmer-I D/c line at Barmer-II PS. The HVDC portion of the scheme includes establishment of ± 800 kV, 6000 MW Barmer-II(HVDC) [LCC] terminal station, ± 800 kV, 6000 MW, South Kalamb (HVDC) [LCC] terminal station along with Barmer-II – South Kalamb ±800 kV HVDC Biploe Line. For further dispersal of power, augmentation of South Kalamb S/s with 4 nos. of 765/400 kV, 1500MVA ICTs is to be implemented. Further, 2 Nos. of Syncon units at 400kV level of Barmer-II PS are also being proposed as part of comprehensive scheme.

Above transmission scheme has been discussed and agreed in the 36th CMETS-NR meeting held on 15.01.2025 and 35th CMETS-WR meeting held on 07.02.2025, 53rd TCC & 78th NRPC meeting held on 16-17th Mar'25, 53rd TCC/53rd WRPC meeting held on 13th Mar'25. Further, the transmission scheme was agreed in 30th NCT meeting held on 30.05.25. Subsequently, Ministry of Power, Government of India, vide its Gazette Notification CG-DL-E-30082025-265828 dated 29.08.2025 has notified the implementation of transmission scheme "Transmission system for evacuation of power from Rajasthan REZ Ph-IV (Part-5 :6 GW) [Barmer Complex] Barmer-II: 6 GW (Solar) (LCC Configuration)" through tariff based competitive bidding process route.

Specific Technical Requirement of 6000 MW (4x1500 MW), ±800 kV HVDC [Type: Line Commutated Converter (LCC)]

1. General

The proposed HVDC link shall be ±800 kV, 6000 MW HVDC line between Barmer-II and South Kalamb using Dedicated metallic return and consist of Bipole-1 (3000 MW) & Bipole-2 (3000 MW). Bipole-1 shall consist of Pole-1 (1500 MW) & Pole-2 (1500 MW) and Bipole-2 shall consist of Pole-3 (1500 MW) & Pole-4 (1500 MW). The HVDC terminals shall be implemented with 100% power reversal capability.

The system shall generally conform to the requirements of CEA (Technical Standards for Construction of Electrical Plants and Electric Lines) Regulations 2022, CEA (Safety requirements for construction, operation and maintenance of electrical plants and electric lines) Regulations, as amended from time to time. Other CEA Regulations/Guidelines, Ministry of Power (MoP) Rules/Guidelines as amended up to date and, as applicable, shall also be followed. Further, any other Rule/Regulations/ Standard/Guidelines as mentioned in the Transmission Service Agreement shall also be followed.

2. Abbreviations

The following terminology shall apply at various places of this specification:

DMR:	Dedicated Metallic Return
DMRTB:	Dedicated Metallic Return Transfer Breaker
DPS:	Dynamic Performance Studies
ESCR:	Effective Short Circuit Ratio
FAT:	Factory Acceptance Tests
HMI:	Human Machine Interface
HVAC:	High Voltage Alternating Current
HVDC:	High Voltage Direct Current
HVRT:	High Voltage Ride Through
IBR:	Inverter Based Resources
Id:	Direct current (any defined value)
LCC:	Line Commutated Converter
LI/SI:	Lightning Impulse/Switching Impulse
LVRT:	Low Voltage Ride Through
MTDC:	Multi-terminal HVDC transmission system
MVU:	Multiple Valve Unit
NBS:	Neutral Bus Switch
NGBS:	Neutral Ground Bus Switch
PCC:	Point of Common Coupling

PMR:	Pole Metallic Return
PMRTB:	Pole Metallic Return Transfer Breaker
RPC:	Reactive Power Control
SAS:	Substation Automation System
SCADA:	Supervisory Control and Data Acquisition
SCR:	Short Circuit Ratio
SSTI:	Sub-synchronous Torsional Interaction
TSP:	Transmission Service Provider
Ud:	Direct voltage (any defined value)
VDCOL:	Voltage Dependent Current Order Limit

3. Definitions

Bipole: A pair of 2 poles which are connected to opposite polarities (positive and negative). For power transmission in one Bipole, two such pairs (consisting of 4 converters) are required.
Forward Power flow direction: Active power transmission from Barmer-II HVDC to South Kalamb HVDC.
Inverter: HVDC terminal which is receiving the power.
MVU (Multiple Valve Unit): An assembly of a number of valves mounted into a single structure (these include components mounted on the valve structure, e.g., saturable reactor, surge arrester) which may be considered part of the valve.

PCC (Point of Common Coupling): The connection point between the HVDC and the power system at which performance requirements are defined.
Rectifier: HVDC terminal which is sending the power.
Reverse Power flow direction: Active power transmission from South Kalamb HVDC to Barmer-II HVDC.
Thyristor level: 'Thyristor level' comprises a single thyristor, control, protection, monitoring, auxiliary power and voltage grading components which make up a single voltage level within the valve.
Valve: Complete operative controllable or non-controllable valve device assembly, normally conducting in only one direction (the forward direction), which can function as a converter arm in a converter bridge
Valve Module: 'valve module' is the smallest assembly, comprising a number of thyristor levels, voltage grading and damping components, valve reactors, etc. from which the valve is built up and which exhibits the same electrical properties as the complete valve, but only a portion of the full voltage capability of the valve.

4. Design Consideration

The salient technical features for HVDC terminals shall be as follows (Table 1):

Table 1

Sl. No.	Item Description	Parameters
1.	Rectifier station location (Forward direction power)	Barmer-II HVDC (Rajasthan) [If the power direction is reversed, Barmer-II will become inverter]
2.	Inverter station location (Forward direction power)	South Kalamb HVDC (Maharashtra) [If the power direction is reversed, South Kalamb will become rectifier]
3.	Rated DC voltage (1.0 pu)	±800 kV DC at Rectifier HVDC Pole Bus
4.	Rated power (1.0 pu)	6000 MW at Rectifier DC Bus
5.	Minimum DC Power	150 MW (Single pole operation)
6.	AC system frequency	Nominal 50 Hz
7.	Fault Current level AC system	63 kA for 1 sec for Barmer-II 63 kA for 1 sec for South Kalamb
8.	Minimum Short circuit level (MVA) at 400 kV Barmer-II (both rectifier and inverter operation)	35400 MVA (with IBR contribution) 29600 MVA (without IBR contribution)
9.	Minimum Short circuit level (MVA) at 400 kV South Kalamb (both rectifier and inverter operation)	15800 MVA *(on each 400 kV section where HVDC is terminating, considering sectionaliser in open condition)*
10.	Overload requirement	1.1 pu for 2 hours 1.2 pu for half hour

Sl. No.	Item Description	Parameters
		1.33 pu for 5 seconds
11.	Reverse power rating	100% of rated Forward direction power transfer rating[$] (with 1.33 pu overload for 5 second only)
12.	Reduced voltage	80% of rated DC voltage [Applicable for both power flow directions]
13.	Converter transformer	Single phase two winding design
14.	Thyristor valve	Water cooled
15.	Valve cooling system	Dry type design
16.	HVDC control system*	Main + hot standby
17.	HVDC protection system*	Duplicated Protection
18.	Auxiliary supply source	Supply sources tapped from 33 kV side of 2 Nos. of 400/220/33 kV transformer at Barmer-II and 33 kV tertiary of 2 Nos. 765/400/33 kV ICT at South Kalamb. Each auxiliary power shall be fetched from both separate sources of the 33 kV auxiliary supply in station. Additionally, one more 33 kV supply from independent source shall be arranged and connected to 33 kV Bus at both Barmer-II and South Kalamb Stations.
19.	DC Harmonic filter	Minimum One DC filter for each pole at each HVDC terminal station
20.	AC Network Impedance	Relevant CIGRE/IEC document shall be used for the Network harmonic impedance together with information in

Sl. No.	Item Description	Parameters
		PSSE network files provided by CTU.
21.	Negative sequence voltage (fundamental frequency)	1% for Design of equipment 1.5% for rating of equipment
22.	HVDC line online fault locator for pole lines	One No. per pole at each terminal station [when not integrated with Control & Protection System]
23.	HVDC paralleling and de-paralleling switch	As per Requirement
24.	Smoothing reactor on DC bus	As per requirement, but not less than 33% of total milli Henry (mH) required for each pole, shall be provided on DC pole bus
25.	Blocking filter	As per requirement
26.	Reliability and Availability Design Targets	As per Table 11
27.	Station Loss evaluation criteria	Methodology as per IEC 61803 and Target figures stated in Table 11
28.	System Grounding	Solidly grounded

*****TSP can provide integrated Control and Protection system as well, meeting functional requirements.

[$]The power reversal in HVDC links shall be possible from the maximum active power transmission capacity from Barmer-II HVDC to South Kalamb HVDC to the maximum active power transmission capacity from South Kalamb HVDC to Barmer-II HVDC within 60 minutes. HVDC System shall be capable of at least three Power reversals in every 24 hours.

The criteria for the design and control of the network shall be as follows:

- 400 kV AC bus voltages shall normally be within ±5.0% of nominal voltage (400 kV). Bus voltages outside this range may occur from time to time and

may exist for long periods due to abnormal loads and/or contingencies. Unless otherwise stated, all equipment shall be rated to operate safely for AC voltages between 360 kV- 440 kV at the converter stations.

- AC system frequency shall normally be within 48.5 Hz to 51 Hz and the HVDC system shall operate without any restrictions on power transfer. However, equipment shall be rated for 47.5 Hz to 52.5 Hz band.

- For calculating reactive power exchange and filter performance, the 400 kV AC voltage variations to be taken shall be from 380 kV to 420 kV and the frequency shall be from 49.0 Hz to 50.5 Hz. However, frequency range for AC/DC filter rating shall be 48.5 Hz to 51 Hz.

5. Environmental Data

The following environmental data shall be considered (Table-2):

Table 2

Sr. No.	System data	Barmer-II	South Kalamb
1	Max/min Ambient temperature (dry bulb one-hour average) Max dry bulb 24 hr average	50 deg C max 0 (Zero)deg C min 40 deg C	50 deg C max 0 (Zero) deg C min 40 deg C
2	Relative Humidity (%, max)	100	100
3	Average annual rainfall	As per rainfall map of IMD	As per rainfall map of IMD
4	Iso-keraunic level	As applicable	As applicable
5	Wind Zone	As per National Building Code 2016	As per National Building Code 2016
6	Seismic Level	As per Seismic zone of the site	As per Seismic zone of the site
7	Altitude above sea level	<1000 m	<1000 m
8	Pollution level (IEC 60815)	Heavy	Heavy

6. System Performance

The HVDC system shall be designed to meet all performance requirements and shall be compatible to existing system. The HVDC system shall not cause instability to the AC existing Network. Also, it shall not cause adverse effects to other HVDC system in vicinity, RE based generation plants (near Barmer-II) as well as RE Generating Units at Barmer-II PS. This shall be verified by stability, multi-infeed and Sub Synchronous Resonance (SSR) studies and any other Study required, if applicable. Steady State, dynamic, HVRT, LVRT, Harmonic and flicker performance requirements as per applicable Rule/Regulations/Standards/Guidelines as per TSA shall be applicable.

The rated power transmission capacity shall be defined and guaranteed at Rectifier DC Bus and rated transmission voltage shall be defined at the rectifier DC bus. In the calculation of the power transmission capability, the most unfavorable combination of control and measurement tolerances shall be considered without redundant cooling and thyristors. All components of the transmission system shall be rated to meet the requirements given in this section and other requirements specified elsewhere under these Specifications.

HVDC system performance and rating requirements for high voltage equipment and other critical equipment shall be determined taking into account the extreme values of environmental and AC and DC system parameters as applicable for performance/ rating requirements given under these Specifications and manufacturing and measuring tolerances.

7. Overload Requirements

Table 3

Rectifier DC bus Barmer-II for Bipole	Duration	Redundant cooling	Converter bus voltage
1.1 pu	2 hours	Available	380 kV - 420 kV
1.2 pu	0.5 hour	Available	380 kV - 420 kV
1.33 pu	5 seconds	Not available	380 kV - 420 kV

These overloads would be available for bipole mode of operation in forward power direction. For monopolar mode of operation or unbalanced mode of

operation the available power rating shall be at least 1.1 p.u. per converter (for 1.1 p.u. overload) and 1.2 p.u. per converter (for 1.2 p.u. overload) for the duration specified in Table-3.

(a) Two Hour Over Load

The HVDC system shall be capable of operating for two hours at transmitted power levels at least 10% (ten percent) higher than the maximum continuous ratings for the specified nominal system conditions and environmental conditions;

If the AC bus voltage at Rectifier or Inverter is below 380 kV, the overload transmitted power capability may be progressively reduced to maintain the direct current at the maximum value obtained with the AC bus voltage at 380 kV.

It shall be permissible to apply the two-hour overload power at least once in every 12 hours period. The overload capability may be for an extended duration upto a maximum of twelve hours, in one or more intervals, in which case the product of power and time shall not exceed (i) 6600 MW-Hrs for each Bipole and (ii) 13200 MW-Hrs for both Bipoles in a 12-hour period and with the maximum limit of power maintained at 1.1 pu in every converter.

(b) Half an Hour Overload

The HVDC system shall be capable of operating for half an hour at transmitted power levels of at least 20% (twenty percent) higher than the maximum continuous ratings and immediately following the five seconds overload conditions.

(c) Five Seconds Overload

The HVDC system shall be capable of operating at least for five seconds at transmitted power levels 33% greater than the maximum continuous ratings and at specified nominal system and environmental condition. It shall be assumed that the AC bus voltages do not change when this overload is applied.

The five second overload rating shall be achieved without tap changer operation, and the pole voltage may be reduced during the period of this overload.

It shall be permissible to apply the five second overload power once in any five-minute period. This five second overload shall also be permitted during operation at the two-hour overload rating with redundant coolers and heat exchangers available for service. Power greater than the two-hour overload shall form the start of five second overload period.

(d) It may be noted that 1.2 p.u. and 1.1 p.u. overload ratings are for power compensation following loss of a healthy converter as well as for transmission of excess power during peak generation with all converters in service, up to 1.1 p.u. (i.e. 6600 MW) and 1.2 p.u. (i.e. 7200 MW). However, the purpose of

33% overload is for system stability, power modulation and dynamic ride through of the system as a whole and can be initiated with the initial system conditions of 1.0 p.u. normal load operation or 1.1 p.u. or 1.2 p.u.overload Operation.

(e) For calculations, maximum line resistance shall be taken at a maximum conductor temperature of 85 ^{o}C with minimum wind velocity and maximum solar radiation while for minimum line resistance the conductor temperature shall be taken as 0 ^{o}C.

8. DC Voltage:

The nominal direct voltage at the Rectifier converter station DC line terminal shall be ± 800 kV relative to neutral. This voltage shall be maintained within ± 20 kV by tap changer and Firing angle control for all power flows (i.e. minimum to overload [1.2 p.u. power rating]) with balanced current between the poles/converters for all AC bus bar voltages between 380 kV and 420 kV and for all AC system frequencies between 49.0 Hz and 50.5 Hz.

In any monopolar operation, or three converter operation (unbalance operation of one Bipole in parallel with a monopole) the Pole Voltage to Ground may be decreased by equivalent Voltage drop in DMR line.

In the event that the AC system voltage is below 380 kV down to 360 kV, the DC line voltage may be correspondingly reduced.

If the AC system voltage at Rectifier or Inverter is above 420 kV but not exceeding 440 kV, the DC line voltage to ground may be increased but shall not exceed 820 kV at Rectifier. Higher than normal firing angles can be utilized to restrict the DC line voltage under these conditions and the equipment should be adequately rated.

The above references to DC pole voltages shall be interpreted as extremes and shall not be exceeded due to measurement error, tap changer control dead band, tolerances in the manufacture or in the control system, or for any other reason.

9. Reduced DC Line Voltage

The HVDC system shall be capable of operating continuously at a nominal pole voltage of 640 kV relative to neutral at rectifier DC bus in bipolar as well as in monopole modes. Rectifier station shall be capable of transmitting not less than 4800 MW in bipolar link and 2400 MW in each Bipole. Redundant cooling may be in service. The pole voltage shall be within 20 kV of the above provided that the AC bus voltage is below 400 kV.

It shall also be possible to set DC voltage reference between 640 kV to 800 kV in either pole in the steps of 10 kV by the operator action.

Power levels in this voltage range shall be as permitted by the main circuit rating of the equipment. However, reduced voltage attempt by DC line protection shall directly first achieve 640 kV. The reduced voltage may be achieved by a combination of tap changer and firing angle control. Reduced

voltage operation shall be possible to be ordered by operator from either station even with telecom out of service. The change from normal to reduced voltage operation and vice versa shall not require a valve group shutdown or reduction in power below that achievable with the reduced voltage. It shall be possible to start the transmission in reduced voltage mode.

10. Converters Operating modes

The HVDC equipment at both Converter Stations shall be designed and rated to operate with different DC power orders. Necessary facilities shall be provided to permit these modes of operation and to allow the individual Pole power and/or current orders and/or voltage to be set as per below.

Each Pole/Bipole shall be capable of transmitting power including overloads and for the system short circuit levels specified in this specification. The minimum operating modes are as follows:

(a) Balanced/ unbalanced bipolar operation
(b) Monopolar operation with Pole Metallic Return (PMR)
(c) Monopolar operation with Dedicated Metallic Return (DMR) [DMR1 or DMR2 or DMR1 parallel to DMR 2] mode or DMR [DMR1 or DMR2 or DMR1 parallel to DMR 2] in parallel with PMR
(d) Three converter operation at each HVDC terminal end: These 3 converters could be any 3 out of 4 converters at terminal station.
(e) Any converter of one polarity at one HVDC terminal can operate with any converter of same polarity at the other end (upto the overload capacity of converters)

All above operating modes shall also be available for reverse power and reduced voltage operation.

11. System Studies

The TSP shall be responsible for overall system engineering and detailed design of all elements, systems, facilities and equipment. The TSP shall have to carry out following studies for this purpose for both directions of power flow. The TSP may note that the following list is only indicative and if any other studies, calculations etc. are required the same shall have to be done by TSP.

(a) Main circuit parameters

(b) Transient Current Requirement and Short circuit studies

(c) Thermal Rating Study for Key Equipment

(d) Studies for Overvoltage Protection and Insulation co-ordination for AC and DC systems

(e) AC, DC Harmonics and Power Line Carrier (PLC)/Radio Interference (RI) filter design, rating and performance;

(f) Temporary overvoltage (Fundamental Frequency Temporary Over Voltage-FFTOV) and Ferro Resonance Overvoltage Studies;

(g) AC and DC Transient overvoltage Study, surge arrester stress;

(h) Runback and run up studies;

(i) AC breaker Transient Recovery Voltage (TRV) and rate of rise of recovery voltage (RRRV) studies;

(j) DC High Speed Switch Requirement Study

(k) Overload study;

(l) AC equivalent study;

The equivalents to be prepared for peak load, light load and extremely weak (minimum SCR) network scenarios. The dynamic network equivalent shall be prepared with full machine models having exciters, governor- turbine, generators, stabilizer models instead of voltage source models, upto a minimum of two buses away. These dynamic equivalent networks shall be used in PSCAD DPS, Real Time Digital Simulator (RTDS) DPS, with actual control & Protection panels.

(m) DC Commutation switch requirements;

(n) Load flow, stability, modulation and frequency controller design study;

(o) Electrical interference study (RI and PLC);

(p) Reliability and availability study;

(q) Audible noise study;

(r) Loss calculations/study

(s) Studies for deciding the operational logic & sequences considering Dedicated Metallic Return Conductor (DMR) operation and Metallic return with pole conductor, in case of monopolar Operation

(t) Impact of parallel AC lines

(u) Real Time Simulator-based studies for testing of actual HVDC Controls (Factory Acceptance Test or Factory System Test)

(v) AC/DC system interaction studies.

(w) Interaction studies between this LCC HVDC and other HVDC stations, STATCOMs which are electrically coupled nearby and other nearby Inverter Based Resources (IBR) & Inverter Based Load

(x) Studies to determine the requirements for communication between the

converter stations and remote Load Despatch Centres (LDCs).

(y) Studies for designing the Equipment for Dedicated Metallic Return Conductor (DMR) operation and metallic return with pole conductor, in case of monopolar operation up to rated power (including overload).

(z) Sub synchronous Resonance & Self Excitation Studies

These studies are to demonstrate that the HVDC system does not excite the torsional modes of oscillations and self-excitation of the generators and Sub- synchronous Resonance in thermal/gas turbine generators near Converter Stations under all defined system operating conditions. The study shall demonstrate that the HVDC system has positive damping for all sub synchronous torsional modes of the generators.

(aa) Studies of DC Current flowing through Windings of Converter Transformers

(bb) AC line and other bays protection co-ordination studies.

(cc) DC over voltage studies

(dd) Station earthing

(ee) LVRT, HVRT, harmonic resonance and other dynamic studies

(ff) Studies for the Control, Protection and Communication Systems

The study reports shall include the following study results:

(i) Dynamic Performance Study including the RE Resources near Converter Stations.

(ii) Hierarchical Structure of the Control and Protection

(iii) Redundancy of the Control and Protection Systems

(iv) DC Power and Current Control Modes and Features

(v) Switching Sequences and interlocking

(vi) AC & DC System Protections

For each protection, the report shall include the following:

a) Purpose of the protection

b) Principle of protection operation

c) Required accuracy of measuring signals

d) Fault detection and coordination between the DC controls and the protection and AC protection.

e) Consequences of protection operation, such as DC control and sequence control initiated at both converter stations

f) Redundancy of protection and operation of backup protection

g) Detailed calculations of the protection settings together with limiting fault cases and/or criteria that determines these settings.

h) Description of the applicable protection in case of loss of telecommunication.

(vii) Reactive Power Control

The study shall include at least the following:

a) Reactive power control principles for converter operation during steady state and transient conditions

b) Reference variable control criteria

c) Criteria for switching of reactive power sub banks

d) Operator operation, including control and monitoring features

e) Equipment description, emphasizing reliability/availability and maintenance features

f) Validity checking of signals

g) Switchover and control feature between AC voltage/reactive power controls

(viii) Telecommunication Interface Requirements

(ix) Station Control and SCADA System

(x) Control for Converter Transformer Tap changer

(xi) Additional Control Study

The report, as applicable shall include the studies of the following control modes with the AC network condition of Barmer-II and South Kalamb and actual performance of converter equipment and possible fault condition being taken into account,:

a) Power ramp down

b) Power ramp up

c) Damping of sub-synchronous oscillations

d) Abnormal AC voltage and frequency control

e) Supplementary modulation signals

(xii) Multi Infeed Interaction Study with nearby HVDC System

(xiii) Commutation failure performance study

Impact of the commutation failure & cascading commutation failure (if expected) on the inverter based resources (IBR) & associated AC network shall also be included in this study.

(gg) Any other studies as deemed necessary by TSP

The load flow and dynamic file shall be provided to the TSP in PSS/E 34 or newer version format. This will include maximum and minimum fault contribution from conventional generation and IBRs considering full power, reduced DC voltage power and other network scenarios which can lead to the highest possible dynamic overvoltage variations. Necessary Generic Models for IBRs or modelling assumptions shall also be provided for studies requiring the same. Conventional generator, lumped mass model and controller models in vicinity shall also be provided. For sharing User Defined Models (UDMs) TSP and Solution Providers will be required to abide with the statutory requirements of the UDM provider if required.

In case of absence of detailed models of nearby inverters, the harmonic distortions shall be considered as per the relevant CEA Regulations. The impedance of RE Park at the Pooling station PCC will be provided to the TSP. The rest of the network may be modelled by the harmonic impedance and the rating and performance studies shall be done accordingly. Harmonic impedance shall take into account all contingencies in base file, N-1, N-2 and other PSS/E scenarios for network for full power and reduced DC power.

PSS/E files are provided based on the data available at the time of issuance of RfP. TSP is required to validate the data before carrying out simulation. However, clarification, if any, may be sought before the bid submission. CEA/CTU shall endeavour to give clarification to the extent possible. In case of any discrepancy observed/non-availability of data for any of the machines and other control devices, typical values may be used in the studies with the intimation to CEA/CTU.

12. Digital Models

TSP shall provide to the CTU the following models of all supplied circuit components and control and protection of the HVDC Systems. The models shall be up to date with all the design features implemented in the Project.

(a) PSCAD
(b) PSS/E

TSP shall provide both UDM and Generic model for RMS based stability model (in PSS/E V36 or above) and EMT (PSCAD v5 and above). All appropriate control features shall be modelled in the above models and necessary documentation on the theory and use of model should be provided. Further, a generic model, benchmarked to the extent possible to the UDM PSS/E and PSCAD model, shall also be furnished. 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)

Data sharing requirements as per Procedure for First Time Charging/Energization (FTC) and Integration of New or Modified Power System Element of Grid Controller of India Ltd. (GRID-INDIA) shall also be done by the TSP. All the requisite data/reports/models including User defined models/documents as required as per the CEA/CTU/Grid India Standards/ Guidelines shall be provided by the TSP.

Data sharing format will be subject to the agreement or other statutory requirements mandated by HVDC OEMs, if required.

13. DC power circuit switching requirement:

The TSP shall provide all DC switching devices as per the requirements of this Specification to enable the smooth and efficient operation of the HVDC system.

All disconnectors or isolators which are used to provide isolation for maintenance on any equipment shall have visible breaks. If a visible break is not inherent then an additional separate isolator having a visible break shall be provided.

The equipment arrangement shall be designed to ensure that no single contingency, fault or loss of any piece of equipment can cause or result in a bipolar shutdown or transient reduction in power transfer to less than the rating of one Pole.

High speed switches (paralleling & de-paralleling switches) for converters shall be provided with disconnectors on both sides.

The station layout shall provide safe access to all equipment for service and maintenance. The DC power circuit arrangement shall provide at least the following functions:

(a) Isolating and grounding Converter Station Pole for maintenance.

(b) Isolating and grounding either or both DC transmission line Poles for maintenance.

(c) Isolating and grounding the DMR conductor at the Converter Station for maintenance when operating in bipolar mode with balanced DC currents. All primary equipment, control, protection and measuring equipment necessary to achieve this function shall be provided. All the studies and design engineering necessary for the HVDC System to operate in such modes shall be performed.

(d) Clearing of a Pole for maintenance without affecting the power flow on the other Pole.

(e) Switching from DMR to "DMR in parallel with PMR" mode of operation during monopolar operation and back.

(f) Grounding of the neutral bus through a high-speed switch (NBGS) during bipolar operation balanced current mode.

(g) Clearing neutral bus fault on one Pole.

14. Insulation co-ordination

(a) HVDC System shall be suitably protected against Impulses and disturbances external and internal to the system such as switching impulses, lighting impulses, steep front impulses, dynamic over voltages and load rejection (1.2 pu power). The insulation of all equipment shall be properly protected and coordinated with surge arresters and/or surge capacitors. Insulation coordination shall be done keeping in mind the minimum electrical clearances, safety clearances and maintenance clearances as per Switching Impulse Withstand Level (SIWL). Insulation coordination shall be done as per relevant IS/IEC Standards.

(b) The insulation of the equipment and protection levels of Surge Arresters connected to the converter AC bus bars of the converter stations at both rectifiers and inverter shall be coordinated with the insulation and surge arrester characteristics of the connected AC systems to which the converter stations are to be connected without exceeding the discharge duty of these arresters so as not to overload these existing arresters of the network. Only 336 kV surge arrester (rated voltage) shall be used on AC incoming 400 kV line side.

(c) The tripping action on Over Voltage for lines shall be as per the Regional Over Voltage Protection Philosophy specified by the RPC. In general or the default tripping action should initiate if the fundamental frequency over voltage exceeds 1.1 p.u. for 10 seconds and if 1.5 p.u. fundamental frequency voltage persists for more than 100 milliseconds. The HVDC over voltage strategy shall be coordinated with such setting.

(d) The minimum insulation levels for 800 kV DC to ground shall be as follows:

Table 4

HV Transformer LIWL/SIWL (kV)	Smoothing reactor LIWL/SIWL (kV)	Thyristor Valve Structure LIWL/SIWL (kV)	DC Busbar LIWL/SIWL (kV)
1800/1600	1800/1600	1800/1600	1900/1600

LIWL- Lightning Impulse Withstand Voltage;

SIWL- Switching Impulse Withstand Voltage

(e) The ratio of **impulse withstand voltage** to impulse protective level shall be in line with Table 3 of IEC-60071-11.

(f) The TSP shall carryout insulation coordination studies for the Project. The TSP shall perform all necessary HVDC digital simulator studies and shall keep detailed report(s) on insulation coordination in its record. The TSP shall carry out insulation coordination studies for rating of all arresters supplied for the project, establishing the required insulation level for supplied equipment and the clearances between energized parts and between energized parts and ground. The arrester arrangement and protective levels shall be selected such that, generally, the overvoltages on the AC side are protected by arresters on the AC side, and overvoltages on the DC side are adequately limited by an arrangement of arresters on the DC side. Critical components of the supplied converter equipment shall be directly protected by arresters connected closest to them. The arresters installed shall be rated such that these arresters are not overstressed for all operating modes and configurations. The studies must show that any existing 420 kV equipment including any existing surge arrestors will not be overstressed for all modes of operation and configurations of either Converter Station when HVDC station is extension of an existing AC station.

The report(s) shall detail the characteristics of the surge arresters,

energy ratings and shall demonstrate that the selected insulation protective and withstand levels, discharge and coordinating currents, and arrester ratings and discharge capabilities are adequately coordinated and comply with the requirements of this Specification. It shall also detail all insulation and air clearances and leakage distances and shall justify the selected values based on the present Specifications. The report(s) shall include all assumptions made for the study parameters and describe the types of events modeled (i.e. AC and DC faults, valve hall faults, converter valve or control mis-operations, etc.) and identify the decisive cases that establish the insulation design.

(g) **Temporary Overvoltages**

The converter valves shall be capable of continuing to operate under the temporary overvoltage conditions specified below, which could occur with the valves deblocked and also that the valves are capable of deblocking under the highest temporary over voltage conditions within 5 (five) cycles of the initiation of a fault or disturbance. Equipment shall be designed for the applicable short circuit ratio and overvoltage arising thereby.

Temporary Overvoltage caused by Bipole link HVDC transmission shall be controlled to 1.54 pu or below. Events caused by other equipment in the AC network shall be controlled within the limits of the capability of the deblocked converter. In case the converter is tripped, and not possible to restart within seconds, filter tripping shall be allowed to limit overvoltages.

The actual temporary over voltage shall be determined by the TSP but equipment shall be designed for temporary over voltage not less than the values given above. In addition, so as to prevent operation and overstressing of the arresters, the TSP shall limit the temporary over voltages including harmonic, resonant, and ferro-resonant effects on the 400 kV AC bus bars so that:

- 705 kV crest phase to ground is not exceeded by more than 3 peaks;
- 565 kV crest phase to ground is not exceeded by more than 10 cycles;
- 510 kV crest phase to ground is not exceeded by more than 20 cycles.

In the calculation of temporary over voltages on the AC side the TSP shall allow for blocking of the complete Bipole(s) from up to the highest

steady state transmission capability of the installation. On the DC side the TSP shall allow for the maximum load rejection which could occur and which leaves converter deblocked.

The converter Equipment shall be designed to withstand temporary over voltages corresponding to AC Side which are not less than 1.5 times 400 kV at converter stations with the converter blocked.

The TSP shall provide and commission all equipment necessary to limit the temporary 50 Hz overvoltage on the AC bus bars to the levels specified above. The actual temporary overvoltage shall be determined by the TSP but AC equipment shall be designed for temporary overvoltage not less than the values given above.

The connected AC harmonic filter shall be assumed to be that with the highest MVAr applicable to the mode of operation which does not exceed the maximum reactive power exchange with the AC system as specified in this specification.

The converter equipment shall be rated for continued operation under the maximum over voltage conditions to be defined by the TSP taking into consideration the dynamic over voltage profiles as determined by the design studies to be performed by the TSP. Irrespective of the over voltage profile derived by the TSP, the equipment shall be rated to withstand an over voltage according to above figures following deblocking.

DC withstand voltage design of equipment shall take due consideration of the temporary voltage stresses that the respective equipment may be exposed to based on studies of different disturbances as applicable.

Any switching equipment within the scope of supply of the TSP which may be called upon to operate at this voltage in either a main or backup role shall have the appropriate capability

HVRT Strategy:

The HVDC Station shall enter into HVRT mode (exit from continuous operating region) when the Voltage at AC bus i.e. 400 kV side (RMS) is above 1.1 p.u. due to faults/control actions/or any other cause.

The HVDC Station shall remain connected to the grid when voltage at the inter-connection point (AC bus), on any or all phases (symmetrical or asymmetrical overvoltage conditions) rises above the specified values

given below for specified time:

Table 5

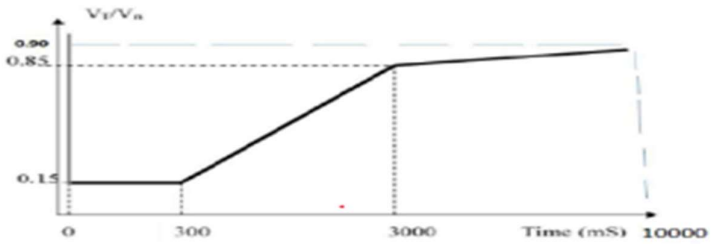
Over voltage (pu#)	**Minimum time to remain connected at POI**
V > 1.50	Instantaneous trip
1.50 ≥ V > 1.30	100 ms
1.30 ≥ V > 1.10	10 sec
V ≤ 1.10	Continuous

1 pu = 400 kV (3 phase RMS voltage at POI)

LVRT Strategy:

The HVDC Station shall enter into LVRT mode (exit from the continuous operating region) when the Voltage at AC bus i.e. 400 kV side (RMS) is below 0.9 p.u. due to faults/control actions/or any other cause.

The HVDC Station must remain connected to the grid when voltage at the interconnection point (AC bus), on any one, two or all phases (symmetrical or asymmetrical overvoltage conditions) dips up to the level depicted by the thick lines in the following curve:



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1 p.u. = 400 kV (3 phase RMS voltage at POI)

During LVRT mode, HVDC Station shall withstand all above low voltage conditions. Restoration of voltage shall be said to be achieved

when the voltage at PoI settles within +5% of pre fault voltage.

(h) **Transient overvoltages**

In the calculation of transient over voltages the TSP shall consider at least:

(i) Lightning surges propagating down the AC and DC overhead lines, including direct strike to line conductors and back flashover;

(ii) Lightning surges due to direct strike within the converter station in the event of shielding failure;

(iii) Steep fronted waves resulting from flashovers or faults, including those within the valve hall and to ground from the valve windings of the converter transformers;

(iv) over voltages due to switching of converter transformers, AC filters and shunt capacitors, shunt reactors, 765 kV and 400 kV transmission lines, 765 kV and 400 kV class transformers or other equipment;

(v) For re-closure of AC filters and capacitor banks, residual voltage on the capacitors shall be considered.

(vi) The saturation effects of converter transformer due to presence of remnant flux shall also be considered.

(vii) Application and clearing of single phase and three-phase to ground faults which may be cleared by AC circuit breakers; Possibilities of breaker re-strikes shall also be considered although the breaker should be designed as restrike free.

(viii) Faults within converter equipment, including control and telecommunication malfunctions;

(ix) Over-voltages due to blocking of 6 pulse or 12 pulse valve groups with and without bypass pair firing;

(x) Over-voltages due to DC and DMR line resonance.

(xi) Uneven distribution of over-voltages, particularly within the converter valves;

(xii) Commutation overshoot, particularly when operating at higher than normal firing or extinction angles coupled with dynamic over voltage conditions;

(xiii) Arrester location relative to protected equipment and arrester characteristics.

(xiv) For determination of maximum transient over voltages at

converter bus with a sequence of clearance of three phase /single phase AC bus fault along with blocking of one pole running at overload with appropriate AC filters remaining connected and subsequent protection actions.

(xv) Continuous commutation failure at the inverter and rectifier valve misfire.

(xvi) Earth faults and short circuits within the valve halls and on DC filter bus.

(i) **Limitation of Overvoltage**

Blocking of the converter valves to protect them and other DC side equipment from sustained over voltages appearing on the AC system shall not be permitted. The use of converter valve group controls to limit temporary (dynamic) over voltages shall be permitted provided that the valves and other converter equipment are adequately rated.

(j) **Determination of Overvoltage**

The TSP shall determine the highest transient and temporary over voltages, which can occur with the equipment parameters selected and with the AC system and DC line as defined in this Specification.

(k) **Arrester Protective Levels**

The transient overvoltages imposed across insulation shall be limited by surge arresters. Dynamic over voltages may also be limited by surge arresters but only if the arresters are adequately rated for such duty.

The discharge current (coordinating current) shall be determined by the TSP appropriate to the arrester location and line & equipment parameters. For arresters connected to the 400 kV AC bus bars, the 8/20 microsecond wave coordinating discharge current shall be 10 kA, 15 kA or 20 kA as appropriate. Where multicolumn arresters are used or where arresters in separate housings are connected in parallel, unequal sharing of the discharge current shall be considered.

The TSP shall design the converter equipment to withstand a maximum continuous AC system voltage of 440 kV. The calculations for determination of arrester energy requirement shall be based on a maximum pre-fault voltage of 440 kV.

(l) **Lightning shield**

The TSP is responsible for the design of the lightning shield. The system shall also be designed to provide "effective shielding" to ensure that almost no insulation flashover can result from atmospheric discharges striking the overhead shielding.

Effective and adequate lightning protection shall be provided to protect all converter equipment including wall bushings and the Converter Station buildings from damage due to atmospheric discharges and shall ensure that any lightning strikes shall not cause flashover or mal-operation of any equipment which can affect the power transmission capability of the Converter Station.

15. Radio Interference (RI), Acoustic Noise (AN) and DC field

(a) All the necessary precautions shall be made during HVDC design to ensure that there shall be no mal-operation, damage or danger to any equipment, system or personnel due to electromagnetic or electrostatic interference effects. The converter terminal(s) shall neither damage nor cause mal-operation of the DC control and protection system or the DC tele-control system.

(b) All the necessary precautions shall be taken in the form of noise suppression techniques, shielding and filtering devices to prevent harmful interference, which may be generated by the converter terminals, with the Power Line Carrier (PLC) systems, Radio communication systems, Television systems, VHF, UHF & microwave radio systems.

(c) The audible noise shall be limited to the following values for various areas of the converter station and buildings. It is to be demonstrated by calculation and site measurement that the specified sound pressure levels are not be exceeded.

Table 6

Valve hall (in places where long term access is required during normal operation) Mechanical equipment indoor areas requiring long term access (measured at 2 meter distance)	90 dBA
Equipment in outdoor areas (measured at 15 meter distance) except converter	75 dBA

transformers	
Office area*	45 dBA
Control rooms*	45 dBA
Diesel generator (Operating area)	75 dBA
Compressor areas (measured at 2 meter distance)	90 dBA
At the station boundary (Outside wall or fence)	70 dBA

* *"Background" noise from the ventilation system.*

(d) For area with permanent access, the total calculated electric field at ground level shall not exceed 20 kV/m excluding space charge in the DC outdoor yard. For area with permanent access in DC outdoor yard, calculated Ion current density shall be less than 20 nA/m^2 at ground level.

(e) Radio Interference (RI)

The TSP shall take the necessary precautions in the form of valve hall and building shielding to meet his own requirements plus the following:

(i) With the Bipole operating at any of the specified operating modes and power levels and within the design range of firing angles, the Radio Interference Level (RIL) from electromagnetic radiation generated by the converter shall not exceed 100 micro volt/m under fair weather conditions at any point outside station fence which are:

500 meters or more from the nearest bus connecting the valve to the converter transformers within the station.

And

at a lateral distance of 30 m for the conductors of any outgoing AC line, HVDC line and electrode line.

This RIL criterion shall be achieved at all frequencies within the range of 150 kHz to 300 MHz.

(ii) The valve hall design shall incorporate the screening requirements. The use of a mesh screen external to the building,

covering all or part of the switchyard shall not be permitted.

(iii) The shielding shall be designed so that the specified radio interference levels shall not be exceeded assuming any earth resistivity between 10 and 1000 ohm-meter.

(iv) Maximum radio interference voltage for frequency between 0.5 MHz to 2 MHz at 1.1 times of maximum DC voltage for 800 kV DC system, 266 kV RMS for 400 kV system and 156 kV RMS for 220 kV system and 92 kV RMS for 132 kV system shall be 2500, 1000, 1000 and 500 micro-Volt respectively.

(f) Television Interference (TVI)

The Television Interference Level (TVIL) shall not exceed 10 micro volts/m at the locations/contour line specified above.

(g) Interference with Power-Line Carrier Systems

The TSP shall take the necessary precautions in the form of noise suppression techniques and filtering devices to prevent harmful interference from the converter stations to Power Line Carrier (PLC) systems operating on the HVAC transmission line networks connected to each station and also to other power line carrier systems located adjacent to the HVDC bipolar line such that PLC systems shall operate reliably in fair weather conditions. The frequency spectra to be protected for PLC system is 40 kHz to 500 kHz.

16. Dynamic Performance

(a) The purpose of dynamic performance design is to determine the control parameters for HVDC system and to ensure that the HVDC system shall have smooth, stable and fast operation for both steady state and transient conditions without adversely affecting the connected AC grid.

The principal objectives of the design shall include:

(i) Optimal response of HVDC controls following step change in ordered parameters like DC current, DC voltage, power, etc.
(ii) Stable operation of the DC system following major disturbances.
(iii) Stabilization of the AC system following major disturbances.
(iv) Control of temporary over-voltages and avoidance of self-excitation of the generators.
(v) Control of frequency following quasi-static (slow) and fast changes in AC system load / generation at the rectifiers and/ or inverter ends.
(vi) Control of power levels depending on the system configuration.

Such a control may require AC line load control (ACLLC) and Run Back control features.

(b) The HVDC system shall recover to 90% of the pre-fault DC power transfer level consistently within 120 ms from the instant of fault clearing, without subsequent commutation failure or sustained oscillation for all inverter AC system fault conditions. For all rectifiers AC system fault conditions, the recovery time, to 90% pre-fault power level, shall be within 100 ms from the instant of fault clearing. The TSP shall verify that such response time does not give rise for any risk of AC system instability in any system configuration. If it is in the interest of the overall improved recovery of the AC/ DC system, in such cases the recovery times other than those specified shall also be acceptable, subject to review.

(c) HVDC should continue operation at reduced power if conditions get outside the voltage, frequency and short circuit capacity ranges specified in system data as much as possible with its inherent capability.

(d) HVDC terminal Characteristic and Step responses: The control behavior at rectifier and inverter end for a typical HVDC Pole should broadly follow the following characteristics. It may be noted that minor justified variation from the below characteristics due to Parallel operation of Bipoles depending in the Control Strategy shall be acceptable.

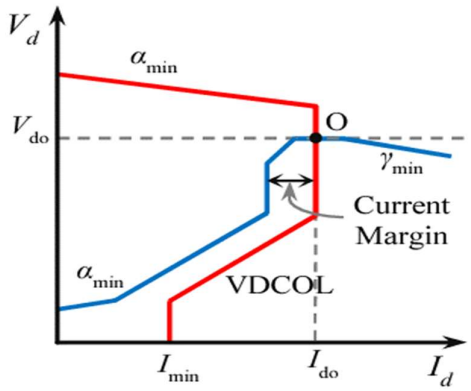
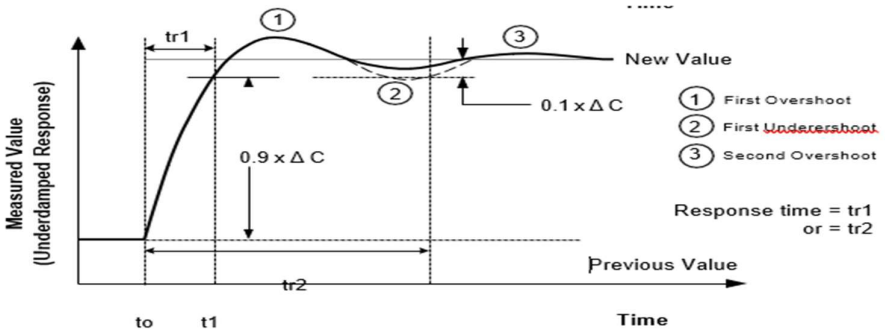


Fig-1- Current margin between rectifier and inverter

The response time (tr1) is defined as the time from the initiation of the order change to the time when 90% of the ordered change has been accomplished, subject to the condition that the measured value remains at the new order within a tolerance of +10% of the ordered change at rectifiers DC terminal after the first overshoot. If the measured value exceeds the tolerance of +10% of the ordered change after the first overshoot, then the response time (tr2) shall be defined to be the interval from the initiation of the order change to the time when the measured value returns to and thereafter remains at the new order within a tolerance of +10% of the ordered change. The first overshoot shall not exceed 30% of the ordered change and the measured value shall settle at the new order within a tolerance of +2% by the second overshoot. For an over damped system, the response times (tr3) is defined as the time from initiation of the order change to the time when 90% of the ordered change has been accomplished. The measured value shall settle at the new order within a tolerance of +2% by four times tr3. Step response to changes in power (current) order shall be executed in the following manner:
When the ordered change is *positive*:



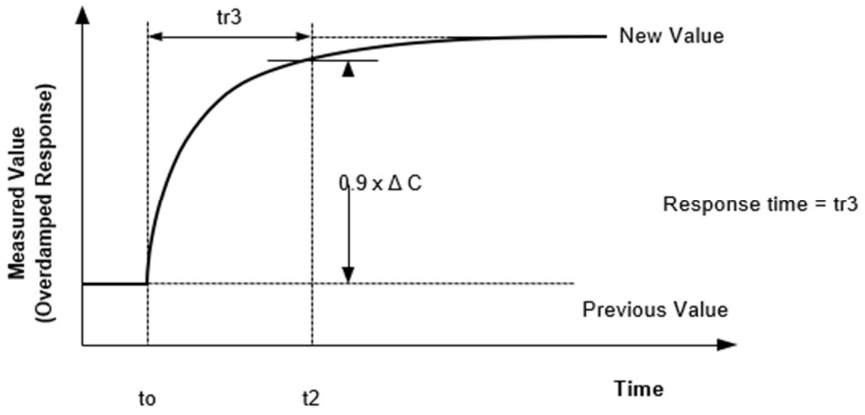
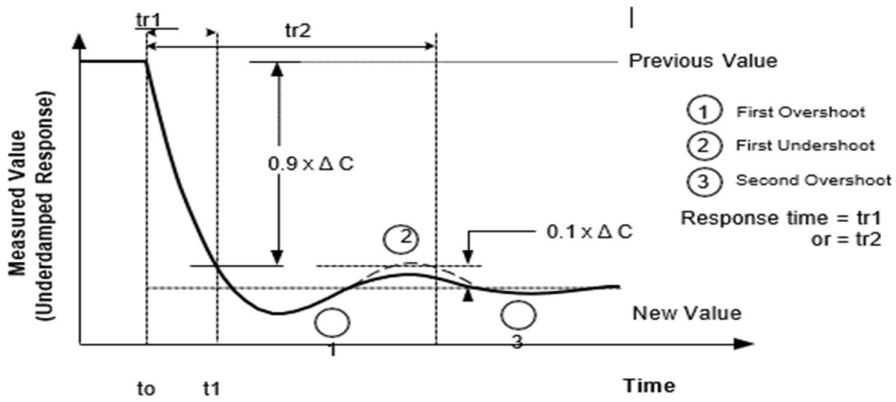


Fig 2- Definition of response to positive step change

When the ordered change is *negative*:



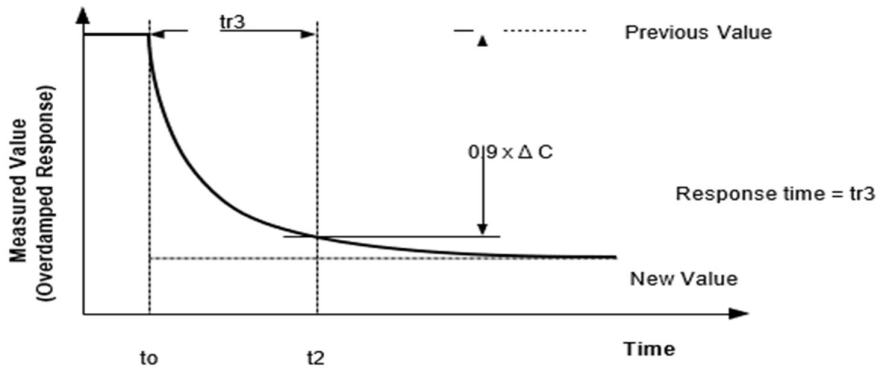


Fig 3- *Definition of response to negative step change*

(e) Power Order Step Response

The HVDC controls, when in power control mode or any other mode where the DC power transfer is controlled, shall respond to maintain the power transfer of the Poles at the ordered or desired level at any power level between minimum and the 30 minutes overload rating of the HVDC system.

When operating at any power order between the minimum and rated power transfer, the DC power controller shall respond to either a step increase or a step decrease in DC power order such that 90% of the ordered change is achieved within 150 milliseconds of the power order change at the rectifier. The TSP shall verify that such response time does not give rise for any risk of AC system instability in any system configuration. If it is in the interest of the overall improved recovery of the AC/ DC system, in such cases the recovery times other than those specified above shall also be acceptable.

(f) Response to AC Bus Voltage Change

The TSP shall demonstrate the response of the power controls to sudden changes in AC bus voltages of -5.0% to + 2.0% from its nominal value and ensure that it is stable.

(g) Power Voltage Instability

HVDC links operating in constant DC power control and weak AC system conditions can lead to power voltage instability under certain disturbances. To prevent such power voltage instability, the TSP shall

provide control measures to prevent AC system collapse during AC system disturbance due to the action of the HVDC control. The TSP may adopt a power reduction or a dynamic gain supervision function in the control system to avoid such instability if the short circuit MVA changes during a particular power transmission level.

17. Main Circuit Design

The purpose of Main Circuit design is mainly to determine the operating characteristics and rating of thyristor valves and converter transformers (MVA, tap changer range etc.). It also forms the input for AC Filter and Reactive compensation design. The main circuit arrangement and circuit shall depend on type of HVDC system, Power Transmission requirements, DC Voltage Levels, connected AC voltage levels, Reactive Power requirements and AC & DC Harmonic requirements. The system shall meet various harmonic performance parameters, as specified elsewhere in this specification, on both AC Side and DC side. This requirement along with those given in Table-2, shall be met simultaneously by the AC/DC filters.

18. HVDC Station Equipment

The function blocks of converter station are Converter area (converter valves, converter transformer, smoothing reactor), DC yard (DC filters, DCCT, DC Voltage Divider, PLC filters of DC side, DC pole arresters, Disconnectors and ground switches), AC filter yard, AC yard and auxiliaries. A typical LCC based HVDC station shall consist of the following main equipment:

(a) Thyristor valves and its accessories e.g. damping and grading circuits, converter cooling system, etc.;
(b) Converter transformers;
(c) Smoothing reactors;
(d) DC filters;
(e) AC filters (Harmonic filters and PLC filters) and shunt compensation;
(f) Control and protection of AC and DC side;
(g) Electrical and mechanical auxiliaries;
(h) Dedicated Metallic Return (DMR);
(i) AC switchyard equipment;
(j) DC switchyard equipment;
(k) AC & DC Surge arresters;
(l) AC & DC Measuring instruments;
(m) Communication system between converter stations (OPGW)
(n) DC wall bushings
(o) AC wall bushings (if applicable)

(p) Auxiliary Power System
(q) Key interlocking system for valve hall, DC filters, AC filter
(r) Fundamental frequency blocking filter, if required

19. Converter Station AC Yard, Transformer yard and valve hall

(a) AC commutating bus equipment

The AC circuit breakers, disconnectors, instrument transformers and other switchyard equipment shall be similar to that of the equipment specified under Regulation 46 of Central Electricity Authority (Technical Standards for Construction of Electrical Plants and Electric Lines) Regulations, 2022. The bus rating shall be adopted according to the calculation considering single bus outage. The switching duties of the AC circuit breakers will be decided based on transient over voltage study, insulation co-ordination, AC filters and protection studies.

(b) Dynamic over voltage limiter devices

Converters connected to relatively weak AC systems may cause dynamic over voltages (DOVs) during load rejection / disturbance. The DOV limiter shall consist of parallel arrester elements connected phase to phase or phase to ground and designed to absorb the desired amount of energy during a system disturbance to protect the HVDC system during the HVRT period. The DOV limiter shall be coordinated with recovery of DC system following a disturbance. The requirements of surge arresters shall be based on the insulation co-ordination study in line with relevant standards. The arresters used shall be metal oxide (ZnO) type conforming to relevant standards.

(c) AC harmonic filters and shunt compensation

(i) The HVDC converter generates harmonics during the Conversion process and AC harmonic filters shall be used to limit AC voltage distortion due to harmonics to acceptable levels and also to meet the reactive power exchange requirements based on the studies carried out.

TSP shall design the AC filter banks in such a way that it is possible to transmit full rated power even with 400 kV bus-sectionalisers open.

(ii) The AC harmonic filters shall be switched in and out by sub-bank circuit breakers in First-in First-out (FIFO) logic to increase lifetime of switchgear. Based on the studies, the reactive power

requirement for the terminal and bank or sub-bank size shall be determined such that reactive power exchange with the AC bus shall remain within specified limits.

The permissible limit of voltage fluctuation for step changes which may occur repetitively is 1.5 percent; for occasional fluctuations other than step changes the maximum permissible limit is 3 percent.

(iii) The main filter equipment namely capacitors, reactors and resistors shall comply with the requirements of following IEC.

A. Capacitors-IEC 60871;
B. Reactors - IEC 60076-6;
C. Resistors - IEC 62001/As per owner's specification.
D. Only air-core reactors shall be used in AC and DC filters for harmonic filtration.

(iv) **Performance Requirement**

The AC filter performance shall be better or equal to as defined by following performance parameters:

A. The individual harmonic distortion, Dn, shall not exceed 1.5%
Individual Harmonic Distortion, Dn, = Vn/V1

B. The total effective distortion, Deff, shall not exceed 3.0%.
Total effective Distortion, Deff = $\sqrt{}$ (Σ $(Vn*100/V1)^2$).

C. The Telephone Influence Factor (TIF) shall not exceed 50.
Telephone Influence Factor, TIF = $\sqrt{}$ (Σ $(Vn*Fn/V1)^2$)

Where Fn: Weighting factor for nth harmonic according to EEI publication - 60-68(1960) corrected to 50 Hz operation by graphical interpolation.

D. The Total Harmonic Distortion, $V_{THD,}$ as defined below shall not exceed 2%:

$$V_{THD} = \sqrt{\sum_{n=2}^{n=40} \frac{V_n^2}{V_1^2}} X100$$

'1' refers to fundamental frequency (50 Hz)

'n' refers to the harmonic of n^{th} order (corresponding frequency is 50 x n Hz)

The performance of the AC harmonic filters shall be determined by calculation and shall be based on either as-tested parameters of components or the extreme values of manufacturing tolerances if as-tested values are not available. Performance requirements are to be met for all operating modes. In all Modes of operation, except the reduced DC line voltage modes, the performance requirement shall be met up to rated power with one larger size filter sub-bank and one characteristic harmonic sub-bank (largest) being out of service. All filter banks, sub-banks and branches shall be rated such that the remaining filter components are not overloaded due to detuning or resonance within the filters or between the filters, the generators, and the AC system for any combination of AC system voltage and/or frequency and configuration, or for any operating condition of the converters, or combination thereof, for which the converter valves are capable of continuous operation, or switching time between de-energized and energized states and there is no restriction on the operating power level for any operating conditions with one filter bank outage for power level up to 1.0 pu. Short-time and transient conditions as well as operation with discontinuous DC current must be fully taken into account. The system shall also meet the reactive power exchange limits on both the AC side.

(iv)(a) System Contribution

Bidder may suitably model nearby different RE generators as all these generators are required to meet harmonics requirement under "CEA Technical standards for Connectivity to the grid" regulations. Models provided by RE developers will be shared with selected TSP.

At Converter station ac bus, combined converter and static compensator (if used) harmonic currents as calculated for rating purposes shall be increased to allow for harmonic currents from the ac system in following manner :

(a) At 3rd and 5th Harmonics the increase in current to be allowed shall be calculated based on the assumption that the existing distortion shall be considered as 2% with respect to nominal voltage at converter Bus. This is to be considered for 3rd and 5th harmonic Filter component rating.

(b) At all even order harmonics and at all other non-characteristic or theoretically cancelled harmonics the increase in current to be allowed shall be not less than 50 (fifty) percent provided that the contribution of the harmonic in question to any rating parameter, in the absence of the above increase, is not greater then 10 (ten) percent of the total harmonic rating.

(c) At all characteristic harmonics or at any other harmonic which is effectively filtered (i.e. the harmonic contributes more than 10% of the total harmonic rating of a component in the absence of the increase) the increase in current to be allowed shall not be below 20 (twenty) percent.

(iv) (b) Power Monitoring Device and Power Quality Recorder

The TSP shall provide one number of Power Monitoring Device and Power Quality Recorder as per IEC 61000-4-30 class-A at suitable location (400 kV AC Bus) at each end of both end Substation for acquisition, visualization, evaluation and transmission of electrical measured variables such as alternating current, alternating voltage, frequency, power, harmonics etc. The acquisition and processing of measured variables and events shall be performed according to the power quality measurement

standard IEC 61000-4-30 class-A compatible with IEC 61850 protocol.

(v) **Shunt Reactor Banks**

Shunt reactors, if required, of suitable size shall be provided to meet reactive power exchange requirements derived from the studies. The shunt reactor must be switched in or out by a circuit breaker. The shunt reactor shall conform to CEA's Standard Specifications and Technical Parameters for Transformers and Reactors (66 kV and above Voltage class). The shunt reactor shall be covered under automatic switching under the reactive power control strategy.

(d) Power Line Carrier (PLC) filtering

PLC filters shall be installed close to converter transformers to mitigate high frequency harmonic currents generated during thyristor switching.

(e) Converter transformers

(i) The converter transformer shall be designed in accordance with IEC- 60076-57-129. The converter transformers shall be single phase two winding units. The maximum flux density in any part of the core and yoke at the rated MVA, voltage and frequency shall be such that under 10% continuous over voltage condition it does not exceed 1.9 Tesla. The Converter transformer shall be capable of withstanding minimum DC current of 10 A per single phase transformer entering through the neutral.

(ii) The insulation level for the transformer AC (line side) windings and bushings shall be as given at Regulation 45 of Central Electricity Authority (Technical Standards for Construction of Electrical Plants and Electric Lines) Regulations, 2022 and insulation levels of the valve side windings shall be determined in accordance with studies. The impedance of the transformer shall be determined as in accordance with studies and variations in impedance shall be as per the requirement of relevant standards.

(iii) Converter transformers shall be equipped with On Load Tap Changer (OLTC) and Metal Oxide Varistor (MOV) devices shall be provided between tap leads of the OLTC. The OLTC tap steps shall be determined in accordance with the operating strategy of both the converters. The OLTC shall be designed for a minimum 2,50,000 operations without repair or change of any part including oil. The OLTC shall be designed for a contact life of minimum

6,00,000 operations.

(iv) The requirements of soak pits and firewalls shall be in line with Regulation 46 of Central Electricity Authority (Technical Standards for Construction of Electrical Plants and Electric Lines) Regulations, 2022 and Regulation 46 of Central Electricity Authority (Measures relating to Safety and Electric Supply) Regulations, 2023.

(v) The converter transformer bushing shall be designed in accordance with IEC-60137/ IEC-65700, as applicable.

20. Thyristor valves and valve cooling system

(a) The thyristor valve assembly shall be designed and tested as per relevant IEC/IS. The valve shall be designed and protected during operating conditions for various over voltage and over current stresses to which it may be subjected to due to faults occurring in various parts of the station.

(b) The thyristor valve modules, used for converting AC to DC or vice versa, shall be complete with associated electronic firing system; protection, monitoring & damping system, auxiliaries and cooling system. Twelve pulse scheme shall be used.

(c) In case of two series converter configuration, a bypass switch shall be provided to bypass any faulty converter and use the remaining series converter at lower DC voltage.

(d) The thyristor valves shall be water cooled, air insulated and indoor type. The valves shall be either suspended type or floor mounted type depending upon the operating DC voltage and seismic requirements. The Double or Quadruple valve design shall be used depending on voltage level.

(e) Necessary control and monitoring including tripping of the HVDC system in case of cooling system failure shall be provided.

(f) The valves shall be placed in the valve hall which shall have a positive pressure over atmospheric pressure and humidity control feature. The pressurization will be maintained by ventilation system.

(g) No oil immersed part is permitted to be used inside the valve as well as valve hall. The electronic components located within the valve shall be designed to eliminate overheat and arcing. Only components of low flammability, high reliability and adequate ratings in margins can be used. All thyristors including spare thyristors shall be identical and interchangeable between the converter stations.

(h) Requisite redundancy shall be kept through a provision of suitable number of spare thyristors in valve modules. The number of redundant thyristors shall not be less than 3.0% of the total number of thyristors in the valve. Status of each thyristor level on the valve while the equipment is in service shall be monitored.

(i) Description of Valve Cooling System:

(i) Fine Water Circuit

The fine water circuit shall consist of a main circuit and a water treatment circuit. The cooling medium in the fine water circuit shall be deionised water with low conductivity.

(ii) Main Water Circuit

The main cooling circuit shall consist of water within the thyristor valves, a de-aeration vessel /venting, pumps and filters.

The main circuit shall be provided with an expansion vessel with level transducers and pressurised with nitrogen, as per requirement of OEM design. The level transducers shall be used for control of the make-up water for the system, if applicable, and for detection of leakages.

There shall be two water pumps. One of the two water pumps shall circulate the 100% water through the main cooling circuit and the water treatment circuit. The other pump shall be included for redundancy purpose. The operation shall be automated and arranged into alternative weeks between these two pumps. Upon failure of the unit in service, the redundant shall be automatically activated.

(iii) Water Treatment Circuit

A part of the main flow shall be circulated in the water treatment circuit. The water treatment circuit shall consist of oxygen removers (if required), ion exchangers and mechanical filter. Sensors shall be provided for measuring conductivity of the water, both in the main cooling circuit and in the treatment circuit at the exit side of the ion-exchanger. The water treatment circuit shall have provision to connect makeup pump and associated valves and strainers. The water pipe for fine water make up shall be connected to main fine water circuit through the water treatment circuit.

(iv) Air Cooled Liquid Coolers

The air-cooled liquid coolers shall cool the water from the thyristor valves. One redundant unit shall be provided by the TSP over and above the quantity required to achieve the operating temperatures for rated power.

All the stations shall have dry type coolers. Each cooler shall consist of cooling fans with separated air channels.

Suitable protection against corrosion, oxidation etc. shall be provided for all cooling equipment.

(v) Mechanical Design

The cooling system shall be pre-fabricated. There shall be three main parts:

- fine water pump unit;
- air cooled liquid coolers;
- piping.

The fine water pump unit shall be mounted on a frame and shall be placed in the valve cooling room. The air-cooled liquid coolers shall be placed outdoors, near to the valve cooling rooms. The piping shall be especially designed stainless steel and adapted to the station building.

(vi) Control Equipment

The valve cooling control equipment shall be specially designed for application to the cooling system for thyristor valves. There shall be two computer-based control systems such that either both are in ACTIVE mode, or when one system is in ACTIVE mode the other system shall be in ACTIVE STANDBY mode. Each computer-based system shall be self-checking and an automatic changeover to the other system shall take place in the case of failure of the active system.

(vii) Design Criteria for the Cooling System

Features to ensure high reliability, proper function and prolonged life time for the cooling system and thyristor valves shall be included. The following main components shall be supplied with redundancy in order to increase the availability:

- main circulation water pump
- air cooled liquid cooler (with one additional standby cooler)
- bypass valves
- transducers
- nitrogen bottles, if applicable

(viii) Design Cooling Requirements

Separate cooling system shall be designed to cool the heat generated in each 12-pulse group of thyristor valves for converter stations.

Cooling system shall be capable to operate and guarantee the design temperature specified steady state and overload conditions, up to max specified design dry bulb ambient temperature. Redundant Uninterrupted Power System/drive for valve cooling for each pole shall be rated for 2 minutes.

(ix) Ambient conditions

Ambient Conditions are specified in Table 2 of the specification.

(x) Materials

The materials in contact with the cooling water as well as for manufacturing of the air-cooled liquid cooler shall be selected in order to minimize the risk of corrosion.

(xi) Measure Against Water Leakage

The design of the valve cooling system shall be made to minimise leakages. The following precautions shall be taken to minimize the risk of water leakage from the system:

- choice of water pipe joint
- number of water pipe joints in the system shall be kept as low as possible, particularly in the thyristor valves;
- velocity of de-ionized water in the pipes and in the thyristor heat sinks shall be kept low
- water circulation within the pipes shall be free from trapped air bubbles

(xii) Valve Cooling Control and Monitoring

The valve cooling control systems shall be redundant and be equipped with an integrated data collecting unit that is connected to the station sequential event recorder system.

(xiii) Cooling Capacity Control

The water temperature to and from the thyristor valves are used as an input to the cooling capacity control.

In order to avoid condensation at the pipe lines within the thyristor valves the inlet fine water temperature shall be kept in an appropriate range.

(xiv) Protections

The following protections/monitoring shall be included:

- Temperature of the water from the valves
- Temperature of the water to the valves
- Water flow through the valves
- Water level in the expansion vessel
- Conductivity of the water from the water processing unit
- Conductivity of the water in the main circuit
- Pressure in the expansion vessel, if required
- Pressure in the nitrogen bottle, if required.

(xv) Leakage Detection

There shall be three leakage detection methods used in parallel

by the cooling control system. These methods can, depending on the nature of the leakage, generate trip of the converter and cooling system. However, one of the methods of leakage detection shall generate a leakage alarm if volume of leakage exceeds the reference volume, during the last 24 hours.
Besides these detection methods alarms for frequent make up and for long make up when automatic make-up of cooling water is used, generated by the cooling control programme shall be provided. The total schematic of valve cooling system with valve position, flow, temperature, make up details, conductivity, pump running etc shall be made available to the SCADA system of HVDC terminal.

21. Converter Station DC Outdoor Yard

(a) The DC yard shall comprise of equipment such as HVDC bushings, smoothing reactors, DC filters, DC current and voltage measuring instruments and switchgear, surge arrester, insulators, clamps and connectors.

(b) The specific creepage distance (corresponding to highest DC voltage) for DC yard and other areas shall at least be maintained as follows:

Table 7

Insulator type	**Under light and medium pollution**	**Under heavy and very heavy pollution**
Indoor porcelain or composite insulators for valve hall (other than valves) and indoor smoothing reactor area (if any)	20 mm/ kV	
Thyristor Valves	14 mm/ kV	
Outdoor porcelain insulators or bushings with RTV coating	50 mm/ kV	60 mm/ kV
Outdoor composite insulators or bushings	50 mm/ kV	

Note: Specific creepage distances less than 50 mm/ kV but not less than 45mm/ kV can be accepted for outdoor silicone rubber bushings due to manufacturing limitations and for HVDC equipment requiring necessary internal/ external insulation co-ordination. However, specific

creepage distance less than 50 mm/ kV and flash distance less than 12 mm/ kV shall not be acceptable for outdoor jointed bushing.

The base voltage applicable for calculation of valve arrester creepage distance shall be:

$$U_{creepage} = \sqrt{\left(\frac{1}{3} + \frac{\sqrt{3}}{8\pi}\right)} * CCOV$$

Where, CCOV: Crest value of Continuous Operating Voltage

(c) **DC wall bushing**

DC wall bushing shall be designed as per IEC-65700. DC wall bushings, used for electrical connection between the equipment inside the valve hall and the outdoor DC yard shall be of polymer housing as per relevant standards. All bushings inside the valve hall including HVDC wall bushing shall be dry type/SF_6 gas filled or combination of both. There shall be no oil filled component inside valve hall.

(d) **Smoothing Reactor**

The smoothing reactor shall be designed as per IEC-60076-6. The smoothing reactor shall be of air core type. The reactors shall comply with relevant standards and shall have successfully passed DC tests as per their application. The smoothing reactor may be divided between pole and neutral for DC voltage above 500 kV. Each converter station shall be provided with one spare coil of smoothing reactor with all fitments, hardware & accessories. Minimum. four nos. of insulators of each type for smoothing reactors shall be provided as spare.

For the design of smoothing reactor, the Si factor has to be within the limits (0.22 <Si< 1) where Si factor is defined as

Si = U_{dn}/ L_d*I_{dn}

U_{dn} = Nominal HVDC Voltage level per pole

I_{dn} = Nominal HVDC Current

L_d = Total DC side inductance = L_{dr} + 3.5 L_{tr};

L_{dr} = Smoothing Reactor inductance

L_{tr} = Converter transformer inductance

The smoothing reactor shall be designed for Class H for inter turn insulation as per IEC 60085, however, the maximum allowed hot-spot temperature rise shall be limited to one class lower i.e. Class F insulation.

(e) **DC Voltage and Current Measuring Devices**

The DC voltage and DC Current measuring equipment shall be installed at each pole. These equipment can be optical type or conventional type. The DC measuring equipment at pole and neutral bus shall be suitably located based on the control philosophy and different protection zones such that complete pole and neutral equipment are protected. The details of DC Measuring Equipment shall be as per '***Appendix-- C.1***'**.**

(f) **DC Filters**

Adequate numbers of DC harmonic filters shall be provided in DC yard to limit harmonic voltages present on the DC lines (pole lines and DMR line). However, minimum one No. DC filter per pole per station shall be provided. Common DC Filter for parallel poles are not acceptable.

The design shall be based on passive DC filters. The DC Filters shall consist of Low order filters, Harmonic Filters and High Frequency Filters as per the requirement of project specific studies. The main filter equipment like capacitors, reactors and resistors shall comply with the requirements of relevant IS/IEC standards/ CIGRE documents. A fundamental frequency series blocking filter shall be provided, as per requirement. The required switches shall be provided. It shall be possible to connect and isolate a single DC filter arm without causing any reduction in transmitted power on the affected Pole.

The calculation of DC filter performance and rating shall be based on values of components, detuning, and harmonic voltages and currents. The TSP shall use "Three Pulse Model" or EMTDC model or equivalent for calculating performance and rating of DC filters.

There shall be no limitation on the energization of the DC filter arms by reason of either ambient temperature, frequency, initial mistuning or DC voltage within the ranges defined in this Specification. The DC filter components shall not become overloaded due to detuning or resonance within the DC filter or between the DC filter arms and the HVDC circuit, or the DMR, for any combination of conditions for which the converters are capable of continued operation.

TSP shall ensure that fundamental and 2^{nd} harmonic resonance and adverse amplification does not occur on DC side. A parallel low order (2^{nd} Harmonic) DC Filter shall be provided across each converter of each station. Earth resistivity along the DC line route will be considered as 250 ohm-m.

DC filter Performance:

The individual harmonic current (In) at any harmonic shall not exceed the value which could cause mal-operation of the HVDC system control and protection equipment supplied. The maximum equivalent disturbing current (Ieq), up to rated power in forward power direction, without any

filter outage, for balanced bipolar and monopolar mode with metallic return or Dedicated Metallic Return (DMR) modes of operation shall be as follows:

Table 8

Operating Mode	Ieq
Balanced bipolar operation	1500 mA
Monopolar mode with metallic or DMR mode	2200 mA

The equivalent disturbing current includes not only the harmonics which flow in the DC Pole conductors and DMR lines but also the harmonics which are induced into the ground wires of the DC transmission line.

Mutual impedance calculation algorithms require that the ground wires be "eliminated" for this configuration; however, as specified herein, the current flow in the ground wires must be eventually taken into account in the calculation of equivalent disturbing current.

In Bipolar operation, the equivalent disturbing current shall be the psophometric weighted residual current of all harmonics of fundamental frequency from the 2nd to the 60th (i.e. 100-3000 Hz) according to the following formula:

$$Ieq(x) = \sqrt{[IeC(x)^2 + IeS(x)^2]}$$

Where,

Ieq(x) is the equivalent disturbing current in milliamps (mA) psophometrically weighted at any point along the transmission corridors specified herein

$IeC\ (x)$ is the magnitude of the RSS equivalent disturbing current component due to harmonic voltage sources at Barmer-II (mA)

IeS(x) is the magnitude of the RSS equivalent disturbing current component due to harmonic voltage sources at South Kalamb Converter Station (mA)

x denotes the relative location along the transmission corridors.

The equivalent disturbing current at any point along the corridor due to harmonics from either Barmer-II or South Kalamb Converter Stations shall be calculated as follows:

$$Ie(x) = \sqrt{\sum_{n=1}^{n=60} \{Ir(n,x) * P(n) * Hf\}^2}$$

Where,

$Ir\ (n, x)$ is the magnitude of the equivalent residual rms current at each harmonic in milliamps

(n) is the psophometric weighting at harmonic "n" as per Consultative Committee for International Telephony and Telegraphy (CCITT)

n denotes the harmonic number.

Hf is the coupling factor which represents the normalized frequency dependent effects of typical coupling impedances to open wire circuits. The coupling factor Hf will be assumed as per table below:

Table 9

Frequency (Hz)	Coupling Factor (Hf)
40-500	0.70
600	0.80
800	1.00
1200	1.30
1800	1.75
2400	2.15
3000	2.55

Frequency (Hz)	Coupling Factor (Hf)
3600	2.80

As defined above, all harmonics up to the 60th shall be included in the calculation of equivalent disturbing current. The equivalent disturbing current shall be based on a “worst consistent set” of harmonic voltages at either end of the line.

The “worst consistent set” is defined as that set of harmonic driving voltages which could occur at any particular operating condition which results in the highest value of equivalent disturbing current that could occur for a period of longer than ten minutes.

A particular operating condition is defined in terms of:

a) The mode of operation, i.e. bipolar or monopolar in any specified mode of operation.

b) The DC voltage anywhere within the normal range for the mode of operation.

c) Reduced DC voltage operation on both Poles and reduced DC voltage on one Pole with the other Pole at nominal DC voltage.

d) The commutating reactance anywhere within the guaranteed range.

e) The firing angle anywhere within the range applicable to the mode of operation as defined above which shall include firing angles associated with reactive power control and AC filter and reactive power bank switching.

f) Worst case induced voltage from any parallel lines.

g) The converter AC bus voltages anywhere within the normal range specified.

h) The maximum 50 Hz negative phase sequence voltage of 1.5% for achievement of performance limits.

i) The DC current anywhere within the range applicable to the mode of operation.

j) Ambient temperature as defined in Table 2.

k) Differences in the smoothing reactor harmonic impedances of the Poles

DC filter rating

The rating of the DC filter components shall be based on the assumption that the per pole harmonic voltage is individually maximized at each harmonic for any particular operating mode, and the filter component currents due to the harmonic voltages at the terminals shall be assumed to add as RSS (Root Sum Squared) at each harmonic.

For the rating of the DC filter components, it shall be assumed that any one DC filter arm can be out of service in any converter Pole. The DC filters shall be rated for any loading up to the inherent continuous overload capability and short-time overload capability for all operating modes. The possible impact of reduced voltage operation and increased reactive absorption on the ratings of the DC filters shall also be considered.

Short time and transient conditions as well as operation with discontinuous DC current must be fully taken into account. Due allowances shall be made for possible current amplification resulting from resonances between the arms of the DC filters. In the calculation of the impedance of the DC transmission system when used for calculation of DC filter component rating, ±10% tolerance in the respective line length shall be included. AC system voltage and frequency variations as functions of duration specified in Table 2 shall be allowed in the calculation of harmonic voltages and DC filter detuning. In addition, capacitor unit or element failures appropriate to the duration for which the DC filter has to remain connected, shall be allowed for in the calculation of DC filter detuning.

(g) **Surge Arrester**

Surge arresters shall be gapless Metal Oxide arresters and shall be designed and tested as per relevant IS/IEC. The arresters shall be designed to absorb the desired amount of energy during a system disturbance and shall be coordinated with recovery of DC system following a disturbance as applicable.

Arresters at appropriate places may be provided as per requirement. However, the HVDC main arresters typically found in a HVDC System are as follows:

(i) Valve Arrester

(ii) Bridge Arrester

(iii) DC Line Arrester

(iv) DC Neutral and DC Filter Arrester

(v) Converter Transformer and AC Filter Bus Arrester

(vi) DMR line arresters

(vii) Smoothing Reactor Arrester (if applicable)

(viii) DC Neutral Switch Arresters

(ix) DC pole bus arrester

(x) Converter transformer primary neutral arrester

(h) **Fundamental frequency blocking filter:**

A fundamental frequency blocking filter may be installed to block the 50 Hz induced current in DC line in order to minimize the risk of converter transformer saturation due to possible induced fundamental frequency current from parallel AC lines

This induced current usually results from AC side second harmonic positive sequence voltage and from AC lines running parallel to DC line. The TSP shall consider any possible inductive and capacitive coupling between these lines.

For design purposes, 50 km of parallel un-transposed 765 kV AC Double Circuit line and 50 km of parallel un-transposed 400 kV AC Double circuit line within a radial distance of 70 m to be considered by the TSP to consider any possible inductive and capacitive coupling between the lines. The parallel section of AC lines shall be considered to be located at a point that results in maximum fundamental frequency current at each converter station.

Such a filter is formed of capacitor, reactor, resistor and arrester. Internal arrangement of these components is left to designer but the overall filter should offer significant impedance to 50 Hz current flowing in DC circuit. Blocking filter reactor shall be designed for Class H for inter turn insulation as per IEC 60085, however, the maximum allowed hot-spot

temperature rise shall be limited to one class lower i.e. Class F insulation. The reactor may preferably have similar design as smoothing reactor to share common spare. The AC/DC/PLC/RI reactor shall be designed for Class F insulation as per IEC 60085, however, the maximum allowed hot-spot temperature rise shall be limited to one class lower i.e. Class B insulation.

(i) **DC commutation switches:**
These switches are required for commutating the DC current from one path to the other. They comprise of Dedicated Metallic Return Transfer Breaker (DMRTB), Pole Metallic Return Transfer Breaker (PMRTB), Neutral Bus Grounding Switch (NBGS). High Voltage High Speed (HVHS) switch and Neutral Bus Switch (NBS) shall also be provided suitably at both ends in all the poles.

22. Dedicated Metallic Return (DMR)

The neutral current return path for bipolar configuration or monopolar configuration shall be via a Dedicated Metallic Return (DMR) conductor connecting both converter terminals.

23. Control and Protection System

It shall be demonstrated that the HVDC control system is stable under all operating conditions and cannot excite oscillations, such as sub-synchronous oscillations, between the HVDC and AC system. The control system shall be tuned for optimal overall performance for all conditions and configurations of the AC system. The details of operator Control and Monitoring are mentioned in ***'Appendix C.2'.***

It shall also be demonstrated, by applying system faults and step responses in current order and power order during the factory acceptance testing (FAT), that the as-built control system does not excite low order harmonic resonance(s) in the AC system and/or between HVDC and AC systems for any system configuration.

The performance of the integrated DC and AC systems shall also be demonstrated using an EMT-type program (such as PSCAD) in order to validate the system performance requirements. In the DPS program, all the HVDC protections shall be modelled. All feeders in the ac converter bus should have the required protections modelled for DPS studies with network equivalent.

Software based controls and protection shall be used to permit flexibility in effecting modifications. Protection and controls shall be

duplicated for reliability. The control & protection shall provide fast controllability of the HVDC system.

(a) Control System:

(i) The control system shall have redundancy with hot standby. Transfer of controls from Active Control system to Hot standby control system shall be seamless and there shall be no power interruption during this transition. Outage of one control system or part thereof, shall not result in any power reduction.

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

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

1. Master Control
2. Station/Bipole Control
3. Pole/ Converter Control
4. Valve Control

(iv) The HVDC Station/Bipole shall have control features (as and when established by system design) including but not limited to the following:

1. Reactive power controller
2. Current and power controller
3. Frequency controller
4. Power modulator, pole power compensation. The modulator, if required, shall have feature which shall provide positive damping of AC network oscillations over the range of frequencies considered during system studies.
5. Sub Synchronous Resonance (SSR) Damping Controller (if required) based on studies.

   All necessary studies shall be carried out to ensure that the DC system shall not excite the mechanical, electromechanical or other natural frequencies of the nearby region generators and turbines under any operating mode. It shall be demonstrated by studies that the nearby generators shall not

be adversely affected by the HVDC system, particularly with regard to Sub Synchronous Oscillation (SSO)/Sub Synchronous Resonance (SSR) and harmonic injection and self-excitation. Sub Synchronous Damping (SSD) Controller shall be provided for converter stations near Generating stations.

6. Run back/Run up controller (10 points) with provision to be linked to Special protection Scheme (SPS) of System Operator
7. AC system stability function, such as power swing damping function
8. RE Park Sub synchronous control interaction, Temporary and Transient over-voltages, harmonic interactions, stability, HVRT, LVRT etc. studies.
9. Interaction studies among various HVDC links and STATCOMs (planned/ execution) which are electrically coupled nearby.
10. The TSP shall study all interaction aspects between these converter stations, STATCOMs and devise control strategies to ensure that no adverse interaction takes place among the above stations during steady state and fault recovery. Various fault cases for the purpose of this study shall be finalized by TSP during detailed engineering.
11. The HVDC system shall conform to the performance requirements specified herein. It shall be designed to optimally co-ordinate all aspects of its controls to ensure safe and reliable operation without adversely affecting the connected AC system and shall assist the latter following disturbances. The performance requirements shall be met under all specified ambient conditions, modes of operation, AC system conditions and other parameters as given under these specifications. Any other Controller as deemed required for stable HVDC system operation with connected AC network.

(b) Protection System

The protection system shall be designed in Main-I and Main-II set up.

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

(A) **AC side protection**

AC side protection function shall cover the zone for converter

transformer, AC filters, shunt capacitors, shunt reactors, and busbars. These protections shall generally follow the same philosophy as in a typical AC substation i.e. detection of fault by relay and tripping of circuit breaker or may be dealt in similar way as described for DC side protection.

(B) **DC side protection**

DC side protection shall cover the zones consisting of the valve hall, DC switchyard including smoothing reactor and DC filters, DC line, and DMR line. The protection equipment shall be designed to be fail safe and shall ensure high security to avoid mal-operation/ unwanted shutdown due to protection equipment failures. 'Main-I and Main-II' or 'Main and Standby' protection philosophy shall be adopted for HVDC equipment and system.

(ii) Following a DC Line fault, the HVDC System shall have the facility to restart. The DC transmission system shall be capable of recovery in a controlled and stable manner without commutation failures during recovery following AC and DC system faults. The post fault power order shall be equal to the pre-fault power order unless AC/ DC systems dictate otherwise.

(iii) Protection system shall have two redundant systems with following protections (Some protection can be combined).

a) Converter differential protection, Converter protection
b) AC, DC over current/under current protection
c) AC, DC bus differential protection
d) AC conductor ground fault protection
e) Commutation failure protection
f) DC filter protection
g) Converter transformer valve winding protection
h) DC line differential protection
i) DC under voltage/ over voltage protection
j) DC line ground fault protection with restarts
k) Dedicated Metallic Return (DMR) protection
l) AC filter protections
m) Thyristor failure monitoring
n) AC overload protection
o) DMR line monitoring and protection
p) Sub Synchronous Torsional Interaction (SSTI) Protection (corresponding to synchronously run Power Plants)
q) Sub Synchronous Control Interaction Protection (corresponding to RE plants) etc.

24. DC Line fault locator

DC online fault locators shall be provided to monitor the entire DC line length and give location of the fault with good accuracy in the range of + 1000 meters for pole conductors. DC line Fault Locators shall utilize a method of measurement of time of arrival at each end of the HVDC line of the steep wave fronts, resulting from a fault on the HVDC, affected by the accuracy of the time measurements. Since the wave fronts shall propagate along the lines at $3x10^8$ m/sec (or 300 metres per microsecond), the time measurements must be in microseconds with an accuracy of ±3 microseconds in order to achieve a location accuracy of approximately ±1 km. Greater precision of fault location would be desirable. The DC online Fault Locator equipment at each station shall be time synchronized to the master clock system at the station in order to facilitate analysis of system disturbances recorded on the DC Line Fault Locators, the transient fault recorders and the alarm monitoring and recording system. Manually re-settable fault counter shall be provided as part of the equipment.

ELECTRIC CHARACTERISTICS

1) Control Panels

Identical control panels shall be provided for each DC Line Fault Locator within its own cubicle(s). The control panel shall include, but not be limited to the following facilities.

- Equipment on/ off control and indication;
- Equipment alarm or failure indications;
- Fault location readout display for the last detected line fault;
- Manual initiation of automatic self-test routines;
- Any other controls or indications

2) Printers

A printer shall be provided for each DC Line Fault Locator or it may be integrated with operator control and monitoring system. The printer shall print the day, hour, minute, second and millisecond of each fault or manual or automatic system test. The printer shall also print the location of each fault in kilometres from the respective station.

If fault locator is integrated with operator control and monitoring system that all these details shall be displayed on Video Display Unit (VDU) and stored in archives in the backup memory.

3) Power Requirements

The equipment shall be suitable for operation from the station battery supply. There shall be no loss of accuracy within specified variations of DC input voltage.

Note: Alternatively, TSP may also propose an integrated solution with the fault locator integrated into the HVDC Control and Protection system meeting the system requirements. If fault locator is integrated with operator control and monitoring system then all these details shall be displayed on Video Display Unit (VDU) and stored in archives in the backup memory.

25. Operations supervision and control

a) The TSP shall provide the control facilities from the operator control desk through a monitor and keyboard/mouse system. These facilities shall include all control operations, digital setting, indicating devices, Station single line diagram and symbols, any other special control devices and meters required for control and monitoring of the complete HVDC system.

b) The layout of the station single line diagram, together with control, indicating and metering devices on the control desk shall be logical, compact, of pleasing appearance, and shall facilitate efficient supervision and operation of the station(s) by the operator. Every detected change of position shall immediately be displayed in the single-line diagram on the station screen, recorded in the event list and printable.

c) Graphic representation of thyristor valves and valve cooling piping network shall be provided on station monitoring system. The graphical representation shall also display faulty thyristors in different colours indicating faulty thyristor position.

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

The details of operator control and monitoring system are provided at '***Appendix C.2*** - Operator Control and Monitoring System'. The Transient Fault Recorder provided for the HVDC system shall be as per '***Appendix C.3***'

26. Telecommunication

For smooth operation of the HVDC system, communication network with high reliability and availability shall be provided for transmission of control and protection signals between the two or more (in case of multi-terminal DC) HVDC terminals. The communication system design shall be as per *'Specific Technical Requirements for communication'*.

A limited remote data transfer of the HVDC system from the Load dispatch centers shall be provided by TSP. All required remote control and remote monitoring facilities shall be provided at each converter station. Complete remote monitoring of each converter station shall be possible from opposite converter station.

The required numbers of Synchro phasor measurement using Phasor Measurement Units (PMUs) as per the "Guidelines on Unified Philosophy for placement of PMUs in Indian Grid" issued vide CEA letter No. CEA-PS-14-12/9/2024-PSETD Division dated 19.03.2025 shall be provided along with fibre optic connectivity, Global Positioning System Receiver and communication equipment.

27. Valve Hall

The valve hall shall mainly contain thyristor valves, its associated structure, cooling and arresters. No oil filled equipment shall be present inside the valve hall. In case the turret of converter transformers (having oil) is protruding inside the valve hall, suitable fire barrier matching with adjacent valve hall wall fire rating shall be provided. The valve halls shall be provided with interference screening, if required by OEM. In addition, the control cable and cable termination rooms shall be suitably screened to minimize radio interference. Necessary measures shall be taken to take care of high frequency noise emission from valves.

The valve halls shall have ample clearances such that the inspection of valves can be possible and allow access of mobile valve servicing equipment without any dismantling. The valve hall building shall be pressurized to prevent the ingress of unfiltered air. In addition, the building shall be properly sealed to minimize the flow of outside air into it and vice versa. Openings for equipment and services shall be weather proof. The Valve hall building shall consist of steel framed structure. The steel building shall be pre-engineered building fabricated in the factory and shall be assembled at site. Minimum two nos. scissor lift for erection and maintenance of valve modules shall be provided per station. Proper cable sealing shall be provided for cable entry

into valve hall and control room to avoid entry of water and moisture.

28. Ventilation System for Valve Hall

Each valve hall shall have an independent ventilation system. Each ventilation system shall consist of two 100% capacity systems, one operating and one stand-by.

The ventilation of the valve hall shall be of a positive pressure type. Once through ventilation system will not be acceptable. The ventilation system shall be a closed cycle with fresh air intake limited to a maximum of 20% of the total air requirement. Fresh outdoor air shall be filtered and dehydrated before being blown into the valve hall by the air fans to avoid dust accumulation and condensation on components present in the valve hall. Suitable measures shall be taken to minimise stagnant air. Each valve hall shall be provided with remotely operated motorized exhaust dampers which shall be normally closed and will be opened under high pressure/emergency conditions only.

To ensure that the air being supplied to the valve hall is free from dust particles, a minimum three stage dust filtration process shall be supplied. This shall consist of at least the following:

1. Pre-Filters: To remove dust particles down to 10 microns in size with at least 95% efficiency.
2. Fine Filters: To remove dust particles down to 5 microns in size with at least 99% efficiency.
3. Absolute Filters: To remove dust particles down to 0.3 microns in size with at least 99.5% efficiency.

All the filters shall be panel type. Easy access should be available to the filters for replacement/cleaning.

It shall be possible to maintain specified conditions continuously inside the valve hall, both automatically and manually controllable from the station service panel (located in the control room) as well as from the local control panel.

In addition to the alarms for particular parameters like pressure, temperature & relative humidity etc., indicating instruments shall be provided for each valve hall. These parameters shall be integrated with station monitoring system also.

The valve hall shall be kept at a pressure above the atmospheric pressure under all conditions. The test shall be conducted at site to measure the pressure inside the valve hall for 48 hours.

Adequate numbers of de-humidifiers shall be provided for each valve hall as per design requirement.

29. Air Conditioning System

Air conditioning shall be provided on a continuous basis in the control room, bay kiosks, valve module workshop & storage rooms, control & protection workshops, offices, first aid room, conference room, entrance halls, corridors etc. and all rooms containing electronic equipment.

The air conditioning system for the control room shall consist of two (2) systems each of 100% capacity; one operating and one stand-by. Both units shall be interconnected so that, in the event of breakdown of one unit, the stand-by unit can be placed into service. Stand-by and operating units shall be alternated monthly for regular operation. The operation of the units shall be automatically controlled including sequential start and stop with single command.

If valve base electronics and/or valve cooling control cubicles are located at places other than in the station control room, these areas can be cooled by using split Air Conditioning units

of appropriate capacity. At least two units shall be provided, one operating and one stand-by with the facility of automatic changeover after operator assigned time period.

A separate air conditioning system shall be provided for other areas of the service building. This shall also consist of two (2) Nos. each of 100% capacity; one operating and one stand-by.

30. Visual monitoring system (VMS) for watch and ward of station premises:

Visual monitoring system for effective watch and ward of substation premises shall cover all the transformers and reactors, outdoor DC yard, valve halls, indoor and outdoor isolators, earth switches, breakers, AC and DC capacitors, all other major AC Equipment (such as CB, isolators, CT, CVT, SA etc. as applicable), panel room, all entrance doors for the service building, other buildings, 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 these locations, 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 30 days) at least @25fps (or better) and stored on network video recorder and followed by transfer of the data to a juke box. 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). The operation of cameras shall be integrated with the Network server placed in Control room of HVDC station. Sensors shall also be placed on boundary walls to prevent intrusion from outside and shall be connected to the CCTV system.

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 & 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 HVAC substations, the visual monitoring system if available shall be augmented as per existing or better specification as required.

31. Building Management System

A fully computerized and automatic Building Management System (BMS) shall control the operation of the mechanical systems serving the valve hall and service building and other systems as detailed below.

Scope of Work

The scope of work shall cover all necessary system provisions (including hardware and software) for synchronizing/integrating the BMS with the control and monitoring of

- Air Conditioning system,
- Valve hall ventilation system
- Fire Fighting Systems including Fire Spray and Hydrant systems, water level in Fire Water Tanks etc.
- Utility Services i.e. Water Storage and Supply,
- Access Control including Motorised Gate at the entrance to the station and for all entrance doors for the control room building including provision of electromagnetic door locks, card readers etc.
- Fire Detection and Alarm System.
- Illumination systems
- VMS

32. Water Supply and Distribution System

The water supply and distribution system shall include the supply, distribution and storage of water in the HVDC Station at least the following purposes.

a) storage of water for the firefighting system;

b) storage of water sufficient for 24 hours of continuous operation of HVDC converter in the event of interruption of water supply to the tanks;

c) water supply for the valve cooling system;

d) water supply for sanitary services;

Two Nos. 100% capacity water storage RCC tanks shall be provided. Each tank shall be constructed in such a way that there shall be segregation between requirement for fire water storage and water for other purposes. Both the tanks shall have interconnection piping with isolation valves for both tanks. Separate piping as per IS/IEC standard for firefighting, valve cooling and other purposes shall be provided from the tanks from independent headers.

33. Grounding & Safety:

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

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

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

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

e) Fencing and electrical interlocking & mechanical key arrangements shall be provided for all non-accessible areas, for valve halls, and for areas where for equipment mounted directly on ground without suitable height of steel structure, e.g. smoothing reactor area, AC and DC filter areas,

as applicable.

f) Safety precautions in regards to gas/oil pipe lines in vicinity of HVDC/ AC lines shall be taken coordination with gas/ petroleum authorities.

34. Cables:

All cables shall be FRLSH type. The High Voltage (6.6 kV to 33 kV) power cables shall be XLPE insulated conforming to IS-7098 Part-2. The Low Voltage power cables shall be 1.1 kV XLPE insulated conforming to IS-7098 Part 1 or relevant IEC standards and/or PVC insulated conforming to IS-1554 Part 1. The control cables shall be 1.1 kV PVC insulated conforming to IS-1554 Part-1. The rating and size of cables shall be determined by TSP. All cables shall be armored except cables used for special purpose as per OEM recommendation. Fibre optic cables conforming to IEC– 60793 and 60794 shall be used to transmit the signals to and from various equipment and panels located in the AC/DC switchyards, Valve Halls, control rooms, valve cooling rooms etc.

35. Auxiliary Power Supply System:

The auxiliary power supply system shall have the following:

a) Highly reliable duplicated supply sources from two separate sources with automatic change-over facilities. Each of the sources of auxiliary power shall be from 33 kV side of 2 Nos. of 400/220/33 kV transformers at Barmer-II and 33 kV tertiary of 2 Nos. 765/400/33 kV ICT at South Kalamb. Additionally, one more 33 kV supply from independent source shall be arranged and connected to 33 kV Bus at both Barmer-II and South Kalamb Stations. This source shall be stepped down to 433 V by means of station service transformer of minimum 2000 kVA capacity and rated 33/0.433 kV.

b) Completely separated secondary distribution (415 V) systems for the auxiliaries of each converter.

c) Duplicated supply by two different 415 V power sources to essential loads

d) Diesel Generator (DG) Set of minimum 1500 kVA capacity per pole shall be provided to meet essential loads. This generator set shall start automatically and cater load immediately in case of loss of all the normal and standby supply sources. The DG sets shall be designed and rated so as to meet the load time characteristics of the essential loads of the entire station as determined by the TSP with a 10% margin on the load.

e) Parallel operation between station service transformers shall not be permitted at any voltage level in order to limit fault currents, prevent back

feed into the AC bus and to ensure independence of supply sources. Also, parallel operation shall not be permitted between transformers and the DG set.

f) Suitable protection on all primary MV and LV supply connections shall be provided.

g) The 220 V DC supply system(s) per pole shall consist of at least two independent DC systems; each system consisting of one float-cum-boost charger, one battery bank and one distribution panel. A 48 V DC system consisting of two battery sets, two battery chargers and two distribution boards shall also be supplied for communication panels (wherever supplied). If desired, 48 V supply may be obtained from 220 V DC battery bank by use of adapters, without compromising backup time.

   (i) The station services DC system shall cater to the DC loads of HVAC and HVDC switchyards, auxiliary services control, valve and pole control, protection circuits, communication system loads etc.

   (ii) Minimum lighting load shall be connected to the station DC system.

   (iii) 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.

h) All auxiliaries shall give rated output at voltage variation of ±10% and frequency variation of -5% to +3%. Sizing of LT Switchgear shall be suitable to cater the requirement for all present and future bays. AC & DC distribution boards shall have modules for all the feeders (including future as specified).

i) For substation extensions, existing facilities shall be augmented as required.

An indicative SLD for the Auxiliary Supply System is enclosed at ***'Appendix-C.5'.***

For the requirement of the Auxiliary Power as described above, Essential Load is defined as per below: -

Essential loads: *These are the loads whose failure shall affect the conversion capability of the HVDC system. These loads shall include, but not be limited to, the cooling and other auxiliaries of the converters, the cooling of transformers and reactors, valve hall cooling, etc. In addition, loads that must*

remain working in case of complete loss of the AC power supply shall also be included in essential loads. These loads shall include, but not be limited to, the station battery chargers, disconnecting switching and circuit breakers operating mechanism, the emergency lighting, fans to keep over pressure in valve halls, etc.

36. Fire Detection, Alarm and Protection system:

A comprehensive fire detection, alarm and protection system as per Central Electricity Authority (Measures Relating to Safety and Electric Supply) Regulations, 2023 shall be provided. Valve Hall shall have Air aspiration system (fast and early smoke detection system). Suitable Infra-Red (IR)/Ultra Violet (UV) detector to detect the flashover inside the Valve Hall shall also be provided. The Valve hall wall towards converter transformers shall be suitable for minimum 3-hour fire rating.

Suitable fire detection system using smoke detectors and/or heat detectors shall be provided in HVDC 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:

Suitable No. of hydrants shall be provided for protection of HVDC Station equipment in the yard and HVDC Station building.

HVWS System:

High Velocity Water Spray (HVWS) system shall be provided for converter transformer, ICTs and Shunt Reactors.

37. Testing and trial operation

All equipment/components including Thyristor valves, Converter Transformers, smoothing reactors, EHV DC Transformer bushings and wall bushings shall be subjected to Type tests, Routine tests, Factory Acceptance Test (FAT), Site Acceptance Test (SAT) as per relevant IS / IEC/ IEEE as applicable. The SAT shall consist of sub-system & system tests and shall be carried out after installation of equipment at site. The sub-system tests cover the major sub-system like valve cooling, AC & DC filters, HVDC converter, auxiliary systems, communication etc. After completion of sub-system tests, system tests covering power transmission tests, transient & dynamic control tests, measurement of electric field and RFI etc shall be conducted. After completion of all system tests, final trial operation of the HVDC System shall be carried out for continuous period of normal operation of not less than 10

days (for each Pole/Bipole separately, followed by entire HVDC link consisting of two parallel Bipoles again for 10 days) during which the converter equipment shall be fully operational. The HVDC System shall be declared under Commercial Operation after the successful completion of its Trial Operation.

38. Reactive power exchange

The reactive power exchange limits with the system for the Converter Stations are specified in this specification.

The following reactive power exchange limits shall be honored by the HVDC system:

(A) Reactive power exchange limits

Table 10

Minimum DC Power **150 MW**	**Maximum DC Power** **3000 MW per bipole**
In the entire range of HVDC power	
400 kV AC SYSTEM Barmer-II bus sections	
Maximum Export at 420 kV 50 MVAR	Import NIL at 380 kV
400 kV AC SYSTEM South Kalamb	
Minimum DC Power **150 MW**	**Maximum DC Power of 6000 MW** **(3000 MW per bipole)**
In the entire range of HVDC power	
Maximum Export at 420 kV 100 MVAR	Import NIL at 380 kV

The control of reactive power exchange shall be fully automatic and shall be continuously monitored. The control equipment, however, shall allow both automatic and operator-initiated switching. In the former case, adequate annunciation shall be provided to the operator. The reactive power control system shall not require any element switching for DC power flow changes of 150 MW in either direction since the last switching operation had taken place. Switching necessary to maintain the AC bus voltage within the ranges specified is permissible for power order changes of less than 150 MW.

Each breaker used for switching shunt reactive elements shall have point-on-wave switching control for energizing its branch, to minimize voltage disturbances while switching capacitors and filters, and minimize DC offset current while switching shunt reactors. Breakers used for switching shunt reactive and filter elements must be capable of de-energizing their branch at the maximum temporary overvoltage conditions specified in this specification, or as determined by the TSP's studies, including full load rejection studies, whichever is greater. The reactive compensation and overvoltage limiting equipment shall be designed such that at any power transfer level up to rated power in either direction, a complete or partial interruption of DC power transfer shall not result in a fundamental frequency over voltage beyond the values specified in this specification. The TSP shall provide controlled or point-on-wave switching for synchronous closing of converter transformer.

All the necessary studies of reactive compensation and voltage control shall be performed. The calculations of reactive power exchange and of voltage control shall be based on the most unfavorable combination of tolerances on equipment, connected system configuration and of changes in operating conditions.

39. Pole Blocking

The HVDC System shall be designed such that the power transfer loss of a faulted Pole due to Pole blocking or during DC line fault clearing is transferred to the remaining Pole. The power transfer on the remaining Pole shall be increased up to its rated short-time power transfer capability to compensate for the power transfer loss on the faulted Pole and to minimize AC network disturbance.

When an increase in power transfer of the healthy Pole is required due to blocking of the other Pole, 90% of the increase in DC power transfer required shall be achieved within 100 milliseconds of the faulted Pole blocking.

For the case where a Pole blocks while communications are not in-service, 90% of the required DC power transfer to the other Pole shall be achieved

within 100 milliseconds of the rectifier blocking.

The HVDC System shall recover to 90% of the pre-fault DC power transfer level consistently within 120 milliseconds from the instant of fault clearing, without subsequent commutation failure on the faulted or healthy Pole or sustained oscillation for all inverter system fault conditions. For all rectifier AC system fault conditions, the recovery time, to 90% pre-fault power level, shall be within 100 milliseconds from the instant of fault clearing. This recovery time shall be achieved for all short circuit levels as defined in this specification.

If it is in the interest of the overall improved recovery of the AC/ DC system, in such cases the recovery times other than those specified shall also be acceptable, subject to review

40. Pole Deblocking and Converter Start-up

A coordinated sequence of starting an HVDC Pole shall be established and demonstrated during FAT. The sequence shall be in a such a manner that it will not impact the connected AC system. It shall be possible to start and deblock at minimum DC power specified in this specification earlier while maintaining all the AC and DC filter performance requirements.

41. AC bus fault

The TSP shall demonstrate the response of the power controller to DC voltage changes in the rectifiers and inverter for solid converter AC bus faults, both single phase-to-ground and three phase-to-ground.

The HVDC system shall recover to 90% of the pre-fault DC power transfer level consistently within 120 ms from the instant of fault clearing, without subsequent commutation failure or sustained oscillation for all inverter AC system fault conditions. For all rectifiers AC system fault conditions, the recovery time, to 90% pre-fault power level, shall be within 100 ms from the instant of fault clearing. This recovery time shall be achieved for the fault levels above the minimum specified in Table-1. Recovery times greater than specified above shall be acceptable only if the higher recovery times results in the overall AC and DC system improvement.

The response time shall be determined in accordance with the general criteria defined in this specification. The specified response for the rectifiers ac system and inverter ac system faults shall be demonstrated [400 kV Barmer-II PS, 400 kV Barmer-I PS, 400 kV Fatehgarh-IV PS(Sec-2), 765 kV Beawar S/s, 765 kV Sirohi S/s, 765 kV Merta-II S/s, 765 kV & 400 kV Fatehgarh-III PS (Sec-2) PS, 400kV Bhinmal (PG)],[765 kV & 400 kV South Kalamb(Sec-

1,Sec-2,Sec-3),765 kV Pune-III,765 kV Boisar-II] for the following conditions:

(i) Single phase-to-ground faults, for five cycle, ten cycle, and twenty cycle fault clearing and with fault levels resulting in voltage reduction to 90%, 70%, 50%, 30%, 20%, and 5% of nominal converter AC bus voltage.

(ii) Three Phase-to-ground faults, for five cycle fault clearing, with fault levels resulting in voltage reduction to 90%, 70%, 50%, 30%, 20% and 0% of nominal converter AC bus voltage.

(iii) Zero impedance three phase 400 kV AC busbar faults at Barmer-II and South Kalamb which are cleared after five cycles and which result in the loss of one DC pole.

(iv) Three phases to ground, five cycle, and Single line to ground, ten cycle faults. The outage of components would include 400 kV single circuits, 400 kV double circuits if these are on same tower, generator, filter bank etc.

(v) Three phase to ground, five cycle, and Single line to ground, ten cycle faults following conditions when system is already running under single contingency and which result in outage of further system components. The outage of components would include 400 kV single circuits, 400 kV double circuits if these are on same tower, generator, filter bank etc. Under such conditions it shall be shown that the system stability is maintained although the time required for recovery may exceed the values given above. For certain cases if there is a need for run back condition on HVDC the same shall be evolved by the TSP.

42. DC Line Faults

The DC line fault protection sequence shall detect the fault, de-energize the faulted line Pole by control action, allow a time period for fault deionization (settable between 50 ms to 1000 ms), and then automatically attempt restoration of the DC power transfer on the Pole.

There shall be 2 full voltage restarts followed by 1 reduced voltage (80% DC voltage) restart attempt. All equipment shall be dimensioned keeping these 3 restart attempts in mind.
For mono-polar Metallic return, minimum one restart attempts shall be considered at full voltage and current corresponding to 20% overload operation.

The minimum total time to restore the DC power to 90% of the pre-fault DC power from the end of the deionization period shall not exceed 100 milliseconds (excluding the time allowed for deionization).

The system shall be designed and capable of the following:

a) During the DC line fault and deionization interval the power transfer on the non-faulted Pole shall be rapidly increased to the extent possible in order to minimize the impact on the DC power transfer.
b) On recovery of the faulted Pole the power transfer on both Poles shall resume the pre-fault values.
c) The transfer of power to the non-faulted Pole during the line fault clearing and recovery sequence shall occur even when the HVDC telecommunications are not in service.
d) The healthy Pole shall not fail commutation when a DC line faults occur on the other Pole or any time there after until the faulty Pole is back to normal operation.

The clearing and recovery of a DC line Pole fault shall be demonstrated in bipolar and monopolar mode at 1.0 pu power transfer prior to the fault for the particular mode. Faults shall be applied at the line ends and at the line midpoint in both power directions. The demonstration shall include the influence of the function provided to transfer power from the faulted Pole to the other Pole.

Suitable modeling of the DC line, which takes into account the electro-magnetic coupling between the Poles, shall be considered in the above studies.

DC reduced voltage restart shall be possible even when there is no telecommunication between rectifier and inverter stations.

43. Operation During Reduced AC Voltage Conditions

To assist in the recovery of the network, the Converter Stations shall be able to continue operation with reduced AC bus bar voltages.
In addition to the requirements of operation under over voltage conditions specified in this specification, the converter equipment shall be able to continue operating without blocking of converters with AC bus voltage reduced to voltage as depicted in the curve mentioned under LVRT Strategy at clause No.-14 “Insulation Co-ordination” during three phase faults, and to zero on one phase during single line to ground faults followed by voltage recovery to 80%. The gate control units shall be able to trigger the thyristor valve as soon as the voltage recovers after the AC bus voltage has dropped. The converters shall continue to transmit power to the extent possible under the above reduced voltage conditions. The valve firing system as well as all the cooling equipment shall be rated for these conditions. The cooling system shall not trip during AC system faults.

44. Controlled Shutdown

Each Pole shall be able to be shut down in a controlled manner by the

automatic reduction in the power order accompanied by appropriate AC harmonic filter bank switching. The block and isolation of a converter Pole shall be done without the block or shutdown of other Pole converters.

45. Power Runback

The controls shall be capable of achieving 90% of any step change requested by run-back modulation signals including within 200 milliseconds of receipt of the run-back signal.

46. Commutation Failure Performance

There shall be no commutation failures for the disturbances described below:

a) Disturbances resulting in AC voltage drops of 15% or less compared to the voltage prior to the disturbance. In this case, repetitive commutation failure shall not occur (though one or two commutation failure may occur).
b) Dynamic AC voltage swings of less than ±10% with an oscillation period of one second or longer.
c) Switching of any reactive element in the Converter Stations.
d) Energization of the converter transformer on the other Pole or any other AC transformer in the switchyard.
e) Sympathetic commutation failures shall not occur on the healthy Pole for faults on the other Pole.
f) The control system shall be designed to prevent multiple commutation failures after one commutation failure is detected.
g) The switching in and out or a tripping due to faults of a filter sub bank at the converter stations shall not result in a commutation failure, except for faults at 400 kV side of the filter sub bank.

47. Cyber security

The designed system shall be compliant with:

a) IEC-27001 Information security management
b) IEC-62443
c) CEA (Cyber Security in Power Sector) Guidelines, 2021

Cyber security shall be incorporated in the overall design of the HVDC controls, protection, communications, HMI and SCADA systems. The TSP shall propose a secure and robust design in the control and LAN systems, using next generation firewalls, dual firewall communication designs, routers, gateways, data diodes, etc. that have built in cyber secure measures.

48. Performance Guarantee for Converter Station (excluding HVDC line)

a) HVDC Station losses: The Guaranteed losses of HVDC converter stations shall include the no load loss and equivalent load loss. The equivalent load loss is the sum of load losses at specific loadings multiplied by weightage factors as per expected loading cycle. The Guaranteed losses shall be verified as per IEC 61803. The above losses shall be guaranteed at nominal DC voltage (± 800 kV at rectifier end) and nominal AC system Voltage (400 kV, 50 Hz) at ambient temperature of 40 °C and relative humidity of 50%.

b) No load loss shall be guaranteed corresponding to converter transformer set at principal tap## with nominal AC system voltage and nominal frequency. Also refer maximum guaranteed loss figures in table below:

c) The system shall meet various harmonic performance parameters on both AC side and DC side as well as the reactive power exchange limits on AC side as per these specifications while calculating the guaranteed losses.

d) Design targets for HVDC station Reliability and Availability^^ and station guaranteed losses^

Table 11

1	Overall Energy availability of HVDC scheme per Bipole of 3000 MW (a) Overall Performance (b) Excluding transformer	 Not less than 97% Not less than 98%
2	Forced Energy Unavailability (FEU) per Bipole of 3000 MW	Not more than 0.6%
3	Schedule Energy Unavailability (SEU) per Bipole of 3000 MW	Not more than 1%
4	Single Pole outage per station per year	Not more than 8 (with average outage duration of 7.5 hours)
5	Bipole outage per station per year	Not more than 0.2 (with average outage duration of 8 hours)
6	No-load operation losses per Station (kW)	0.1 % of Bipole Rating
7	Equivalent load loss per Station (kW)*	0.35% of Bipole Rating

* **Equivalent load loss**= Load loss at 1000 MW in kW*0.4 + Load loss at 1500 MW in kW * 0.16 + Load loss at 2500 MW in kW * 0.16 + Load loss at 3000 MW in kW * 0.28).

^ - These loss figures shall be calculated on per station and per bipole basis as per details mentioned in (a), (b), (c) and (d) of this clause.
^^The details for calculating Availability are mentioned in ***'Appendix C.4'.***
Principal tap is the Tap Position of converter transformers when HVDC converters shall be delivering 1 p.u. power (6000 MW) at nominal DC voltage at rectifier (± 800 kV) keeping AC system voltage 400 kV, 50 Hz at 40 ^{o}C ambient temperature and humidity of 50%.

For the loss guarantee stated above, following equipment/systems shall be considered:

e) Determination of losses

The total losses of the HVDC converter station shall be calculated as the sum of the losses determined for each individual equipment. The major components to be included in the loss calculation and guarantees and the method of assessment for each component shall be as follows:

1. Converter Transformers as per IEC 60076-57-129
2. DC Smoothing Reactors
3. Thyristor Valves as per IEC 61803
4. Reactive Power Equipment, AC FILTER
5. Auxiliary Power Transformers
6. DC Filters and 50 Hz blocking filter as per IEC 61803
7. Miscellaneous Losses for the following equipment shall also be included:
    a) Devices used for TOV suppression
    b) Direct current voltage transformer
    c) Surge capacitors
    d) RI & PLC filters

Specific Exclusion:

Equipment specifically excluded from the loss calculations shall be the oil treatment plant and firefighting load, station auxiliary system energy consumption (such as illumination of indoor and outdoor services, Air conditioning & ventilation system for control room, service building, kiosk, battery & battery charger etc.) except auxiliary power consumption required by Converter transformer cooling and Valve cooling system.

f) Guaranteed Failure Rate of Thyristors

The maximum annual guaranteed thyristor level failure rate shall not exceed 0.2% per 12 pulse valve group. The failure rate shall not include failures directly attributable to operating and maintenance errors.

g) AC/DC HV Filter Capacitor Failure Rate Guarantee

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

h) Flashover Guarantee

Flashover is defined as breakdown of insulation for self-restoring insulation media which leads to outage as defined elsewhere in this specification. TSP shall guarantee that there shall be not more than two pollution related flashovers per station per year for DC yards (base environmental conditions as given in this specification will be considered) for each Bipole separately. In case of a flashover, TSP shall make necessary investigations to establish the cause of the same, propose mitigation measures and implement the same. In case of flashover in common neutral area of both Bipoles, the flashover shall be counted in one of the Bipole with lesser number of flashover.

i) Guaranteed Failure Rate of Relay Module/ C&P Module/Component

The guaranteed failure rate of relay module/ C&P module/ component shall not be more than 0.5% (except 1st unit failure). This will include individual circuit boards but not computers. The failures directly attributable to operation & maintenance errors and other incidents unrelated to the DC system shall not be included in the calculation. The relay module/ C&P module/ component failure rate shall be monitored on per pole per station basis.

49. Commissioning and start of operation

The purpose of commissioning period is to demonstrate to the Nodal Agency satisfaction that the equipment is ready for its purpose and it functions satisfactorily under normal operating conditions. The testing and commissioning period will have the necessary duration to demonstrate the proper functioning of all the Project equipment and systems.

a) Site Testing

After the installation and preliminary adjustments of equipment, the Site tests shall be performed in the following stages:

- Erection checks
- Commissioning tests
- Sub-system tests
- Sub-system energization tests
- System tests

The site testing has been categorized in above stages for the sake of convenience only. There may be overlapping of two or more stages for particular tests. The TSP shall perform the site testing with complete responsibility.

The TSP shall provide all instruments, equipment and facilities required to perform these site tests. Calibration certificates for the test equipment shall be made available at site prior to the start of the testing.

All special and test equipment necessary to simulate devices or switching sequences and required for commissioning shall be provided by the TSP. Results of the site tests shall be well documented and shall form a part of plant documentation.

50. Mandatory Spares:

The mandatory spares for the HVDC Station shall be as per 'Annexure-B, 4. Mandatory spares for HVDC stations (substation/switchyard level)' of CEA's 'Guidelines for availability of spares and inventories for power transmission system, transmission lines & substation/switchyard) assets, 2020'.

The specific exclusion to the above list is Sl. No. 2.1, Converter Transformer and Sl. No. 3, Smoothing Reactor. Other Converter Transformer spares from Sl.No. 2.2. to Sl. No. 2.41 to be provided. The spare requirement for Smoothing Reactors shall be as per Clause 22 (d).

Minimum one No. (single phase two winding) spare Converter transformers of each type and rating per station, shall be provided. The spare Converter Transformers shall be inclusive of all fitments, hardware, bushings, as well coolers if mounted on the tank, accessories and oil complete in all respect.

51. HVDC building:

The Building shall comprise of but not limited to the following facilities:

1. Control & Relay Panel room
2. ACDB & DCDB room
3. Battery room
4. Service Room cum workshop

5. Valve hall
6. Cooling system room
7. AHU Room
8. Valve Hall Ventilation Room
9. Any Other room/facilities as per functional requirement

52. For Type Test requirement of equipment, CEA's 'Guidelines for the Type Tests for major equipment of Power Sector' is to be followed.

53. Applicable Standards:

All equipment and material shall be designed, manufactured, tested and commissioned in accordance with latest Indian Standards / IEC or IEEE standards, / CIGRE guidelines and the Acts, Rules, Laws and Regulations of India. Some of them are as follows:

Table 12

Sr. No.	Description	Standard
1	Terminology for HVDC transmission	IEC 60633
2	Thyristor valves for HVDC transmission	IEC 60700(1-2)
3	Performance of HVDC with line commutated converters	IEC 60919(1-3)
4	Determination of power losses in High-Voltage Direct Current (HVDC) converter stations with line-commutated converters	IEC 61803
5	High-Voltage Direct Current (HVDC) installations - System tests	IEC 61975
6	High-Voltage Direct Current (HVDC) systems - Guidance to the specification and design evaluation of reactive power exchanges	IEC 62001 (1-4)
7	Bushings for DC Applications	IEC 65700
8	Insulation Coordination	IEC 60071 (1- 5)
9	Application guide for metal oxide arresters without gaps for HVDC converter stations	CIGRE report 33/14-05
10	Converter transformers	IEC 60076-57-129
11	Power transformers - Part 6: Reactors	IEC 600076-6
12	Shunt capacitors for AC power systems having a rated voltage above 1000 V	IEC 60871-(1-4)
13	Semiconductor devices - Part 6: Discrete devices –Thyristors	IEC 60747-6
14	Fire aspects of HVDC thyristor valves and valve halls.	CIGRE-TB 136 1999 SC 14 TF 14.01.04

Sr. No.	Description	Standard
15	Guidelines for the system design of HVDC project	IEC/TR 63127 Ed. 1.0
16	High voltage direct current (HVDC) power transmission - System requirements for DC-side equipment - Part 1: Line-Commutated Converters	IEC/TS 63014 Ed. 1.0
17	Guidelines for operation and maintenance of HVDC converter station	IEC/TR 63065 Ed. 1.0
18	Guidelines on Asset Management for HVDC Installations	IEC/TR 62978 Ed. 1.0
19	Transformer for HVDC applications	IEC:60076-57-129
20	Surge Arresters – Metal Oxide Surge Arresters without gaps for HVDC converter stations	IEC60099-9-Part -9
21	CT's and VT's	IEC 61869
22	Disconnectors and Earthing Switches	IEC 62271
23	Cyber Security	IEC 62443 IEC 27001
24	UPS, SMPS and Other Power supply units	IEC 62040 IEC 61558
25	Other items as per relevant and prevailing standards specified elsewhere in the specification for substation works.	

Appendix- C.1

DC Voltage Measuring Equipment

A proven type of voltage divider shall be provided for DC voltage measurement. The accuracy of the device shall not vary more than 0.5% with an ambient temperature change of 50^{o} C. The overall voltage measuring system shall have an accuracy of at least 1.0% of full scale. The response time shall not be longer than 150 micro seconds, accepting an overshoot of up to 20% at that rise time. The measuring system shall achieve proper operation of the control and protection system to which it is connected.

The measurement range shall be sufficient to measure voltages up to 1.5 pu. Preference shall be given to devices which provide isolation between the HV primary connection and the output signal. If the output signal is not completely isolated from the HV connection, protection shall be provided to limit the possible output signal voltages to less than 2 kV in the event of a fault on the device.

All low-level signals shall be cabled separately from high level signals. The divider shall be so arranged that no leakage current on the surface of the insulator can pass to the measuring circuit. The insulator shall for this reason be continuous without any metallic intermediate flanges. Furthermore, the interior of the divider shall be so arranged that interior leakage currents do not influence the measurement.

For voltage measuring equipment to be erected in the outdoor switchyard, it shall be ensured that discharge activity on the housing shall not cause interference with the output signal.

For each voltage measuring device furnished, all necessary auxiliary power plus any equipment necessary for the transformation of the auxiliary power to an acceptable form shall be provided. Such transformation equipment shall be mounted in the control cubicles.

Direct Current Measuring Equipment

Direct Current Transducers supplied shall be mounted in bushings, if available. In locations where bushings are not available, free-standing transducers shall be provided. For each transducer furnished, the all-necessary auxiliary power plus any equipment necessary for the transformation of the auxiliary power to an acceptable form shall be provided.

The design of the measuring system shall be based on maximum interchangeability where any electronic module shall be compatible with any of the core and coil assemblies.

The transducer output signal shall be of sufficient magnitude to ensure that the content of the signal is usable at all levels of primary current from 1% to 300% of the rated current, with a measurement output possible up to 600% before saturation of the output signal occurs.

In the event of high current (up to 0.2s short circuit current), the DC CT shall remain unsaturated for 20 ms or longer. This time shall be measured from the instant the current attains 10 pu. The DC CT shall be provided with interlock circuits that indicate saturation of the DC CT, as well as DC CT faults.

It shall be ensured that any low-level signals generated are kept shielded from interference due to other higher voltage circuits. The low-level signals shall be cabled separately from high level signals.

It shall be ensured that all DC current measurement outputs are accurately calibrated with all the respective loads connected. If required, on-site adjustments to output calibration shall be possible. The sensitivity of the devices supplied for such calibration shall be appropriate for setting the required accuracy.

The electronic module shall be provided with interlock circuits to indicate that the measuring system is fully operable.
In case of Optical DC measuring system, the materials used in it shall be non-corrosive in nature.

Stationary Accuracy

The composite accuracy of all DC current measurement systems used for protective purposes shall be equal to or better than ±2% of rated DC current up to 120% of the maximum rated current and ±10% of rated DC current up to 1.2 times peak calculated fault DC current.

All DC current measuring system used for control purposes shall have a composite accuracy of ±0.75% of rated DC current from minimum rated current to 120% of the maximum rated current and ±10% of rated DC current from 120% up to 300% of the rated current.

All transducers used for corresponding functions, e.g. pole differential protection etc shall have matching accuracies equal to or better than ±2% of rated current up to 300% of the rated current.

Dynamic Accuracy

The response of the measuring systems shall be such that a linear current change within 150% of maximum rated current and with a rise time of 45 ms, is tracked by the transducer output with an error which does not exceed +0%, -2% of rated current on any point of the curve. The rise time is defined as the time required for the current to change from 10 to 90% of the full current change. The frequency response shall be within +3% at 1500 Hz.

Appendix C.2

Operator's Control, Monitoring and Support Systems

A. General Requirements

All hardware such as computers, computer peripherals/printers/ accessories, testing equipment etc and networking products shall conform to latest products based on industry standard. It shall be possible to fully monitor and control both stations as described below-

- Operation control of both converter station (from monitors) from South Kalamb
- Operation control of both converter stations (from monitors) from Barmer-II
- In separate operation control mode, all the terminals shall be able to control their own station individually.

The above selection modes shall be separately provided for control of the DC system and the AC systems of either station.

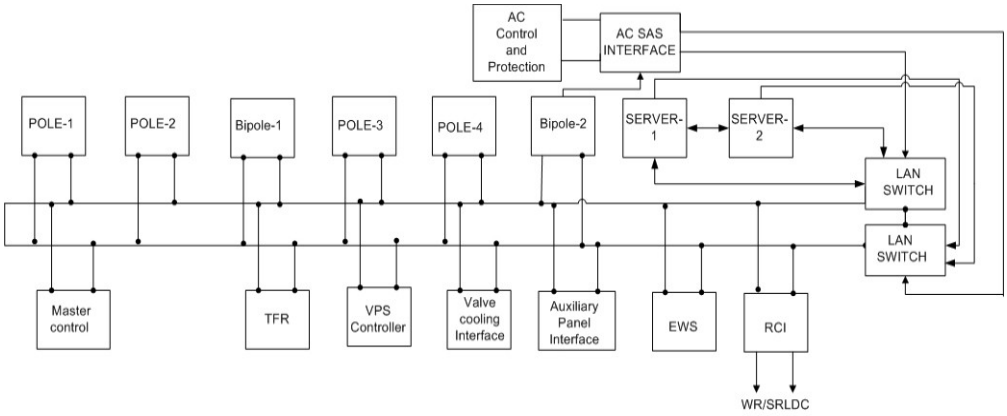
A Station operator desk to be supplied at each converter station shall be able to control the stations. The control shall be possible from TFT Monitors and operator key board/ mouse. In the event of failure of the system, control and monitoring shall be by means of direct control at the Bipole control panels, circuit breaker controls panels etc generally as shown in 'Figure-A'. This control could be made from PC connected to these control panels and necessary interface shall be provided to achieve this. The control functions to be provided from the equipment control panels shall include at least those listed under 'Table-A' and 'Table -B'. It shall also be possible for operator to know individual alarms by selecting the particular panel on the display monitor.

The TSP shall provide the equipment necessary for the purpose of control, status indication and metering of all equipment (keeping in view the intermediate Bay Kiosks to be provided in AC & DC yard,) at South Kalamb and Barmer-II.

The control room shall generally house the following equipment:

- Operator control, monitoring and support system
- DC line fault location equipment, if not integrated within C&P system.
- Transient fault recorders, if not integrated within C&P system.
- Master controller equipment, if not integrated within C&P system.

- Station fire alarm, control & monitoring panel



Typical station control and monitoring system

'Figure – A'

(System shall be redundant with system A and system B. Only one system has been represented.)

i. HVDC Controls

The station control room at each converter station shall have facilities that include, but not be limited to, the functions shown on Table-A and B

A description of major HVDC control functions is outlined below:

1. Controlling Station (Master Station) Selector Switch

Control location selector switches shall be provided in each station control room. These selector switches shall enable the operator to control the HVDC system and/or the HVAC yard of any converter station from either South Kalamb and Barmer-II stations. HVDC and HVAC yard control & monitoring of other converter station shall be provided from TFT Monitors.

2. Bipole Controls

Bipole controls shall refer to the common control functions that affect both poles in a Bipole. These functions are typically Bipole power order, power direction, power limit and power ramp rate.

The power flow over the Bipole shall be maintained at the Bipole power order as set by the operator.

The power ramp rate shall control the timing sequence for loading Bipole at a pre-selected rate (within specified range) set by the operator.

The power limit control shall enable the operator to set different limits to Bipole loading. It shall also be possible to operate each pole separately from Bipole Controls.

3. **Pole/Converter Current Order/Limit**

The power setting divided by voltage shall determine the current order to either pole. However, this shall not preclude the ability to control each pole, by means of a directly entered manual current order signal.

The pole current limit set point shall enable the operator to raise/ lower current limits to optimize link capabilities under varying conditions such as ambient temperature, temporary reduction in capability etc.

4. **HVDC System Control Mode Selection (Per Pole)**

The following basic control modes shall be provided:

a) Power Control Mode
b) Current Control Mode

Disturbance free transfer of any pole from one control mode to another shall be possible.

5. **Miscellaneous Operator Controls**

a) DMR (Dedicated Metallic Return) Line Current Null Control

This control shall enable the operator to null the current flowing in the DMR (Dedicated Metallic Return) Line resulting from unequal sharing of load between poles during balanced operation.

b) Block/ Deblock

This control shall enable the operator to stop (block) or start (deblock) a converter. Automatic sequences shall be provided to fullfil preconditions for deblock. A normal stopping sequence initiated by “block" contact involves a sequence at each end that causes the voltage and current to drop to zero.

c) Pole Start/ Stop

This control shall enable start or stop of the complete pole, comprising converters at either of the rectifiers and the inverter and shall take care of all interlocks, start/stop preconditions and sequences automatically.

d) Direction of Power Transfer

Power flow shall be possible in both directions.

e) Pole Metallic Return/DMR (Dedicated Metallic Return)/DMR-PMR parallel Mode

This selector switch (or switches) shall enable an automatic sequence from Pole metallic return to DMR and vice versa. This mode change shall be possible even with power flowing in the DC system. It shall also be possible to operate DMR & PMR conductors in parallel.

f) DC Filter Connect/ Isolate

Motorized disconnects are specified for switching the filter arms to allow disconnection of a faulty filter bank or arm and for restoration to service as quickly as possible. An automatic switching sequence shall be provided which shall take care of all the interlocks.

g) DC Line Isolator

DC line isolators are specified for maintenance purposes and their electrical operation in local shall be possible. Operation shall be permitted only with pole blocked and station ground connected. Automatic operation shall also be possible if required by any sequences subject to satisfying all interlocks permitting the operation.

h) Grounding Switches in DC Yard

Grounding switches are specified for the DC switchyard area to allow each isolatable section of bus to be grounded. Only local electrical operation is required. However, if operation of any grounding switches is part of any automatic sequence(s), or is specified elsewhere, then those grounding switch(es) shall be operable locally as well as remotely.

i) Valve Hall Ground Switches

Remotely controlled motor operated grounding switches are specified for the valve halls to protect maintenance personnel. The operation of all the valve hall ground switches together as a group shall be possible by initiating a sequence from the control room. Provision shall however be made (key operated switch) for defeating the interlock to permit entry of authorised personnel into the restricted area of the valve hall.

j) Maintenance/Bypass Isolators for Metallic Return Transfer Switch / Bus (MRTS or MRTB)

Electrically local operated isolators shall be provided to establish a ground reference when MRTS is being maintained. These shall be interlocked with the MRTS.

k) Emergency Stop

An emergency stop button on pole basis shall be provided in the control room. Operation of this button shall automatically ramp down at a fast rate the direct power, lead to blocking of the converters and reach safe shut down with Operation of High speed parallel/ De-parallel switches.

l) HVAC Controls

HVAC controls shall consist of close-open operations for circuit breakers and motor operated disconnectors.

ii. Station Control Facilities

The TSP shall provide the control facilities from the operator control desk through a TFT monitor and keyboard/ mouse system. These facilities shall include all control operations, digital setting, indicating devices, Station single line diagram and symbols, any other special control devices and meters required for control and monitoring of the complete HVDC system. The layout of the station single line diagram, together with control, indicating and metering devices on the control desk shall be logical, compact, and shall facilitate efficient supervision and operation of the station(s) by the operator.

iii. Station Level Status Supervision

The position of each switchgear e.g. Circuit breaker, isolator, earthing switch, transformer tap changer etc shallbe supervised continuously. Every detected change of position shall immediately be displayed in the single-line diagram on the station screen, recorded in the event list and an option to take hard copy printout of event list shall be available. Alarms shall be initiated in the case of spontaneous position changes.

The switchgear positions shall be indicated by two auxiliary switches, normally closed (NC) and normally open (NO), which shall give ambivalent signals. An alarm shall be initiated if these position indications are inconsistent or if the time required for operating mechanism to change position exceeds a predefined limit.

iv. System Indications and Power Measuring Facilities

The TSP shall provide DC and AC system / equipment indication facilities in the station control room at each converter station that shall include, but not be limited to, the functions shown on Table A and Table B. Alarms of slave stations shall be indicated and displayed both at Master Station and slave stations and vice-versa.

3-Dimensional graphic representation of thyristor valves and valve cooling piping network shall be provided on station monitoring system. The graphical

representation shall also display faulty thyristors in different colours indicating faulty thyristor position.

Pressure, temperature and relative humidity of each valve hall shall also be displayed in the control room. Alarm(s) shall be raised in case any of the parameters exceed limits.

'Table A' provides a list of minimum AC and DC metering facilities required, which shall be included on TFT monitors.

v. Energy Metering

Energy meters as per relevant CEA Guidelines and Specifications/Regulations for the 765 kV, 400 kV, 220 kV & 132 kV AC switchyards (as applicable) and 33 kV feeders at HVDC terminals shall be provided by the TSP.

B. System Requirements

General

The main control and monitoring systems shall be configured as dual redundant computer-based systems in a main and hot standby configuration generally as shown in 'Figure A'. The operator control, monitoring and support system could be integrated with station control system. Outage of any subsystem or complete loss of one system shall not affect the control and monitoring of the HVDC station. The system shall be based on open system concept in hardware and software and industry standard communication protocols and graphical user interface.

The redundant, computer-based system shall accept control inputs from the Operator by means of TFT monitor/ mouse etc and send these commands to the HVDC and the HVAC control systems.

The system shall gather alarm, status and measurand data from the plant and display it to the Operator on the mimic diagram on TFT monitors, loggers etc as further defined below. The system shall be so designed that no alarm and status data or control data shall be lost.

Table -A Controls & Indications at South Kalamb and Barmer-II:-

Sl. No.	Signal Name	South Kalamb	Barmer-II
	CONTROLS SIGNALS		

Sl. No.	Signal Name	South Kalamb	Barmer-II
1.	Bipole power order	√	√
2.	Bipole power order ramp	√	√
3.	Bipole power order limit	√	√
4.	Bipole power/current control	√	√
5.	Power direction P1.P3, P2.P4	√	√
6.	Power/Current control	√	√
7.	Current order setting	√	√
8.	Current ramp start/stop	√	√
9.	Current order ramp setting	√	√
10.	Current limit setting	√	√
11.	Master station transfer	√	√
12.	Metallic/DMR switching	√	√
13.	Reduced voltage on/off P1, P2,	√	√
14.	Start/Stop & Block/deblock P1,	√	√
15.	Power Swing modulation on/off	√	√
16.	DC power /current control	√	√
17.	Emergency stop P1, P2, P3, P4	√	√
18.	Frequency control/on/off	√	√
19.	Frequency target/limits	√	√
20.	Connect/isolate P1, P2, P3, P4	√	√
21.	Joint/separate, Sync/Async	√	√
22.	DC Filter connect/isolate P1, P2,	√	√
23.	RPC auto/man off switching	√	√
24.	RPC Volt/Reactive Selection	√	√
25.	RPC MVAr/Voltage set points	√	√
26.	Open line test auto/man P1.P3,	√	√
27.	AC Filter (bank/ sub-bank)	√	√
28.	Conv. Trans Breaker	√	√
29.	AC Filter (bank/sub-bank)	√	√
30.	Con. Trans Disconn open/close	√	√
31.	Tap changer auto/man P1, P2,	√	√

Sl. No.	Signal Name	South Kalamb	Barmer-II
32.	Valve hall Gr. Switch open/close	√	√
33.	South Kalamb Sw. yard Breaker	√	√
34.	Barmer-II Sw. yard Breaker open	√	√
	INDICATIONS		
35.	DC OP Mode Pwr./current	√	√
36.	Gr/metallic return indication.	√	√
37.	Power direction P1.P3, P2.P4	√	√
38.	Pole Telecommunication healthy	√	√
39.	Pole blocked/deblock P1, P2,	√	√
40.	Master station South Kalamb-Barmer-II- LDC	√	√
41.	DC Station overload in use	√	√
42.	Power ramp in progress	√	√
43.	Stabilization control on/off	√	√
44.	Full/reduced DC voltage	√	√
45.	Tap changer Auto/Man	√	√
46.	Pole connect/isolate indication.	√	√
47.	Power direction normal/reverse	√	√
48.	Runback activated indication.	√	√
49.	Frequency control on/off	√	√
50.	Frequency control activated	√	√
51.	AC bay Circuit breakers	√	√
52.	AC bay disconnectors indication.	√	√
53.	AC Filter (Sub-bank) Circuit	√	√
54.	AC Filter (Sub-bank)	√	√
55.	DC filter con/isolated indication.	√	√

Table -B Indication Signals to RLDC

S.No	Signal Name	RLDC
1.	Bipole power order	√
2.	Power Swing modulation on/off	√

3.	DMR/metallic return indication. P1.P3, P2.P4	√
4.	Pole blocked/deblock P1, P2, P3, P4	√
5.	Runback activated indication.	√
6.	Frequency control on/off	√
7.	Frequency control activated	√
8.	Full/reduced DC voltage indication.	√
9.	AC bay Circuit breakers indication.	√
10.	AC bay disconnectors indication.	√
11.	DC Power Bipole	√
12.	DC Line current/ voltage P1.P3, P2.P4	√
13.	AC side A/MW/MVAR/ P1, P2, P3, P4	√
14.	AC Filter/Cap A. Mvar all banks	√
15.	AC Lines A/MW/MVAR/	√
16.	Station/AC system MW exchange	√
17.	Station/AC System MVAR exch.	√
18.	AC Bus Voltage	√
19.	AC Bus Frequency	√

The system shall also be designed to allow input of signals from the Dispatch centre - for example, load frequency control (LFC) signals. The system shall be capable of meeting the control and monitoring requirements of each converter station and LDC while operating at maximum rating, with a reserve capacity of minimum twenty-five per cent. Equipment bins that are not fully equipped with cards shall be fully wired and be ready to accept additional cards. Power supply units shall be rated to meet the full capacity requirements.

C. Functional Requirements

1. General

The redundant computer-based system shall be a highly reliable integrated system, which shall provide Operator's interface, alarm and monitoring system and operator guidance/ expert system.

The high-voltage apparatus within the station shall be operated from different places:

- Remote control centres
- Station operator control.
- Local Bay controller IED (in the bays)

Operation shall be possible by only one operator at a time. The operation shall depend on the conditions of other functions, such as interlocking, synchro-check etc.

2. **Run Time Command Cancellation and Self-Supervision**

Command execution timer (configurable) must be available for each control level connection. If the control action is not completed within a specified time, the command should get cancelled. Continuous self-supervision function with self-diagnostic feature shall be included.

3. **User Configuration**

The monitoring, controlling and configuration of all input and output logical signals and binary inputs and relay outputs for all built-in functions and signals shall be possible both locally and remotely.

It shall also be possible to interconnect and derive input and output signals, logic functions, using built-in functions, complex voltage and currents, additional logics (AND-gates, OR gates and timers). (Multi-activation of these additional functions should be possible).

The Functional requirement shall be divided into following levels:

a) Bay Level Functions.
b) System Level Functions.

D. Computer Information System Requirement:

A computer-based information system shall perform following functions:

- Initiation of commands to control HVDC system.
- Control and monitor the Valve cooling system.
- Monitoring of process data to give brief overview as well as a comprehensive view of each subsystem.

- Sequence of event recording and alarm system including determination of Event Categories (major, warning, alarm).
- Process data archiving and trending.

Soft copy of complete station documentation shall be available on Operator Work Stations.

All the system trends shall be available at least for one-year period and retrievable on demand from the main storage system. The process data

logging shall have hourly/ daily logging of station data. Archiving and back up storing facility of the log sheets shall be possible and facilities taking backup on External hard discs/ Drives minimum 2 tera bytes shall be provided.

E. Remote Control, Monitoring and Tele Control systems

The TSP shall provide facilities for coordinated control and monitoring of the HVDC system. All required remote control and remote monitoring facilities shall be provided at each converter station. Complete remote monitoring of each converter station shall be possible from opposite converter station. The HVDC tele-control system equipment shall be used in the processing of signals to be transmitted over the fibre optic communication system between the converter stations of Bipolar scheme.

Appendix C.3

Transient Fault Recorders

1. General

The transient fault recorders (TFR) shall continuously monitor the power system. These could be integrated with operator control and monitoring system or supplied as standalone units.

Below requirements are specified for standalone units. Similar functional requirements will be applicable for integrated TFR.

One recorder per pole shall be provided at each converter station. The TFR may be provided in the form of central unit together with Data Acquisition Units (DAUs). Initiation by any one of the fault detecting sensors or external initiating contacts shall cause the fault recorder to record on all channels. The record shall comprise-fault information, time of fault information and post fault information. The TSP shall determine the number of analog and event inputs required for each recorder and supply these number plus minimum 25% spare channels. The TFR shall also have facility for harmonic analysis upto 50th harmonics of waveforms. Recorders shall be of solid-state modular construction microprocessor based and without moving parts. First in, first out (FIFO) printing logic shall be used. The necessary software for directly analyzing the records on the memory of the TFR shall also be supplied.

Facilities shall also be provided for data retrieval from TFR and analyse by means of a master station based on compatible PC having minimum configuration of 2.8 GHz clock speed, 1 TB hard disc & 16 GB RAM capacity, complete with 24-inch LED monitor, keyboard/ mouse etc and include laser colour printer with capability to print on A3 and A4 size paper. All necessary software package(s) along with facility to communicate between TFR & PC shall be provided by the TSP.

2. Input Signals

The input signals and starting sensors required for the HVDC system for commissioning and operation shall be determined by the TSP. The input signals to each fault recorder system for a pole shall include, but not be limited to, the following:

- Valve group firing pulse markers;
- Valve group ignition delay angle response;
- Valve group voltage;
- Pole current order;
- DC line voltage (own pole);

- DC line voltage (other pole);
- DC neutral Bus voltage (Both poles)
- DC line current (own pole);
- DC line current (other pole);
- DC power (each pole and both converters)
- DC power (other pole and both converters)
- Current order
- AC bus voltage (3 phases);
- AC current to each valve group and transformer primary currents.

The Triggering of TFR shall include, but not be limited to following inputs:

- Pole Block/ Deblock
- Pole Commutation Fail
- Pole Firing pulse loss
- Pole last Breaker opened
- Pole DC Protection Voltage level trigger
- Pole DC Protection dv/dt triggger
- Pole di/dt
- Pole 30 minutes, 2 hours and 5 seconds overload operated
- Pole MR/ GR sequence initiated
- AC Over voltage/ under voltage Protection operated.
- Full voltage/ RVO Changeover
- I_{dc} Limit by VDCOL
- DC O/V, U/V
- Telecommunication Fail

Each fault recorder shall be equipped with suitable input circuits and starting sensors for all of the input signals. The TSP shall ensure that the characteristics of the input circuits and starting sensors are well matched to the characteristics of the signal sources.

3. Electrical Characteristics

(i) Monitoring Systems

The recorder shall be a digital based type. Operation of the equipment shall be based on programs stored in non-volatile solid-state memory. Programs shall be stable and no inadvertent change of program(s) shall occur.

The recorder shall be equipped with a built-in post fault record- length timer, adjustable over a range of 0.5 to 10 seconds after the fault.

Normally open operation alarm contacts shall close while the fault recorder system is operating and be utilized as inputs to the alarm monitoring and reporting system. A three digit, manually resettable operations counter shall be provided that indicates the number of faults or disturbances recorded.

Facility for automatic storage of information to a PC or an independent storage device (e.g. a disc drive) shall be provided. The output shall be possible to be printed on plain paper in the A4/A3 format.
The recorded information shall include but not necessarily be limited to:

- Station Identification
- Identity of trigger source
- Record Identification for Analog, Event and Sensor traces
- Date/ Time: Year, Day, Hour, Minute, Second, Millisecond
- Analog traces
- Event traces
- Sensor traces
- Time marker trace which shall allow time interpolation of records to 2 ms.
- Start of record line.

(ii) Operations

The fault recorder shall continuously monitor the power system. Initiation by fault detecting sensors or by other input contacts or pre-selected events shall cause that particular recorder to record the fault information. The other pole recorder shall also record in a slave mode. Operation of any one of the initiating sensors shall start the recording mechanism or otherwise cause all channels to record until the fault clears or the record-length timer setting is exceeded.

The transient fault recorder shall have facility for suitable interface for transmission of recorded analog and digital information to a remote station. This shall be demonstrated by the TSP at site by using inter-station communication.

(iii) Input Circuitry

The input circuits for the recording channels shall be insulated for operation at potentials of 2000 Vrms between channels and between channel and ground. Each input recording channel shall be capable of operating from the

output of 1A rms nominal secondaries of current transformers and capacitive voltage transformers with 63.5 V rated secondary. Each channel shall be supplied with a selection of current shunts and voltage multipliers to provide a range of high and low current or voltage ranges which can be selected by straps or similar method. The recorder shall also be capable of operating from the DCCT's and direct voltage devices supplied for the station. Any device required for processing of input signals in order to make them compatible to the equipment shall form an integral part of the supplied equipment. However, such processing of input signals shall in no way distort its waveform. The equipment shall be carefully screened, shielded, earthed and protected as may be required for its safe functioning. It shall be possible to position the reference point of any of the analog channels to any position on the record. The individual traces shall be identified on the record by numbering them in the order they are connected at the input.

The current values of scaling parameters related to the various channels shall be printed on each printout to enable quick interpretation of the records.

(iv) Starting Sensors

The initiating or detecting devices, which start the recording, shall be solid state and automatic self-resetting type.
Each sensor shall be equipped with an indicating lamp, viewable from the front of the cabinet, which operates when the sensor operates. The lamp shall remain 'on' until reset by the station operator. Failure to reset the lamp shall not affect subsequent operation of the sensor. Sensor settings shall be easily adjustable and easily accessible. One starting sensor for at least each of the following types of changes shall be provided.

- Level Changes Over Current Over Voltage Under voltage
- Swing Rate of change of nominal input
- Frequency
- Under frequency
- Over frequency

It shall be possible to adjust the response time of the sensors, in each case, to ensure the most rapid operation consistent with the characteristics of the analogue quantity being monitored.

It shall also be possible to initiate the fault recording, as required, by additional external relay contacts, either NO or NC.

(v) Pre-fault Periods

The recording system shall accurately record power system transient disturbances with a pre-fault period, which shall be settable between 50 to 250 ms.

(vi) Memories

Sufficient memory shall be provided to prevent any loss of records under all normal operating circumstances.

(vii) Time

A means shall be provided to record on the chart the time of occurrence of each fault or disturbance to a resolution of 2 milliseconds or better. The time clock shall be synchronized with the station master clock signal. Facility shall exist to display the time in hour, minutes and seconds on the front of the panel.

(viii) Calibrations

The recording system shall be so designed that each channel may be calibrated separately. Calibration shall be accomplished by applying the calibration level input in the test switches. Controls and switches shall be provided on the front panel to facilitate calibration.

(ix) Resolutions

a) Analog resolution

Analog to digital conversion shall be 12 bits (minimum). The amplitude of the recording shall be adjustable and magnification in fixed steps, of the recording, shall be provided.

b) Events Resolution

The event resolution at the lowest scan rate shall be two milliseconds or better.

c) Transient Response (analog channels)

The transient response delay of the analog input conditioning circuits to a step function input shall be less than 400 microseconds between 10% and 90% values of the step function with overshoot of the final value of the step function being not more than 2%.

(x) Recording Quality

Static trace width	1.5 mm maximum
Residual channel noise	0.1% of full-scale maximum at 50 Hz or any harmonic thereof
Recording resolution	0.1% of full scale
Phase error between channels	Less than 5 degrees at 50 Hz
Crosstalk	Lower than 50 dB (DC to 1500 Hz)

Scale alteration/ expansion facilities shall be provided.

(xi) Alarm Circuits and Indicators

Alarm circuits shall be provided to indicate inability for automatic operation due to power failure, out of paper condition, incorrect switch positioning or other failure(s), which shall be prominently visible on the recorder panel. Each alarm circuit shall include a normally open contact which shall be integrated into the station alarm monitoring and reporting system.

(xii) Power Requirements

The recording system shall be suitable for operation from the station battery supply. There shall be no loss of accuracy in the recording system for specified variations of DC input voltage.

Appendix C.4

DEFINITIONS

OUTAGE TERMS

1. Outage

   The state in which equipment or a unit of equipment is unavailable for normal operation due to an event directly related to the same equipment or some unit of equipment.

2. Scheduled Outage

   Scheduled outage is an outage which can be scheduled at least one week in advance. This includes planned maintenance, normally conducted on annual basis, and also unplanned maintenance or repair which can be deferred at least one week subsequent to discovery of the need for maintenance or repair. If the outage is extended due to additional work which would have otherwise caused a forced outage, the excess period is counted as a forced outage.

3. Forced Outage

   The state in which equipment is unavailable for normal operation, but is not in the scheduled outage state, i.e. an outage which is not a scheduled outage.

4. Pole Outages

   An outage which causes a reduction in the Bipole DC power system transfer capacity equal to or less than the power rating of one pole

5. Bipole Outages

   An outage which causes a reduction in the bipolar DC system power transfer capacity greater than the power rating of one pole

CAPACITY TERMS

1. Maximum Continuous Capacity (Pm)

   The maximum bipolar HVDC system capacity (MW) for which continuous operation under normal conditions is possible referred on to the rectifier DC bus, i.e. 3000 MW.

2. Outage Capacity (Po)

   The capacity reduction in MW which the outage would have caused if the HVDC system were operating at its maximum continuous capacity (Pm) at the time of the outage.

3. Outage Derating Factor (ODF)

   The ratio of outage capacity (Po) to maximum continuous capacity (Pm). ODF = Po/Pm

OUTAGE DURATION TERMS

1. Actual Outage Duration (AOD)

   The time elapsed in hours between the start and the end of an outage. The time shall be counted to the nearest 1/10th of an hour. Time less than 1/10 of an hour shall be counted as having duration of 1/10 of an hour.

2. Equivalent Outage Duration (EOD)

   The actual outage duration (AOD) in hours, multiplied by the outage derating factor (ODF), so as to take account of partial loss of capacity.

   EOD = AOD x ODF

   Each equivalent outage duration may be classified according to the type of outage involved, i.e. equivalent forced outage duration (EFOD) and equivalent scheduled outage duration (ESOD).

TIME CATEGORIES

1. Period Hours (PH)

   The number of hours in the reporting period.

   In a full year the Period Hours are 8760 h (8784 h for a leap year). If the equipment is commissioned part way through a year the period hours shall be proportionately less than 8760 h. (This shall not be applicable for verification of guarantees).

2. Actual Outage Hours (AOH)

   The sum of actual outage durations within the reporting period

AOH = ∑ AOD

The actual outage hours (AOH) may be classified according to the type of outage involved, i.e. AFOH and ASOH.

3. Equivalent Outage Hours (EOH)

The sum of all equivalent outage durations within the reporting period.

EOH = ∑ EOD

The equivalent outage hours may be classified according to the type of outage involved, i.e. equivalent forced outage hours (EFOH) and equivalent scheduled outage hours (ESOH).

If outage duration overlaps the beginning or end of a reporting period, only the EOD which lie within the reporting period shall be included in EOH.

AVAILABILITY AND RELIABILITY TERMS

1. Energy Unavailability (EU)

Energy unavailability is a measure of the energy which could not have been transmitted due to (scheduled & forced) outages. The impact of overload capability of the individual poles shall not be considered for calculating the Energy unavailability.

Energy Unavailability % (EU) = EOH/PH x 100

Forced Energy Unavailability % (FEU) = EFOH/PH x 100

Scheduled Energy Unavailability % (SEU) = ESOH/PH x 100

2. Energy Availability (EA)

A measure of the energy which could have been transmitted except for limitations of capacity due to outages, arising from any cause, either forced or scheduled.

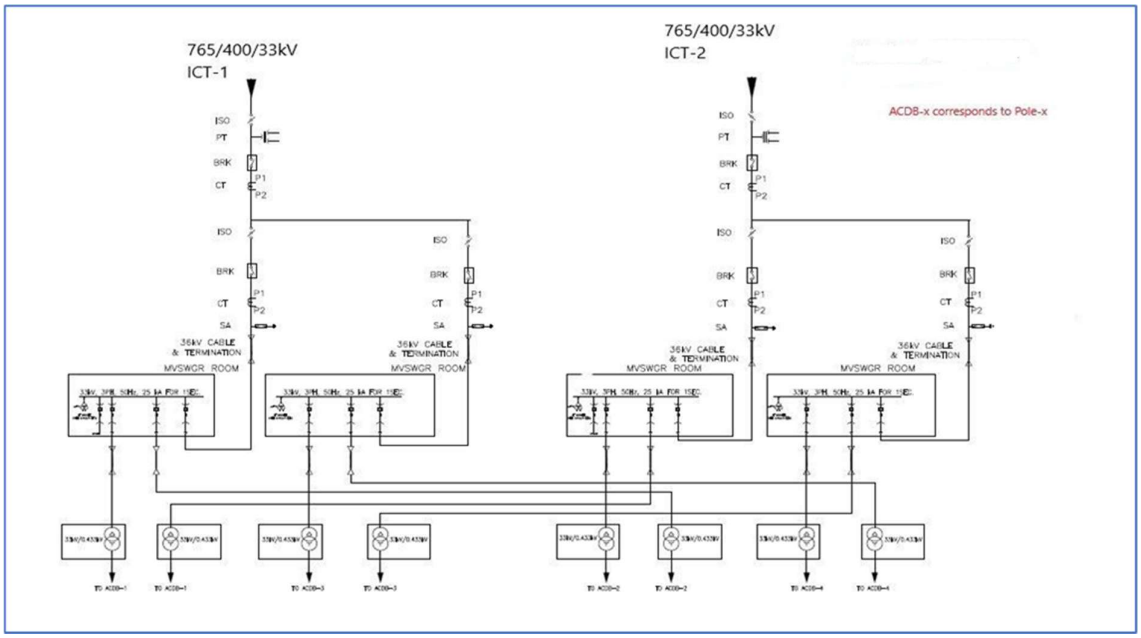
Energy Availability % (EA) = (100 - EU)

3. Energy Utilisation (U)

A factor giving a measure of energy actually transmitted over the system.

Energy Utilisation % (U) = [Total energy transmitted/ (Pm x PH)] x 100]

Appendix-C.5


765/400/33kV
ICT-1
765/400/33kV
ICT-2
ACD8-x corresponds to Pole-x
ISO
PT
BRK
CT
P1
P2
SA
36kV CABLE & TERMINATION
MVSWGR ROOM

SPECIFIC TECHNICAL REQUIREMENTS FOR HVDC TRANSMISSION LINE

A.1.0 The design, routing and construction of HVDC transmission lines shall be in accordance with 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.2.0 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.2.1 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.2.2 Towers shall be designed as per IS-802:2015, however the drag coefficient of the tower shall be as follows: -

Solidity Ratio	Drag Coefficient
Upto 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.3.0 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.4.0 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.5.0 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.6.0 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.

a) For power line crossing of 400 kV or above voltage level (if crossed over the existing line), large angle & dead-end towers (i.e. D/DD/QD) shall be used on either side of power line crossing.

b) 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.

c) 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.

d) For crossing of railways, national highways and state highways, the Rules/Regulations of appropriate authorities shall be followed.

A.7.0 The relevant conductor configuration shall be as follows: -

i. Type of conductor: ACSR / AAAC / AL59

Basic parameters for Transmission Line associated with HVDC Bipole link:

Transmission line	**ACSR Conductor**	**AAAC conductor based on 53% conductivity of AL Alloy**	**Minimum size of AL59 conductor based on 59% conductivity of AL Alloy**	**Minimum size of AL59 conductor based on 59% conductivity of AL Alloy**	**Sub-conductor Spacing**
±800 kV HVDC	Lapwing: Stranding				

Transmission line	**ACSR Conductor**	**AAAC conductor based on 53% conductivity of AL Alloy**	**Minimum size of AL59 conductor based on 59% conductivity of AL Alloy**	**Minimum size of AL59 conductor based on 59% conductivity of AL Alloy**	**Sub-conductor Spacing**
transmission lines *(hexa bundle configuration per pole)*	45/4.78 mm-Al + 7/3.18 mm-Steel; 38.22 mm diameter; 807.5 mm^2, Aluminium area; Maximum DC Resistance at 20°C (Ω/km): 0.0358; Minimum UTS: 188.69 kN	Stranding details: 61/4.38mm, 39.5 mm diameter; 921 mm^2 Aluminium alloy area; Maximum DC Resistance at 20°C (Ω/km): 0.0361; Minimum UTS: 244.0 kN	Stranding details: 61/4.36 mm, 39.2 mm diameter; 910 mm^2 Aluminium alloy area; Maximum DC Resistance at 20°C (Ω/km): 0.0326; Minimum UTS: 199.0 kN	Stranding details: 61/4.17 mm, 37.53 mm diameter; 833 mm^2 Aluminiu m alloy area; Maximum DC Resistance at 20°C (Ω/km): 0.0356; Minimum UTS: 181.96 kN	457 mm

Transmission line	ACSR Conductor	AAAC conductor based on 53% conductivity of AL Alloy	Minimum size of AL59 conductor based on 59% conductivity of AL Alloy	Minimum size of AL59 conductor based on 59% conductivity of AL Alloy	Sub-conductor Spacing
Twin Lapwing transmission lines for DMR *(2 Nos. Dedicated Metallic Return line with Twin bundle configuration)*	Lapwing: Stranding 45/4.78 mm-Al + 7/3.18 mm-Steel; 38.22 mm diameter; 807.5 mm^2 Aluminium area; Maximum DC Resistance at 20°C (Ω/km): 0.0358; Minimum UTS: 188.69 kN	Stranding details: 61/4.38mm, 39.5 mm diameter; 921 mm^2 Aluminium alloy area; Maximum DC Resistance at 20°C (Ω/km): 0.0361; Minimum UTS: 244.0 kN	Stranding details: 61/4.36mm, 39.2 mm diameter; 910 mm^2 Aluminium alloy area; Maximum DC Resistance at 20°C (Ω/km): 0.0326; Minimum UTS: 199.0 kN	Stranding details: 61/4.17 mm, 37.53 mm diameter; 833 mm^2 Aluminium alloy area; Maximum DC Resistanc e at 20°C (Ω/km): 0.0356; Minimum UTS: 181.96 kN	450 mm

Note: *The transmission lines have to be designed for a maximum operating conductor temperature of 85 ^oC.*

A.8.0 The required pole to pole spacing shall be governed by the tower design as well as minimum live metal clearances under different insulator swing angles. However, the spacing between Pole and DMR shall not be less than 9.7 m and pole to pole clearance shall not be less than 22.0 m. Also, the DMR line shall be placed above the pole.

A.9.0 All electrical clearances including minimum live metal clearance, ground clearance and minimum mid span separation between earth wire and conductor shall be as per Central Electricity Authority (Measures Relating to Safety & Electric Supply) Regulations, 2023 as amended from time to

time and relevant Indian Standards. For the clearances which are not included in CEA Regulation/ Indian Standard, following values shall be considered:

1) Minimum live metal clearances for ±800 kV line:

a.(i) Swings and Clearances:

Wind pressure Condition	Minimum electrical clearance
a) Swing angle (0º)	7.7 m
b) Swing angle (21º)	6.5 m
c) Swing angle (53º)	2.0 m

a.(ii) Swings and Clearances: For Jumper

Wind pressure Condition	Minimum electrical clearance
a) Swing angle (0º)	7.7 m
b) Swing angle (25º)	6.5 m
c) Swing angle (72º)	2.0 m

a.(iii) Swings and Clearances: For Jumper with pilot insulator

Wind pressure Condition	Minimum electrical clearance
a) Swing angle (0º)	7.7 m
b) Swing angle (25º)	6.5 m
c) Swing angle (66º)	2.0 m

b) (i) Minimum ground clearance for AL 59 conductor (61/4.17 mm, 37.53 mm diameter): 19 m

(ii) Minimum ground clearance for other conductors: 18 m

c) Minimum mid span separation between earthwire and Pole conductor: 12.0 m

2) Minimum live metal clearances for DMR line:

a) Swings and Clearances:

Wind pressure Condition	Minimum electrical clearance
a) Swing angle (0º)	1.53 m

b) Swing angle (15º)	1.53 m
b) Swing angle (30º)	1.37 m
d) Swing angle (45º)	1.22 m
e) Swing angle (60º)	1.07 m

b) Minimum mid span separation between earthwire and DMR conductor: 6.1 m

A.10.0 Shielding angle shall not exceed 10 deg for Pole and 30 deg for Dedicated Metallic Return.

A.11.0 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. However, minimum size of Galvanized Stranded Steel (GSS) shall be 7/4.5 mm & diameter 13.50 mm.

A.12.0 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.13.0 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 & 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.14.0 Transmission line route shall be finalized, in consultation with appropriate authorities soas to avoid the habitant zones of endangered species and other protected species. Bird diverters, wherever required, shall be provided on the line. In order to optimize the route use of GATISHAKTI platform shall also be made.

A.15.0 The transmission lines shall be designed with porcelain/glass/ Composite Insulators as per site pollution severity level in the concerned area. However, minimum creepage distance and insulator length shall be as per follows:

Sl. No.	Description	Type of Insulator	Insulator for ±800 kV HVDC Transmission Lines	Insulator for 132 kV Dedicated Metallic Return Conductor
1.	Minimum Creepage Distance for both Light and Medium as well as for Heavy and very heavy pollution level	Composite Insulator	50400 mm	8000 mm
	Minimum Creepage Distance for Light and medium pollution level	Porcelain/Glass Insulator	37760 mm	5550 mm
2.	Minimum length of insulator	--	As per design requirement	2550 mm

A.16.0 Wherever, transmission lines are passing through cyclone prone areas (i.e. areas upto 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 gram/m^2 of surface area except for plates and sections below 5 mm thickness which shall have a minimum overall zinc coating of 610 gram/m^2 of surface area. The average zinc coating for all sections and plates of 5 mm and above thickness 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/m^3.

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/m^2 per coat shall be applied on all exposed faces of foundation (i.e. pedestal & base slab).

d) Double coat of 20 mm thick cement plaster shall be provided on all exposed concrete surface up to 300 mm below ground level to give 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.17.0 The raised chimney foundation is to be provided in areas prone to flooding/water stagnation like paddy field /agricultural field & 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 HFL (High Flood Level) 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.18.0 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.19.0 The TSP shall abide by the Guidelines of CEA w.r.t. shifting of transmission lines for NHAI projects and other projects.

A.20.0 Safety precautions in regards to gas/oil pipe lines in vicinity of Transmission lines shall be taken in coordination with gas/ petroleum authorities.

A.21.0 The stringing of the transmission line in the forest area shall be carried out through drones.

A.22.0 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 HVAC TRANSMISSION LINE

A.1.0 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.2.0 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.2.1 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.2.2 Towers shall be designed as per IS-802:2015, however the drag coefficient of the tower shall be as follows: -

Solidity Ratio	Drag Coefficient
Upto 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.3.0 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.4.0 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.5.0 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.6.0 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 railways, national highways and state highways, Regulations of appropriate authorities shall be followed.

A.7.0 The relevant conductor configuration shall be as follows: -

Type of conductor: ACSR / AAAC / AL59

Basic parameters:

Transmission line	**ACSR Conductor**	**Equivalent AAAC conductor based on 53% conductivity of Al Alloy**	**Equivalent AL59 conductor based on 59% conductivity of AL Alloy***	**Sub-conductor Spacing**
400 kV D/C (Quad Bundle) transmission lines	**Moose: Stranding** 54/3.53mm-Al + 7/3.53 mm-Steel; 31.77 mm diameter;	**Stranding details:** 61/3.55mm 31.95mm diameter; 604 mm^2, Aluminium alloy area;	**Stranding details:** 61/3.31 mm 29.79 mm diameter; 525 mm^2, Aluminium alloy area;	457 mm

Transmission line	ACSR Conductor	Equivalent AAAC conductor based on 53% conductivity of Al Alloy	Equivalent AL59 conductor based on 59% conductivity of AL Alloy*	Sub-conductor Spacing
	528.5 mm^2, Aluminium area; Maximum DC Resistance at 20°C (Ω/km): 0.0549; Minimum UTS: 159.60 kN	Maximum DC Resistance at 20°C (Ω/km): 0.05506; Minimum UTS: 159.80 kN	Maximum DC Resistance at 20°C (Ω/km): 0.0566; Minimum UTS: 124.70 kN	

Note:

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

A.8.0 The required phase to phase spacing and horizontal spacing for 400 kV line shall be governed by the tower design as well as minimum live metal clearances for 400 kV voltage level under different insulator swing angles. However, the phase to phase spacing for 400 kV lines shall not be less than 8 m.

A.9.0 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 400 kV line:

a) (i) Under stationary conditions:

From tower body: 3.05 m

(ii) Under Swing conditions

Wind Pressure Condition	Minimum Electrical Clearance
a) Swing angle (22º)	3.05 m
b) Swing angle (44º)	1.86 m

b) Minimum ground clearance: 8.84 m

c) Minimum mid span separation between earthwire and conductor for 400 kV line: 9.0 m

A.10.0 Shielding angle shall not exceed 20 deg for 400 kV transmission line.

A.11.0 The Fault current for design of line shall be 63 kA for 1 sec for 400 kV.

A.12.0 In case of 400 kV 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 Standard Steel (GSS) or Aluminum Alloy Conductor Steel Reinforced (AACSR) conductor type or any other suitable conductor type depending upon span length and other technical consideration.

A.13.0 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 at tension tower for direct earthing of both shield wires. If site condition demands, multiple earthing or use of earthing enhancement compound shall be used.

A14.0 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 flooddischarge 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.15.0 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. Bird diverters, wherever required, shall be provided on the transmission line. In order to optimize the route use of GATISHAKTI platform shall also be made. A.16.0 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 gram/m^2 of surface area except for plates and sections below 5 mm thickness which shall have a minimum overall zinc coating of 610 gram/m^2 of surface area. The average zinc coating for all

sections and plates 5 mm and above thickness shall be maintained as 127 microns and that for plates and sections below 5 mm thickness 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/m^3.

c) The surface of the reinforced steel may 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/m^2 per coat shall be applied on all exposed faces of foundation (i.e. pedestal and base slab).

d) Double coat of 20 mm thick cement plaster shall be provided on all exposed concrete surface up to 300 mm below ground level to give 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.17.0 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 HFL (High Flood Level) 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.18.0 Routing of transmission line through protected areas of India shall be avoided to the extent possible. In case, it is not possible to avoid protected areas, the towers of the transmission line upto 400 kV level which are installed in protected areas shall be designed for Multicircuit (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 & BPC by the TSP.

A.19.0 The TSP shall abide by the Guidelines of CEA w.r.t. shifting of transmission lines for NHAI projects and other projects.

A.20.0 Safety precautions in regard to gas/oil pipelines in vicinity of Transmission lines shall be taken in coordination with gas/ petroleum authorities.

A.21.0 The stringing of the transmission line in the forest area shall be carried out through drones.

A.22.0 The tower shall be designed considering the porcelain Insulators with creepage factor of 31 mm/ kV irrespective of type of insulator used.

A.23.0 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 HVAC SUBSTATION

The **proposed HVDC and 400/220 kV HVAC Barmer-II S/s** shall be conventional Air Insulated Substation (AIS) type generally 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 of 765/400 kV South Kalamb S/s shall be conventional Air Insulated Substation (AIS) type generally 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 upto 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	400/220 kV Barmer-II S/s		Extn. of 765/400 kV South Kalamb S/s	
		400 kV System	220 kV System	765 kV System	400 kV System
1.	System operating voltage	400 kV	220 kV	765 kV	400 kV
2.	Maximum voltage of the system (rms)	420 kV	245 kV	800 kV	420 kV
3.	Rated frequency	50 Hz	50 Hz	50 Hz	50 Hz
4.	No. of phase	3	3	3	3
5.	Rated Insulation levels				
i)	Lightning Impulse withstand voltage for				

Sl. No.	Description of parameters	400/220 kV Barmer-II S/s		Extn. of 765/400 kV South Kalamb S/s	
		400 kV System	**220 kV System**	**765 kV System**	**400 kV System**
	(1.2/50 micro sec.) - for Equipment other than Transformer and Reactors - for Insulator String	1425 kV p 1550 kV p	1050 kVp 1050 kVp	2100 kV p 2100 kV p	1425 kV p 1550 kV p
ii)	Switching impulse withstand voltage (250/2500 micro sec.) dry and wet	1050 kV p	-	1550 kV p	1050 kV p
iii)	One-minute power frequency dry withstand voltage (rms)	630 kV	-	830 kV	630 kV
6.	Corona extinction voltage	320 kV	-	508 kV	320 kV
7.	Max. radio interference voltage for frequency between 0.5 MHz and 2 MHz	1000 micro-volts at 266 kV rms	1000 micro-volts at 156 kV rms	2500 micro-volts at 508 kV rms	1000 micro-volts at 266 kV rms
8.	Minimum creepage distance for insulator string/ longrod insulators/	13020 mm (31 mm/ kV)	7595 mm (31mm/ kV)	24800 mm (31 mm/ kV)	13020 mm (31 mm/ kV)

Sl. No.	Description of parameters	400/220 kV Barmer-II S/s		Extn. of 765/400 kV South Kalamb S/s	
		400 kV System	220 kV System	765 kV System	400 kV System
	outdoor bushings				
9.	Minimum creepage distance for switchyard equipment	10500 mm (25 mm/ kV)	6125 mm (25 mm/ kV)	20000 mm (25 mm/ kV)	10500 mm (25 mm/ kV)
10.	Max. fault current	63 kA	50 kA	50 kA	63 kA
11.	Duration of fault	1 Sec	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	220 kV side
400/220 kV Barmer-II S/s	--	One & Half breaker	Double Main and Transfer
Extn. of 765/400 kV South Kalamb S/s	One & Half breaker	One & 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 the 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) 400 kV Bus Sectionalisers shall be placed such that each section shall have even distribution of Poles, ICT, Feeders and filter bank(s)/sub-bank(s) so as to have maximum operational flexibility.

iv) HVDC Bipole -1 and Bipole-2 shall be on two different 400 kV bus sections.

v) 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 numbers of feeders.

vi) 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.

vii) Space for 765 kV and 400 kV future line bays shall be kept considering provision of switchable line reactors as per the scope of work.

viii) One (1) set of bus sectionalizer for 400 kV shall comprise 2 Nos. of bus sectionalizer bays with associated Circuit Breakers, Isolators and Current Transformers for both Main-I and Main-II buses.

ix) *One (1) set of bus sectionalizer for 220 kV shall comprise 2 Nos. of bus sectionalizer bays with associated Circuit Breakers, Isolators and Current Transformers for both buses.*

x) TSP shall plan the distribution 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.

xi) 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.

xii) ***Barmer- II S/s****:*

400 kV Bus Sectionalization and space provision shall be with the following feeder distribution.

400 kV Bus Section-1	**400 kV Bus Section-2**	**400 kV Bus Section-(Future)**
a) 3 Nos. of present 400/220 kV ICT b) 1 No. of present Bus Reactor c) 4 Nos. of present 400 kV Line d) 2 Nos. of present 400 kV Line (RE interconnection) e) 1 No. present SynCon along with 400 kV bay (1 No.) f) 2 Nos. of future 400 kV Line along with switchable line	a) 3 Nos. of present 400/220 kV ICT b) 1 No. of present Bus Reactor c) 2 Nos. of present 400 kV Line d) 2 Nos. of present 400 kV Line (RE interconnection) e) 1 No. present SynCon along with 400 kV bay (1 No.) f) 2 Nos. of future 400 kV Line along with switchable line	a) 3 Nos. of future 400/220 kV ICT b) 1 No. of future Bus Reactor c) 6 Nos. of future 400 kV line bay (2 Nos. with switchable line reactor) d) 1 No. future SynCon along with 400 kV bay e) 1 set future sectionalizer

400 kV Bus Section-1	400 kV Bus Section-2	400 kV Bus Section-(Future)
reactor g) 1 No. future STATCOM along with 400 kV bay (1 Nos.)	reactor g) 1 No. future STATCOM along with 400 kV bays (1 No.) h) 1 No. future SynCon along with 400 kV bays (1 No.) i) 1 No. of future 400/220 kV ICT	

200 kV Bus Sectionalization and space provision shall be with the following feeder distribution

220 kV Bus Section-1	*220 kV Bus Section-2*	*220 kV Bus Section-3(Future Space Provision)*
a) 3 Nos. of 400/220 kV ICT b) 4 Nos. of 220 kV Line (for RE connectivity) c) 1 No. Bus coupler & 1 No. Transfer Bus coupler	a) 3 Nos. of 400/220 kV ICT b) 3 Nos. of 220 kV Line (for RE connectivity) c) 1 No. of 220 kV future Line bay d) 1 No. Bus coupler & 1 No. Transfer Bus coupler e) 1 No. of future 400/220 kV ICT	a) 3 Nos. of future 400/220 kV ICT b) *4 Nos. of 220 kV future Line bays* *c) 1 No. Bus coupler & 1 No. Transfer bus coupler* *d) 01 No. sectionaliser bay*

xiii) Extension of South kalamb S/s:

765kV Bus Sectionalization and space provision shall be with the following feeder distribution

765 kV Bus Section-1	765 kV Bus Section-2	765 kV Bus Section-3 (Future)
a) 04 Nos. 765 kV line (existing)	**a) 3 Nos. of present 765/400kV ICT**	*a) 4 Nos. of future 765/400kV ICT*

765 kV Bus Section-1	765 kV Bus Section-2	765 kV Bus Section-3 (Future)
b) 02 Nos. 765/400 kV ICT (existing) c) 02 Nos. 765 kV Bus Reactor (existing) **d) 1 No. of present 765/400 kV ICT** *e) 1 No. of future 765/400 kV ICT*	**b) 2 Nos. of present 765 kV Bus Reactor** *c) 1 No. of future 765/400 kV ICT* *d) 4 Nos. of future 765kV line along with switchable line reactor*	*b) 2 Nos. of future 765 kV line along with switchable line reactor* *c) 2 Nos. of future 765 kV Bus Reactor*

400kV Bus Sectionalization and space provision shall be with the following feeder distribution

400kV Bus Section-1	400kV Bus Section-2	*400kV Bus Section-3 (Future)*
a) 2 No. of 765/400 kV ICT (existing) b) 2 Nos. of 400 kV Line (existing) c) 2 Nos. of 400 kV Bus Reactor (existing) **d) 1 No. of present 765/400 kV ICT** **e) 2 Nos. for present interconnections for (2x1500 MW) for 6000 MW, ± 800 kV South Kalamb (HVDC) [LCC] terminal station** *f) 1 No. of future 765/400 kV ICT* *g) 6 Nos. of future 400 kV Line*	**a) 3 Nos. of present 765/400kV ICT** **b) 2 Nos. of present 400 kV Bus Reactor** **c) 2 Nos. for present interconnections for (2x1500 MW) for 6000 MW, ± 800 kV South Kalamb (HVDC) [LCC] terminal station** *d) 1 No. of future 765/400 kV ICT* *e) 6 Nos. of future 400 kV Line*	*a) 4 Nos. of future 765/400 kV ICT* *b) 8 Nos. of future 400 kV Line* *c) 4 Nos. of future 400/220 kV ICT* *d) 2 Nos. of future 400 kV Bus Reactor*

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 minimum capacity.

Sl. No.	Description of bay	400/220 kV Barmer-II S/s		Extn. of 765/400 kV South Kalamb S/s	
		400 kV	220 kV	765 kV	400 kV
1.	Bus Bar	4000 A	3000 A	4000 A	4000 A
2.	Line bay	3150 A	1600 A	--	--
3.	Converter bay	3150 A	--	--	3150A
4.	ICT bay	3150 A	1600 A	3150 A	3150 A
5.	Bus Reactor bay	3150 A	--	3150 A	3150 A
6.	Bus Sectionaliser bays	4000 A	3000 A	--	--
7.	Bus Coupler bay	--	3000 A	--	--
8.	Transfer Bus coupler bay	--	1600A	--	--

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 website.

Connection arrangement for utilization of existing Spare Single Phase Transformer unit:
TSP shall make the arrangement of present ICT bank in such a way that the existing spare unit can be utilized for Transformer bank under present scope without its physical movement.

B.2.2 400/220 kV Autotransformer

500 MVA 400/220 kV, 3-phase Autotransformer 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.

B.2.3 (765/√3) kV, Single Phase Shunt Reactor

110 MVAr, 765/√3 kV, 1-Phase Reactor (including arrangement for 3-phase bank formation of 330 MVAr) 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.

Connection arrangement for utilization of existing Spare Single Phase Reactor unit:

TSP shall make the arrangement of present bank in such a way that the existing spare unit can be utilized for Reactor bank under present scope without its physical movement.

B.2.4 420 kV, 3-phase, Shunt Reactor

125 MVAr, 420 kV, 3-Phase Reactor 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.

B.2.5 765 kV, 400 kV and 220 kV AIS Substation equipment (as applicable)

B.2.5.1 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 and 60 ms for 220 kV circuit breakers. 765 kV, 400 kV and 220 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 ohms maximum with 9 ms insertion time or with Controlled Switching Device (CSD). The Circuit breakers controlling 400 kV lines shall be provided with pre insertion closing resistor of about 400 ohms with 8 ms insertion time or with 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 and in Main and Tie circuit breakers of line with non-switchable line reactors, bus reactors and Transformers of voltage class 400 kV and above voltage class.

B.2.5.2 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 and 220kV 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 and 220 kV shall be of extended mechanical endurance class - M2 as per IEC-62271-102. Isolator rated for 220 kV shall be suitable for bus transfer current switching duty as per IEC-62271-102. Main blades and earth blades shall be interlocked and interlock shall be fail safe type. 765 kV, 400 kV and 220 kV earth switch for line isolator shall be suitable for induced current switching duty as defined for Class-B.

B.2.5.3 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) and 220 kV Current Transformers shall have five cores (four for protection and one 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 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 upto 400 kV and less than 10 for CTs of 765 kV voltage class.

B.2.5.4 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 and 220 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.2.5.5 Surge Arresters (AIS)

624 kV336 kV Station High (SH) duty and 216 kV Station Medium (SM) duty gapless type Surge Arresters with thermal energy (Wth) of minimum 13 kJ/kV, 12 kJ/kV and 7 kJ/kV conforming to IEC 60099-4 in general shall be provided for 800 kV, 420 kV and 245 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 Reactor 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.2.6 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 IEC 61850 protocol with RTU/SAS/IEDs of different OEMs. All numerical relays shall have built in disturbance recording feature.

The protection circuits and relays of the 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, 400 kV and 220 kV shall have Main-I numerical three zone distance protection scheme with carrier aided inter-tripping feature. 765 kV, 400 kV and 220 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 Fiber 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 owner.

Further, all 765 kV, 400 kV and 220 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 and 400 kV lines shall also be provided with two stages 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, 400 kV and 220 kV transmission lines, directional IDMT earth fault relay should be provided as standalone unit or in-built feature of Main-I and Main -II feature.

In case of 220 kV line bays where the line lengths are not indicated, Numerical Distance protection relay as Main–I and Line Current differential relay (with back up distance protection feature) as Main-II shall be provided. Further, in such case, the matching line current differential relay for remote end shall be provided by the remote end bay owner.

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.

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) 765 kV and 400 kV 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, 400 kV and 220 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 future bays envisaged i.e. input/ output modules for future bays for the bus section under present scope shall also be provided.

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

In case, the bus section is provided, then each side of bus section shall have separate set of bus bar protection schemes.

Peripheral Units (PUs) shall be provided by the respective bay owner.

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, 400 kV and 220 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.2.7 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 fiber 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 the new substations, the Substation Automation System (SAS) shall be suitable for the operation and monitoring of the complete substation including proposed future bays/elements.

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

In the 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 and processing equipment required to receive time signal through GPS/NavIC 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 operation & maintenance of substations as described below shall be provided at new substation. In existing substation, these facilities have already been provided and would 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 220 V 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.

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

iv) 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.

v) At new substation, sizing of battery and battery chargers shall be done based on the number of bays specified (including future bays).

vi) 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 & 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.

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 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 also.

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 Control Concept

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

B.3.7 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), 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.4.0 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 conductor for 765 kV, Quad conductor 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 requirements/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 gm/m^2 however, for coastal/ creek regions it shall be at least 900 gm/m^2 (if applicable).

e) In 400kV and 765 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 the Highest Flood Level (HFL), it shall be ensured that there is no seepage , leakage or logging of water.

h) As per CEA (Technical Standards for Construction of Electrical Plants and Electric Lines) Regulations, 2022 and CEA Manual on Transmissions Planning criteria 2023, Line approaching substation shall normally be perpendicular to the substation boundary for a stretch of 2-3 kms. 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

Bidder is also advised to visit the substation sites and acquaint themselves with the topography, infrastructure such as the requirement of roads, cable trench, drainage and also the design philosophy.

SPECIFIC TECHNICAL REQUIREMENTS FOR SYNCHRONOUS CONDENSER

1. INTRODUCTION

This technical specification for Synchronous Condenser Stations consists of Synchronous Condenser (SynCon) units alternatively referred to as Synchronous Compensator where a SynCon unit consists of one synchronous condenser along with associated step-up transformer (s), cooling systems, flywheels (if applicable), auxiliary system and all associated switchgears.

Synchronous Condenser shall provide Inertia, Short Circuit support, continuous and dynamic supply of reactive power (capacitive and inductive) support for the regulation and stabilization of the voltage of 400 kV at Point of Common Coupling (PCC) under normal and transient conditions. The station shall operate in the leading and lagging MVAr region, as required to meet the specified inertia, short circuit requirements and reactive power capability curve and dynamic performance criteria.

The SynCon primarily shall be designed for continuous operation under varying grid conditions. The SynCon shall be equipped with a digital AVR (Automatic Voltage Regulator), Under/Over Excitation Limiters (UEL/OEL), V/Hz protection, and high inertia flywheels (if applicable) to enhance transient stability and damping.

The SynCon Station may consist of multiple identical synchronous condenser units, each operating in parallel and connected to the 400 kV HV bus (PCC), as per the design and space available. The design shall ensure compliance with grid code requirements, and the provision of inertia and fault current to support reliable and stable system operation.

1.1 Definitions

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

PCC (Point of Common Coupling): Point of Common Coupling (herein also called as Point of Interconnection (POI) is the connection point between the Synchronous Condenser (SynCon) Station/plant (HV Side of step-up transformer) and ISTS at which performance requirements are defined.

Reference Voltage (Vref): The voltage set-point at the PCC where SynCon is expected to regulate voltage by injecting or absorbing reactive power while maintaining system stability.

MV (Medium Voltage): The voltage level at the low-voltage side of the step-up transformer, where SynCon and associated equipment are connected.

SynCon (Synchronous Condenser): SynCon is a DC-excited Synchronous machine that runs at no load and is used to control reactive power, which improves voltage stability and power factor in electrical grids

In the entire document the notion synchronous condenser refers to the synchronous machine installed in the **Synchronous Condenser unit**. The synchronous condenser shall be connected to the step-up transformer via the generator circuit breaker by an Isolated Phase Bus duct.

Following convention is used in this specification to define the reactive power output of the *Synchronous condenser unit*:

a) The notion **capacitive reactive power** (indicated as "+ MVAr") is used when the Synchronous condenser unit is injecting reactive power to the grid, i.e. when the synchronous condenser is operating in the overexcited capability range.
b) The notion **inductive reactive power** (indicated as "- MVAr") is used when the Synchronous condenser unit is absorbing reactive power from the grid, i.e. when the synchronous condenser is operating in the under excited capability range.

SynCon Unit (Synchronous Condenser Unit): In the entire document *Synchronous condenser unit* refers to the full scope of equipment working as one system at PCC. It includes but is not limited to:

(i) Synchronous Condenser and its auxiliaries.
(ii) Excitation System (Static/Brushless)
(iii) Flywheel and its auxiliaries, if option chosen
(iv) Step-up Transformers
(v) Generator Circuit Breaker (GCB)
(vi) Unit Transformer (Auxiliary Transformers)
(vii) Isolated Phase Bus Duct (IPBD) connecting Generator and Step-up Transformer
(viii) Lube Oil System
(ix) Auxiliary Power Supply (medium voltage/ low voltage)
(x) Equipment for control and protection of the equipment supplied under the specifications.

(xi) Reactive Power Oscillation Damper (RPOD)
(xii) Cooling System
(xiii) Other auxiliary systems required for power operation of the Synchronous Condenser.
(xiv) SynCon starting system (SFC/Pony motor)

AVR (Automatic Voltage Regulator): A digital control system associated with each SynCon Unit responsible for regulating the field excitation to maintain the terminal voltage or reactive power output, always fully redundant, this is channel A and B in terms of control and power circuits, with hot standby and automatic switch functionalities. AVR shall include functionalities like:

(a) UEL (Under Excitation Limiter): A protective function or control logic that prevents the SynCon from operating in unstable or under-excited regions of the capability curve, avoiding excessive reactive power absorption.

(b) OEL / OVEL (Over Excitation Limiter): A protection system that limits the field current to prevent thermal damage to the field winding during overexcited operation (i.e., high reactive power generation).

Flywheel: A rotating mechanical mass connected to the SynCon shaft to increase its inertia and provide additional damping and system strength benefits.

Step-up Transformer: A Transformer connecting the SynCon (MV side) to the ISTS (400 kV side i.e. PCC), designed to match voltage levels and system impedance characteristics.

Capability Curve: The operational envelope of the SynCon showing the permissible limits of reactive power generation or absorption with respect to voltage at PCC and stator current.

Lagging Operation: Operation in which the SynCon absorbs capacitive reactive power (under-excited operation).

Leading Operation: Operation in which the SynCon generates capacitive reactive power (over-excited operation).

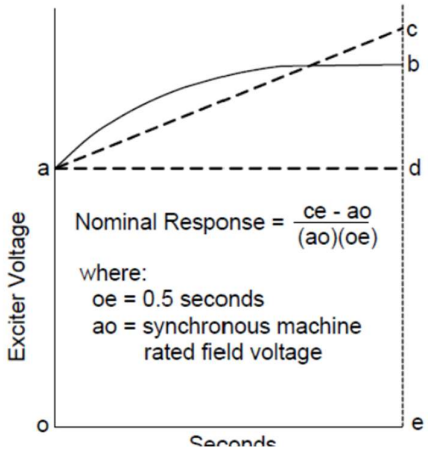
Response Time: The duration from a step change in control signal until the voltage changes by 90% of its final change, before any overshoot.

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

Overshoot: The maximum system output minus the final settled value, divided by the actual change in system output (i.e., from its initial value to the

final settled value), when the final settled value is within the defined settling band, expressed as a percentage.

Excitation response ratio: It is called the excitation system nominal response and defined as the rate of increase of the excitation system output voltage determined from the excitation system voltage response curve, divided by the rated field voltage. This rate, if maintained constant (curve ac), would develop the same voltage-time area as obtained from the response (curve ab) over the first half-second interval (unless a different time interval is specified). The RR is a measure of the speed of response for the excitation system, the higher the RR, the faster the response



Response ratio

Reactive power oscillation damper (RPOD): A reactive power oscillation damper (RPOD) implemented through control strategy designed to damp low-frequency electromechanical oscillations (typically 0.2–2 Hz) in power systems by modulating the SynCon reactive power output (Q) in response to system oscillations. When equipped with an excitation control system and a power oscillation damping (POD) controller, it can also actively damp oscillations in the grid by modulating its reactive power.

1.2 APPLICABLE STANDARDS

Unless otherwise specified herein, the plant shall be in accordance with the latest edition and amendments of Indian Electricity Grid Code (IEGC), CEA Technical Standards, appropriate International Electrotechnical Commission (IEC) and Institute of Electrical and Electronics Engineers (IEEE) standards operative at the Reference Date. In particular, the plant shall comply with the following Standards (as applicable):

CEA (Technical Standards for Connectivity to the Grid) and as amended time to time

IEC 60034 - Rotating Electrical Machines

IEC 60255-27 - Measuring relays and protection equipment (Product safety requirements)

IEEE C50.13 - Cylindrical-rotor 50 Hz and 60 Hz Synchronous Generators 10 MVA and Above

IEEE 115-Guides for Test Procedures for Synchronous Machines

IEEE 43 - Recommended Practice for Testing Insulation Resistance of Electrical Machinery

IEEE C37.013 - IEEE Standard for AC High-Voltage Generator Circuit Breakers Rated on a Symmetrical Current Basis

IEEE 421.5-2016 (IEEE Recommended Practice for Excitation System Models for Power System Stability Studies)

IEEE Std 1110-2019 - IEEE Guide for Synchronous Generator Modeling Practices and Parameter Verification

IEEE PES TR (2020) - Dynamic Performance and Application of Synchronous Condensers for Renewable Integration. (A technical report (not standard), but it explicitly describes the use of reactive power modulation for oscillation damping, with control block examples).

2. SCOPE OF WORK

The scope of works comprises the design, supply, factory testing, delivery, installation, commissioning and testing of the synchronous condenser unit (s), each of which comprises the key elements, but not limited to, the following:

(a) One XX MVA synchronous condenser (or as close as possible to this size) including rotor, stator, shaft, bearings, and base frame in case of cylindrical rotor or stator frame sole plates in case of salient pole solution, Excitation System & Voltage Regulating Equipment including Automatic Voltage Regulator (AVR), Power System Stabilizer (QSS) and Field Circuit Breakers for steady-state and dynamic voltage support

(b) Instrumentation, Monitoring and Control Systems including local and remote monitoring, diagnostic tools, and condition monitoring systems

(c) Slip Rings and Carbon Dust Extraction System (if static excitation

system)

(d) One bank of three single phase transformer or three phase transformer XX MVA, xx / 400 kV step up transformer (size and secondary voltage to be finalised by the supplier, in accordance with the size of the offered synchronous condenser units) along with one spare (spare can be common for all the SynCon units), with secondary winding(s), complete with bushing CTs. Spare shall be of same rating as that of the main 1-ph or 3-ph transformer.

The synchronous condensers step-up transformers are to have continuous ratings that support sustained operation at all operating points on the reactive power capability curve

(e) 400 kV side bay equipment

(f) Bus duct (isolated) between the power transformer and the synchronous condenser

(g) Medium voltage generator circuit breaker complete with disconnectors, surge arresters, earth switches and instrument transformers (voltage to be confirmed by the supplier, in accordance with the size of the synchronous condenser units)

(h) Protection Systems including differential, overcurrent, under/overvoltage, out-of-step, loss-of-excitation, and backup protections.

(i) Static frequency converter (SFC) as per requirement

(j) Pony motor (s) for start–up (if required) and associated variable frequency drives

(k) Fly wheel (s) for increased inertia (as per requirement)

(l) One station transformer for auxiliary supplies in case one independent source of Auxiliary Power is a Station Transformer (this will be in common to all SynCon units)

(m) Unit Transformer (Auxiliary Transformers)

(n) LV auxiliary supply complete with back up supply

(o) LV surge arresters

(p) Control, SCADA and protection systems housed in a dedicated room inside the synchronous condenser building

(q) Fire walls and enclosures – as required by the fire and oil/water containment, or noise mitigations

(r) Any other equipment for completion of the complete installation of the synchronous condenser

(s) SynCon Building (PEB - Pre-Engineered Building) – (Common machine hall for SynCons of all the SynCon Station is acceptable to reduce the requirement of the number of EOT Crane.)

Each equipment shall be type tested. Further, in respect of type test, CEA's 'Guidelines for the Type Tests for Major Equipment of Power Sector' shall be followed.

2.1 System Studies and Compliance

The TSP shall be responsible for conducting system studies including steady-state, transient stability, dynamic simulations, and electromagnetic transient studies to evaluate the impact of Synchronous Condenser operation on the grid.

The Grid data required for the studies shall be provided by CTU.

All study files and reports shall be documented and submitted to **CEA/CTU/GRID-INDIA** as per regulatory requirements.

SynCon unit shall be designed to operate at rated MVAr capacity upto an ambient temperature of 40^{o} C. Beyond ambient temperature of 40^{o} C, TSP shall provide the derating curve, however, derating rate shall not be more than 1% of rated MVAr per degree Centigrade. There shall not be any impact on rated Short circuit current and Inertia due to increase in ambient temperature beyond 40^{o} C. OEM/TSP shall submit temperature to MVAr derating curves (continuous & time limited). The SynCon shall be designed to support grid operation within a voltage range of ±10% and a frequency range of **47.5 Hz to 52 Hz at the PCC**.

2.1.1 System Studies

The TSP/supplier of Synchronous Condensers unit shall carry-out system studies in order to verify and demonstrate that the synchronous condensers units shall meet the specified performance requirements.

Load flow studies shall be performed in the initial stage to determine the optimal synchronous condensers units operating point for different system conditions.

The TSP/supplier of Synchronous Condensers unit shall perform studies to determine and confirm the design ratings and requirements of all plant and material to be supplied under this RfP.

The TSP/Supplier Synchronous Condensers may also refer IEEE Std 1110-2019 - IEEE Guide for Synchronous Generator Modelling Practices and Parameter Verification

System studies shall be performed as per the requirement. Studies are required to demonstrate that the synchronous condensers units shall meet all specified performance criteria.

When performing the designs, the following shall be considered:

1. All modes of operation specified in these specifications; and
2. The worst-case system conditions up to and including first contingency outage in the network.

The load flow and dynamic file shall be provided to the TSP in PSS/E 36 or newer version format.

PSS/E files are provided based on the data available at the time of issuance of RfP. TSP is required to validate the data before carrying out simulation. However, clarification, if any, may be sought before the bid submission. CEA/CTU shall endeavour to give clarification to the extent possible. In case of any discrepancy observed/non-availability of data for any of the machines and other control devices, typical values may be used in the studies with the intimation to CEA/CTU. The final tuning of generic parameters for various applicable scenarios shall be under the scope of TSP of the subject cited project. TSP after SPV transfer shall do the final tuning in consultation with CEA, CTU and Grid-India and share the converged dynamic files with CEA, CTUIL & Grid-India.

RMS & EMT Models shall be submitted in the format stipulated by CTUIL/ Grid-India.

2.1.2 Steady state operation study

The TSP/Supplier of Synchronous Condensers unit shall carry out such electrical studies and basic design studies as are required to design the synchronous condensers units. They shall perform design and verification studies to ensure adequate design and operation of the system.

This study comprises the verification of the design of the synchronous condenser units with respect to the steady-state performance. The steady-state operating points of the synchronous condenser units shall be simulated at the specified voltage range.

The main purpose of the steady state studies shall be:

1) Confirm short circuit capability including transformer

2) Confirm design of transformer OLTC and control settings

3) Demonstrate reactive capability including transformer under range of operating conditions

The operating points shall be represented as voltage/MVAR diagram. The load flow study points shall be also graphically included to determine the reactive power capability chart for the synchronous condenser units as built at the high voltage side of the step-up transformers. Additionally, steady-state voltages, currents and power through main components shall be demonstrated. The worst-case stresses of the individual components which occur on the operating points are input parameters for the component specification.

In addition to above following study shall also be carried out.

1) Open circuit and short-circuit characteristics tests
2) Negative sequence impedance tests.

Following test as indicated in “IEEE 115-Guides for Test Procedures for Synchronous Machines” shall also be carried out.

Test No.	Test Name	Purpose / Determination	Key Reference (IEEE 115-2019)
1	Visual & Mechanical Inspection	Verify nameplate data, connections, physical condition, alignment, cooling system, bearing, and mechanical integrity.	Clause 6.1
2	Insulation Resistance & Polarization Index	Measure stator and field insulation condition using a megger test (1 min and 10 min readings).	Clause 6.2
3	Measurement of DC Resistance	Determine stator winding resistance (per phase) and field winding resistance for copper loss calculation.	Clause 6.3

Test No.	Test Name	Purpose / Determination	Key Reference (IEEE 115-2019)
4	No-Load Saturation Curve (Open-Circuit Characteristic, OCC)	Plot generated voltage vs. field current at rated speed — defines excitation requirements and saturation.	Clause 7.1
5	Short-Circuit Characteristic (SCC)	Plot armature current vs. field current at rated speed with terminals shorted — used with OCC to compute synchronous reactance.	Clause 7.2
6	Synchronous Impedance and Reactance Determination	From OCC and SCC — obtain per-phase synchronous reactance Xs = Eoc/Isc.	Clause 7.3
7	Zero Power Factor (ZPF) or Potier Test	For large machines — determine leakage reactance and field current for rated voltage at full-load condition.	Clause 7.4
8	Load (Performance) Test	Operate under various loads and power factors to measure efficiency, voltage regulation, and temperature rise.	Clause 8.1
9	Efficiency Test (Direct or Indirect)	Compute efficiency using segregation of losses or input–output method.	Clause 8.2
10	Temperature Rise Test	Verify compliance with permissible temperature rise limits under rated	Clause 8.3

Test No.	Test Name	Purpose / Determination	Key Reference (IEEE 115-2019)
		load conditions (stator, rotor, bearings).	
11	Excitation System Performance Test (Steady-State)	Measure field current, voltage, and reactive power under rated voltage conditions.	Clause 9.1
12	Field Discharge and De-excitation Check	Confirm safe decay of field energy upon trip or fault.	Clause 9.2
13	Magnetic Balance / Unbalanced Loading Test	Verify current and voltage symmetry among phases.	Clause 10.1
14	Loss Segregation Tests	Separate core loss, friction & windage, and stray-load losses for efficiency evaluation.	Clause 8.2.3
15	Voltage Regulation Test (Calculated)	From OCC and SCC, determine regulation under various power factors using synchronous impedance or Potier method.	Clause 7.3.2
16	Armature Reaction Test	Assess effect of armature current on main field under lagging/leading conditions.	Clause 7.5
17	Open-Circuit and Short-Circuit Ratio Tests (SCR)	Compute short-circuit ratio (SCR = field current for rated voltage / field current for rated short-circuit current).	Clause 7.6

Test No.	Test Name	Purpose / Determination	Key Reference (IEEE 115-2019)
18	V-Curve (for Synchronous Condenser)	Plot stator current vs. field current at constant terminal voltage; determines stability margin and reactive power range.	Clause 8.4
19	Reactive Capability Curve Test (for Condenser/Generator Mode)	Determine leading and lagging VAR capability vs. field current and stator current limits.	Clause 8.5

2.1.3 Transient and stability study

Transient and stability studies shall be used to demonstrate the synchronous condenser unit control system performance, and, if applicable, to optimize the controller parameters of synchronous condenser unit during system disturbances, such as major faults or voltage changes at the PCC. Such studies shall be performed using the PSS/E and PSCAD software applying dynamic simulations, using a full PSS/E and PSCAD case. List of contingencies performed is attached in **Annexure D**.

The transient and stability studies shall be analysed in the following cases. These studies should demonstrate compliance with the relevant Performance requirements as per network configuration:

1. Analysis of the synchronous condensers unit's system response to step changes in the point of common coupling voltage or in the reference voltage, which can be performed in a single machine infinite bus case as relevant for the scenario.
2. Analysis of the synchronous condenser unit system response for faults for a range of system short-circuit power levels, to demonstrate compliance.
3. The following fault scenarios shall be analysed:
   a) A range of three-phase faults as specified (e.g. different duration, fault locations, retained voltage, network configuration).

b) A range of unbalanced faults as specified (e.g. different duration, fault locations, retained voltage, network configuration).

c) Control for the synchronous condenser units according to the requirement, i.e. Q-Control or U-Control

4. Analysis of the synchronous condenser unit system response for frequency disturbances.

5. V/Hz study and demonstration of stable operation of the V/Hz limiter

The design shall ensure the adequacy of the synchronous condensers units in order to ensure stability during system transient, dynamic and fault conditions. This is inclusive of synchronous condenser units' response time (rise time and settling time) and of the synchronous condensers units' behaviour and contribution to the system's recovery from faults and network disturbances.

2.1.4 Small signal stability studies

1. **Voltage Step/impulse response**—

+/- 5% step tests for Voltage control set points and then quantify rise time, overshoot, settling time for relevant control loops, and obtain frequency response (gain/phase margins) for critical control loops.

2. **Off-line frequency sweep (transfer function) tests for AVR and PSS:**

Frequency response of the excitation system to be assessed over a frequency bandwidth of at least **0.01 – 10.0 Hz** by injecting sinusoidal signals with the specific bandwidth into the control blocks. The gain and phase variations with frequency of each measured transfer function are then compared with those obtained from the model

3. **Controller interaction studies** — evaluate interaction between synchronous condenser control loops (AVR, PSS/filter, reactive control, power/frequency control) and other nearby plant controllers (conventional generators, HVDC/FACTS, large converter plants). Include frequency-domain (Bode/Nyquist) and time-domain cross-validated tests as required.

4. **Oscillation Rejection Test:** This is a control and response sensitivity test. It is expected that SynCon model maintains a stable operation for all voltage modulated frequencies and for measured responses to be consistent with the changes.

   Grid voltage shall be modulated at following modulation frequencies through model playback or similar feature in SMIB model:

   (a) 0.1 Hz
   (b) 0.3 Hz
   (c) 0.6 Hz
   (d) 0.9 Hz
   (e) 1 Hz
   (f) 2 Hz
   (g) 3 Hz
   (h) 4 Hz
   (i) 8 Hz
   (j) 10 Hz
   (k) Or any other frequency based on requirement

2.1.5 Software simulation models

The TSP shall provide the latest PSCAD (V 5.0 or above) and PSSE simulation model(s) (V36.0 or above) and parameters to CEA/CTU/GRID-INDIA along with detailed documentation for the purpose of future simulation to adequately represent and model the proposed SynCon system in the respective software:

For the simulation of SynCon unit in the PSS/E file (load flow and dynamic) and PSCAD (Transient), a model for SynCon unit is required for the study. TSP will share SynCon unit models with CEA, CTU and Grid-India along with detailed documentation for the 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 (UDM), confidentiality shall be maintained by the CEA, CTU and Grid-India.

Both UDM (PSCAD and PSS/E) and Generic model (PSCAD and PSS/E) shall be provided by OEMs to CEA/CTU/GRID-INDIA without any NDA (Non-Disclosure Agreement). RMS & EMT Models shall be submitted in the format stipulated by CTUIL/GRID-INDIA.

Model documentation shall include the following details of the model:

a) The transfer function block diagram must include all functional controllers and physical plant that materially affect the performance of the model.
b) Instructions on how the model should be set up and used.
c) The models of the controllers and items of SynCon unit must be easily identifiable.
d) Dynamic data must be provided as 'per unit' quantities on the machine megavolt amperes (MVA) base.
e) Shortest time constant (name, use and identifiable in the control block diagram) confirmed for both PSS/E models and also PSCAD models.

Model quality test of EMT & PDT model:

f) The submitted EMT & RMS (UDM) model shall be the representative of SynCon unit I with actual controls.
g) The EMT & RMS model should work appropriately within the PCC SCR range of 3 to 10 and X/R range of 3 to 14.
h) The applicable protections shall be appropriately modelled in the UDM Models.
i) EMT model should work appropriately on a range of simulation time step within 10-20us.
j) PDT (RMS) model work appropriately with a simulation time step of 1ms to 10 ms.
k) Submitted EMT model should have pre-compiled libraries and there should not be any need for loading dependent library/other files.
l) EMT model should initialize and complete the flat run in 5 sec. PSCAD & PSS/E models must allow stable initialisation and steady state run up to 5 minute.
m) Models must be initialised successfully for the entire intended plant operating range i.e reactive power set point from minimum to rated.
n) PSCAD models must have snapshot capability.
o) For User Define Model (UDM) EMT of SynCon unit, the complete model shall not be black-boxed and there shall be a full visibility/accessibility of

passive components. TSP may black box the control/other parts wherein their Intellectual Property (IP) rights are involved.

p) For UDM models, TSP shall submit the schematics/block diagrams and its descriptions.
q) The RMS & EMT model used guide should contain the description of each parameter.
r) The range of parameters shall be mentioned in the PSS/E and PSCAD model user guide.
s) TSP shall specify the configurable and non-configurable parameters in the model user guide (PSS/E and PSCAD) for both Generic as well as UDM.
t) Model structure to be contained within its own module block including its plots.
u) PSCAD transformer model should include transformer specific saturation data where available (and not default model library provided settings)
v) EMT Models shall be compatible with

- Intel 15 Update 5 and newer (64-bit) and Visual Studio 2015 and newer
- Model should works across a range of time steps and does not require a specific time step
- These models must not be dependent on a specific Intel Visual FORTRAN version and should not have dependencies on additional external commercial software.

TSP shall fulfil and submit the technical connection data including models/data sheets etc. as per Grid India First Time Energization process & CTUIL Connection details process.

2.2 Functional Requirements

The Synchronous Condenser unit shall:

- Provide dynamic and steady-state reactive power support (both capacitive and inductive).
- Contribute to voltage stability, grid inertia, and short-circuit strength.
- Assist in damping of power oscillations and mitigation of sub-synchronous oscillations, if any.
- Assist in damping of reactive power oscillations and mitigation of oscillations, if any.
- Be capable of continuous operation during worst-case voltage and

frequency conditions.

2.2.1 Design Considerations

- The Synchronous Condenser shall be designed with inertia specified to enhance system strength and frequency stability.
- Dedicated & coordinated control systems shall be provided in case of multiple SynCon units to ensure selective operation and avoid simultaneous tripping under common disturbances.

3. REQUIREMENT, RATINGS AND DESIGN INFORMATION

3.1 SynCon building

The SynCon station shall have independent building (PEB type) including a separate control room different from the main control room building of the main Substation. The building shall comprise of SynCons unit(s), EoT crane, control room, LT Switchgear room, Battery room, workshop space, Document/Library and general facilities etc. Adequate space shall be provided for smooth unloading and maintenance purposes of all the equipment in the SynCon building.

The SynCon Building shall comprise of following facilities:

1. Control & Relay Panel room
2. Excitation Room
3. ACDB & DCDB room
4. Battery room
5. Service Room cum workshop space
6. Conference room
7. SynCon unit(s)
8. Lobby
9. Corridor with minimum width of 1600 mm
10. Portico
11. Toilet facilities
12. Provision of shaft for electrical, sanitary, water supply facilities
13. Other facilities as per functional requirement of building

14. AHU Room

4. Ambient Condition

The following environmental data shall be considered (Table-1):

Table 1

Sr. No.	System Parameters	Values
1	Max/min Ambient temperature (dry bulb one-hour average) Max dry bulb 24 hr. average	50 deg C max 0 (Zero) deg C min 40 deg C
2	Relative Humidity (%, max)	100
3	Average annual rainfall	As per rainfall map of IMD
4	Iso-keraunic level	As applicable
5	Wind Zone	As per National Building Code 2016
6	Seismic Level	As per Seismic zone of the site
7	Altitude above sea level	<1000 m
8	Pollution level (IEC 60815)	Heavy

5. POWER SYSTEM REQUIREMENTS

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

Table 2

Sl. 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	440	kV
3.	Minimum continuous ac system voltage, line-to-line	360	kV
4.	Maximum short-term ac system voltage, line-to-line	As per HVRT Table	
5.	Maximum duration of item 4		
6.	Minimum short-term ac system voltage, line-to-line	As per LVRT Curve	
7.	Maximum duration of item 6		
8.	Nominal ac system frequency	50	Hz
9.	Maximum continuous ac system frequency	52	Hz
10.	Minimum continuous ac system frequency	47.5	Hz
11.	Lightning Impulse Withstand Voltage (LIWV)	1550	kV peak
12.	Switching Impulse Withstand Votlage (SIWV)	1175	kV peak
13.	Power Frequency Withstand Voltage	630	kV
14.	1) Maximum three-phase fault curren a) for performance requirements b) for rating of SynCon 2) X/R (Positive/Negative Seq)	 1 a) 63 1 b) 63 2) 31	 kA kA for 1s

Sl. No	Power System Characteristic	Value	unit
	3) X/R (Zero Seq) 4) Clearing time - normal 5) Clearing time – backup	3) 12 4) 0.10 5) 0.75	 s s
15.	1) Maximum three-phase fault current (with IBR contribution)* 2) Maximum three-phase fault current (without IBR contribution)*	51.1 42.7	kA kA
16.	Minimum three-phase fault current (without IBR contribution)* -for performance requirements -for safe operation	 38.7 38.7	 kA kA
17.	1) Maximum single-phase fault current (with IBR contribution) * 2) Maximum single-phase fault current (without IBR contribution) *	43.6 35.6	kA kA
18.	Minimum single-phase fault current(without IBR contribution)*	32.8	kA
19.	Power System Phase Rotation	CCW	
20.	Rated voltage at SynCon terminals (to be selected by the Contractor)	xx	kV
21.	Capacitive capability on PCC at 1.0 p.u. voltage	+300	MVAr
22.	Inductive capability on PCC at 1.0 p.u. voltage	-200	MVAr
23.	Capacitive & Inductive capability on PCC at different Voltages (p.u.)	See below capability diagram	
24.	HV Side rated Voltage (at PCC)	400	kV

Sl. No	Power System Characteristic	Value	unit
25.	Voltage variation at unit step-up transformer high-voltage side (for normal operation)	±10	%
26.	Stored Energy - Inertia at Machine Terminal	>3000	MWs
27.	Short Circuit Contribution (SCC) on PCC at 1.0 p.u. voltage (calculation of SCC as per section 6)	>1200	MVA
28.	SynCon rated power factor	Zero	
29.	Rated frequency	50	Hz
30.	Maximum Overspeed shall not be more than % (of rated speed)	20	%
31.	Sub transient ratio xq''/xd''	< 1.1	
32.	Start-up and synchronization time (Contractor may offer lower times based on the SFC rating selected and overall Inertia of the SynCon & Flywheel)	30	Minutes
33.	Shut-down time to complete standstill	45	Minutes
34.	Stator winding connection	Wye	
35.	Neutral Grounding	High resistance grounding through Neutral Grounding Transformer with secondary	

Sl. No	Power System Characteristic	Value	unit
		loading Resistor	
36.	Sound pressure level (SPL) when measured at approximately 1 m distance from the Synchronous condenser surface during normal operation at rated ratings & ambient conditions.	≤95	dB
37.	THD of L-L voltages	≤ 3%	
38.	**Temperature rise over 40°C cold air** Stator winding (installed RTDs) Rotor winding (resistance method)	 85 90	 K K
39.	**Unbalanced load** Maximum value for continuous operation (I_2/I_n) Maximum short term unbalanced load $(I_2/I_n)^2.t$	 10 20	 % s

*values calculated as per studies

6. Technical Requirements

6.1 General Requirements

(b) Under design maximum ambient temperature conditions, all the SynCon units in a SynCon Station, combinedly, shall have a nominal reactive power capability of not less than +300 MVAr at 0.9 p.u. voltage and -200 MVAr at 1.1 p.u. voltage, as measured at PCC, including all tolerances for components for the equipment installed inside the building such as the synchronous condensers, the pony motor, the fly wheel and the generator circuit breaker and for the equipment installed outdoor such as the step-up power transformers, the TEWAC cooling system, the station transformers, the isolated phase bus duct etc. The expected availability of the synchronous condenser unit shall be not less than 97%.

(c) Indicative schematic diagram of a SynCon unit and typical capability curve of a SynCon Station (+300 MVAr/ - 200 MVAr) are given below

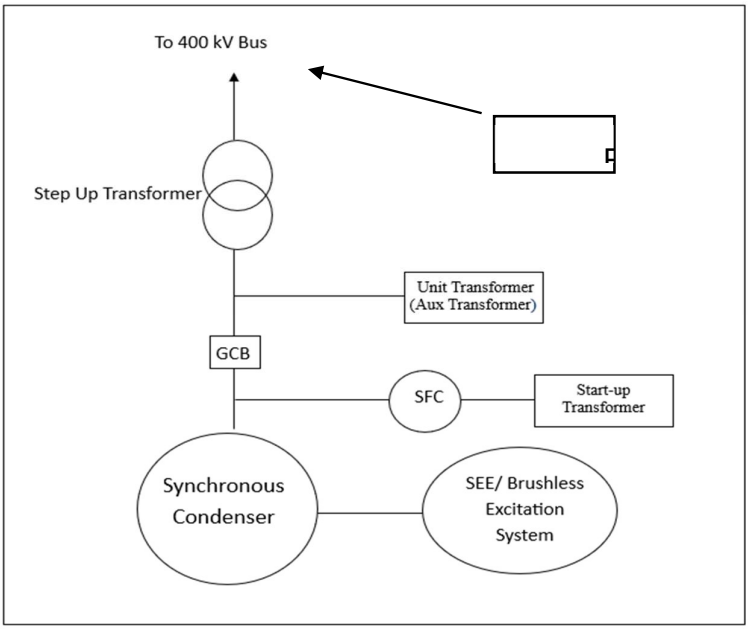
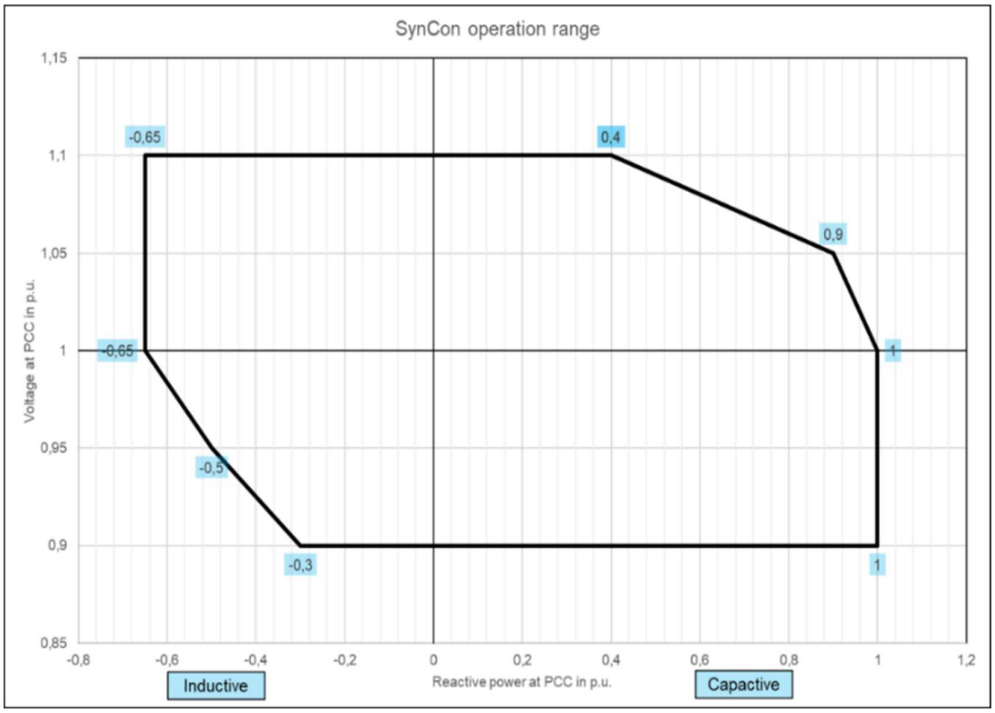


Figure-1: Conceptual Indicative Schematic diagram of SynCon Unit



Note: On x-axis, the base rating is taken as 300 MVAr

Figure-2: Capability Curve of SynCon Station

(d) The Terminal Voltage of SynCon shall be in the range of 10 kV to 28 kV.

(e) Insulation of SynCon shall be thermal class F for Stator and Rotor Winding as per relevant International Electrotechnical Commission with temperature rise limited corresponding to thermal class B insulation.

(f) The construction of the generator shall be such that the rotor poles and stator coils can be handled out or in without removal of the rotor and without disturbing the upper bearing bracket in case of vertically installed SynCon.

6.2 Voltage and Frequency

The synchronous condenser unit shall cope with voltage and frequency variation and stay in connection with the system for at least the minimum times as per Central Electricity Authority (Technical Standards for Connectivity to the Grid) Regulations, 2007 and amendments.

The following ranges of voltage and frequency are applicable:

1) Nominal voltage shall be 400 kV (1.0 p.u.) phase to phase
2) Minimum continuous voltage of 0.9 p.u.
3) Maximum continuous voltage of 1.1 p.u.
4) Max negative sequence voltage during normal operation of 1% measured at the HV side of the step-up transformer over a 10-minute averaging period
5) Nominal frequency of 50 Hz
6) Maximum continuous frequency of 52 Hz
7) Minimum continuous frequency of 47.5 Hz.

The synchronous condenser unit shall be capable of withstanding frequency variation and maintain continuous uninterrupted operation for frequency ranges of 47.5 Hz to 52 Hz within a voltage range of ±10%. Further**,** the Synchronous Condensers Unit shall be capable of **unrestricted** and uninterrupted continuous operation for the following frequency ranges.

Table: Frequency Variations Withstand Requirements for Unrestricted Operation

Sl. No.	Frequency Range (Hz)	Duration
1.	49.5 to 50.5	Continuous
2.	49.0 to 49.5	10 Minutes
3.	50.5 to 51	10 Minutes
4.	47.5 to 49	5 Minutes
5.	51 to 52	5 Minutes

The Synchronous Condenser Units shall be capable of continuous uninterrupted operation for Rate of Change of Frequency (ROCOF) up to 4Hz/second for 0.25 seconds and 3Hz/second for 1 second. Rate of change of frequency (ROCOF) is calculated as the average rate of change for multiple calculated system frequencies for a time period of greater than or equal to 0.1 second The measurement of the rate of change of frequency shall not react to the sudden changes in the waveform of voltage caused by disturbance in the system i.e. during fault occurrence or clearance.

Provided that Frequency should be calculated over a window of time. Instantaneous calculated frequency should not be used for protection; this calculation should occur over a time window. Typical window/filtering lengths are three to five cycles (60–100 ms).

The SynCon Station shall continue to absorb reactive power during HVRT Conditions in a controlled manner as per the following for symmetrical and asymmetrical cases:

Table-3

Nominal Voltage (pu)	**Minimum time for remaining connected to the Grid and providing reactive power support (absorption)**
V > 1.50	Instantaneous trip
1.50 ≥ V > 1.30	100 milli seconds
1.30 ≥ V > 1.10	10 seconds
V ≤ 1.10	Continuous

[#] 1 pu = 400 kV (3 phase RMS voltage at POI)

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

The SynCon Station shall remain connected to the grid and shall be able to operate at rated reactive power capability at PCC when the applicable voltage at the interconnection point dips up to the level depicted by the thick lines in the following curve (for specified time):

V_T : Actual Voltage; V_n: Nominal Voltage

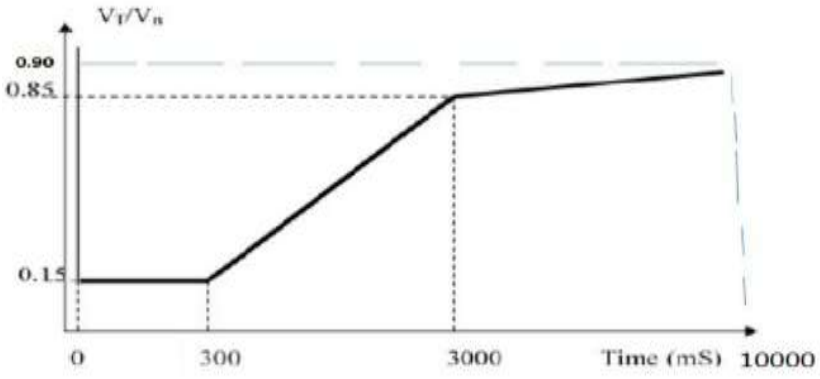


Figure-3: LVRT Curve

The synchronous condenser Station shall remain connected to the grid for a series of up to 10 voltage disturbance below 0.9 p.u within any 5-minute period as per the LVRT capability.

Provided that during such period synchronous condenser Station shall remain connected for at least 06 voltage disturbance below 0.5 p.u.

Provided further that during the multiple LVRT conditions, the SynCon Station shall meet the performance requirements specified in LVRT conditions.

TSP shall include the simulation tests to demonstrate the LVRT & HVRT compliance of SynCon and shall include the following simulations tests in the study reports on both Generic and UDM of PDT (RMS) and EMT models as per **Annexure D:**

Validation of AVR & PSS response:

In order to validate the AVR and PSS response, TSP shall carry out the testing of such controller(s) either through Hardware In Loop (HIL) test or in a laboratory as applicable. Based on the AVR controller response (open loop and closed loop) and PSS response received from HIL, the TSP shall benchmark such results with simulation-based results.

6.3 Continuous Ratings

1) The Synchronous Condensers Units shall be capable of operating continuously without tripping at the Voltage level from 0.9 p.u. to 1.1 p.u. at PCC in the specified ambient conditions.

   There are additional requirements for operation for periods of time beyond the 0.9 and 1.1 p.u. Voltage as described in Table 3. The Synchronous Condenser Units shall confirm that they are capable of operating in accordance with these requirements.
   For the Voltage under 0.9 p.u. SynCon Units shall be capable to operate as per Figure-3.

2) The supplier of Synchronous Condensers shall select the nominal operating voltage for the low voltage side of the step-down transformers, to optimize the design of the Synchronous Condensers Unit(s)

3) The nominal continuous operating capability of SynCon Station shall be no less than 300 MVAr capacitive at 0.9 p.u. to no less than 200 MVAr inductive at 1.1 p.u. voltage as measured at PCC, including all tolerances for components upto designed temperature. Component tolerances shall be considered, when designing against the requirement for continuous rating and considering design ambient temperature conditions. Beyond design maximum ambient temperature, TSP shall provide the derating curve, however, derating rate shall not be more than 1% of rated MVAr per degree Centigrade. OEM/TSP shall submit temperature to MVAr derating curves (continuous & time limited). There shall not be any impact on rated short circuit current and Inertia due to increase in ambient temperature beyond design maximum ambient temperature.

4) The Synchronous Condensers Units shall be capable of continuous uninterrupted operation for system frequencies in the ranges of 47.5 Hz to 52 Hz.

5) The voltage reference for the voltage control at the point of connection should be continuously (or using steps of negligible size) controllable in the interval 0.9 p.u. to 1.1 p.u.

6) The Supplier of Synchronous Condensers shall confirm that the synchronous condensers will be rated and capable to operate for all the frequency ranges listed.

6.4 Voltage and reactive power control

Voltage and reactive power control capabilities shall be as per requirement specified. The Synchronous Condenser unit shall be able to control the reactive power and voltage at the PCC by the excitation system and by use of unit step up transformer on-load tap changer (OLTC) regulation range as appropriate.

7. SHORT CIRCUIT CONTRIBUTION

The Synchronous condenser unit for project /substation shall be able to supply a short circuit power (Short-circuit power must be calculated according to IEEE 551-2006, using saturated sub-transient reactance and transformer impedance).

Calculation of short circuit contribution (SCC) shall be done according to following formula:

$$\boldsymbol{SCC} = \frac{\boldsymbol{S_{SC}}}{(\boldsymbol{X_d}'' + \frac{\boldsymbol{S_{SC}}}{\boldsymbol{S_T}}\,\boldsymbol{u_k})}$$

$S_{SC} =$ rated S [MVA] of SynCon

$S_T =$ rated S [MVA] of transformer

$X_d'' =$ subtransient direct − axis reactance (saturated) in p.u.

$u_k =$ $unit\ step - up\ transformer$ impedance in p.u.

8. SYNCHRONOUS CONDENSER DESIGN AND CONSTRUCTION FEATURES

The Synchronous condenser unit installed shall be based on either salient pole (or) non-salient pole with air-cooling or water cooling. Hydrogen-cooled SynCon will not be accepted.

8.1 General Design Requirements

The synchronous condenser shall be totally enclosed water-air cooled (TEWAC) with air-water heat exchangers connected to a closed water-cooling system shall also be provided (as per system requirements).

The pipework shall be marked with colours and arrows to show which fluid is circulating which way in the respective pipe.

All necessary auxiliaries (lube oil system, cooling system), foundation plates and bolts, covers, air and oil coolers with adjacent piping shall be included (if applicable).

Suitable arrangement shall be mounted inside the synchronous condenser enclosure to prevent condensation during shut-down periods.

Sensors, detectors, and instrumentation necessary for supervision and control shall be installed.

Detectors to provide signals for the speed measurement shall be installed. These detectors are also used for overspeed protection.

A vibration monitoring/protection system shall be provided.

Relative shaft vibration - monitoring; absolute bearing casing vibration – protection shall also be provided.

The synchronous condenser shall be designed for continuous operation and 10,000 starts/stops in its lifetime (35 years).

8.2 Inertia Requirement

If the specified inertia requirements as mentioned in the Table-2 cannot be achieved with the rotor only, the TSP shall consider the installation of an additional flywheel.

8.3 Stator

8.3.1 Stator Frame and Core

The stator frame shall be of welded construction and equipped with suitably arranged braces to ensure structural rigidity. The interior of the stator casing/stator frame partly forms the cooling ducts and therefore the braces in the stator frame shall be arranged in such a manner that an optimum air flow will be obtained.

For easier transportation (if required) the stator casing/stator frame can be split up into two sections. The sections of the iron core and of the stator casing shall be clamped together by means of liberally dimensioned bolts. Care will be taken to avoid vibrations at the insulated joints.

The stack of laminations shall form the active part of the Synchronous condenser and shall be made of silicon alloy steel sheets. The segments shall be coated with an insulating varnish of good thermal and mechanical properties on both sides and stacked interleaved.

The core shall be clamped between non-magnetic pressure plates. A certain number of through bolts to be provided for an adequate and permanent compression of the active core. The compression fingers integrated in the pressure plates, distributing the pressure over the whole surface of the core uniformly.

The pressure fingers, plates and the core beams shall be designed to give stable and equal distributed pressure on the lamination.

The enclosure shall have openings to inspect the core and the windings.

All steelworks shall be thoroughly protected against corrosion.

Welded steel constructions shall follow relevant ISO standards.

8.3.2 Stator Core Tests

Before the stator winding is installed, the stator core shall be subjected to stator core loop test with high flux density (minimum 1T).

8.3.3 Stator Winding

The stator winding shall be three-phase with 6 terminals brought out from the synchronous condenser enclosure. Neutral of SynCon star point shall be earthed in NGT panel through dry type distribution transformer with secondary loaded with a resistor.

All material inside the slot and the winding insulation shall be of thermal class F. No kind of magnetic material, such as for slot wedges, is permitted within the slots.

The winding must be capable of being easily substituted by removing a few adjacent coils or bars (as applicable). The end windings must be suitably braced and supported by rings of non-magnetic materials to withstand any forces caused by short circuit at the terminals of the machine in grounded or ungrounded operation.

The stator winding insulation shall be made of thermosetting epoxy resin impregnated mica tape system and shall be equipped with corona protection systems suitable for the selected rated voltage.

8.4 Rotor

The shaft shall be forged of steel and sufficiently rigid. It shall have an ample margin of strength and be provided with a forged coupling to Flywheel or other (if applicable) and specified in the technical specification.

For cylindrical rotor design, the shaft shall be machined from a single alloy steel forging to give the required mechanical, metallurgical and magnetic characteristics. Rotor shall have an adequate margin between critical speed and the operating range of speed to ensure smooth running.

The rotor shaft and rotor itself shall be designed to withstand all the operating conditions as well as overspeed.

For salient pole construction, poles shall have claws to fit in matching claw slots accurately machined on the rim/ Rotor body. The pole along with field coil shall be properly secured in the slots and wedged there properly.

The rotor assembly shall be of such design that the assembling and dismantling can easily be done at site.

8.5 Damper Winding

A low resistance damper winding made of full-length copper rods or copper rotor wedges shall be provided on all the poles to dampen rotor oscillations. They shall be short circuited at the ends by a completely connected ring on either side. The damper windings shall be strong enough to withstand all the electrical and mechanical stresses occurring during operation.

All contacts shall either be brazed or safely pressed by means of bolts and elastic elements. Contact surfaces of pressed contacts shall be protected against oxidization and corrosion, i.e. by appropriate galvanization.

8.6 Collector rings and brushes (if applicable)

The collector rings shall be insulated from the shaft system by epoxy glass laminations and spaced sufficiently apart and the brushes arranged to eliminate the possibility of accidental short circuit while changing or adjusting the brushes. The brush gear for the collector shall be mounted on insulated studs from the top of the exciter brush gear housing. The slip ring housing shall have sufficient space for maintenance purposes. There shall be provision for the replacement of brushes while the machine is in operation, without interrupting the excitation or normal operation of the machine.

Carbon dust collection system shall be provided to remove carbon dust generated from carbon brushes. The filters used shall be metallic and

washable type having high efficiency. The piping should be routed in a way to optimize spaces.

8.7 Rotor Winding/ Poles

The rotor winding shall have an insulation that fully conforms to thermal class 155 or higher.

For salient pole type construction, the field poles shall be of laminated construction and the material used shall be of high strength. On both ends, end plates of high-grade steel shall bebe fitted. The pole core and the pole end plates shall be clamped together by screwed bolts. The insulation materials used shall provide sufficient mechanical strength.

8.8 Instrumentation

All temperature sensors shall be Resistance temperature detectors (RTDs) of duplex type and be wired to a terminal box with shielded cables.

8.8.1 Stator winding/Core

Detection / measurements shall be provided by means of RTDs; i.e. at least 3 (three) active RTDs and 1 (one) spare RTD per phase and per circuit distributed between phases and circuits around the stator bore, located between the upper and lower bar in the same slot; at least 3 (three) RTDs in the core located at each end and in the middle.

8.8.2 Rotor winding

Rotor winding temperature shall be measured using the resistance method as per IEC 60034-1.

Sufficient number (at least 12) of Duplex RTDs shall be provided, distributed as per OEM design to monitor the temperature.

8.9 Terminal Boxes

Terminal boxes shall be of weatherproof construction to eliminate entry of dust, vermin and water with a degree of protection IP54. The terminal boxes on the SynCon shall be suitable to connect cable size required.

The phase terminal of the windings shall be brought out of stator frame by appropriate means and interfaced to insulated phase bus of adequate size & capacity. The leads on the neutral side shall be brought out of the stator frame and shorted through a suitable size bus bar. Provision shall be made on the main (Phase) side & neutral side of the SynCon for mounting of required no of CTs for AVR, control, protection & metering.

The phase terminals or a fitted cubicle shall be suitable for IPB termination. Insulated protective cage cover connection between stator and bus duct for line terminals shall be provided for safety of O&M and personnel.

A suitable neutral grounding cubicle shall be fitted to the neutral terminals. The cubicle shall allow for installation of all required CTs, neutral earthing via neutral earthing transformer and resistor.

Terminal boxes shall be provided for termination of the following signals/ terminals:

- Instrumentations
- Space heaters
- Temperature detectors

8.10 Bearings

The bearings shall be designed for the weight of the rotor of the synchronous condenser as well as for additional loads owing to abnormal service conditions.

The bearing pedestals may be a cast or welded structure, in any case providing the required strength and stiffness. To avoid the formation of shaft currents one pedestal is insulated from the foundation frame, pipe connections, etc. Suitable protection shall be provided to avoid the escape of oil and oil vapor via the shaft.

If the grid connection is tripped the synchronous condenser bearings shall be fed by the emergency DC pump from oil supply system until the synchronous condenser is on standstill (0 rpm).

The bearings shall withstand a defined overspeed of 10% during start-up.

A central oil mist extractor shall be present in the oil system to evacuate oil mist from the bearing housing.

The contractor shall ensure complete protection, control, and measurement for the bearing's safety and diagnosis, consisting of RTDs, at least one triple element per bearing, to monitor bearing metal temperature.

8.11 Lube oil system

The flood lubricating system of the bearings shall be separately mounted. The oil plant shall comprise the bearing/oil container, the oil/water cooler for frictional heat dissipation, the flood-lubrication pump, as well as all necessary fittings, pipes, filters and supervisory instruments.

8.12 Lube oil pumps

A high-pressure oil system shall be provided for the bearing to avoid mixed friction at a low speed. A high-pressure pump with non-return valve shall take the oil from the sump and presses it between the lower part of the bearing and the shaft. The arrangement in the shell of the oil-jacked bearing ensures that no pressurized oil can infiltrate between the bearing lining and the shell.

The lube oil system shall have redundant (2 x 100%) oil pumps to supply lube oil to the bearings. They shall be fed by AC power supply. An automatic change-over from main to back-up AC pump shall occur in case of loss of lube oil pressure.

An emergency DC pump of sufficient capacity shall pump the oil until the synchronous condenser has come to a complete standstill in case of the grid connection is tripped. The DC pump shall be fed from the station battery.

8.13 Cooling system

To reduce the complexity of the synchronous condenser unit, the synchronous condenser shall be air-cooled. H2-cooling is not permissible.

Extraction of losses shall be via water-to-air heat exchangers (TEWAC cooling scheme). The secondary cooling system i.e water to air heat exchanger, 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 SynCon unit.

In case of Water cooled Stator Winding, Stator water cooling System shall be closed loop type with 2x100% AC motor driven circulating water pumps, 2x100% de-mineralised water heat exchangers, 2x100% filters, one mixed bed de-mineraliser and one alkalizer unit (as applicable).

The scope of this system shall include but is not limited to:

a) a Pump skid with all relevant components and measurement devices
b) a Set of outdoor coolers (chillers).
c) an Expansion tank (installed on the pump skid)
d) a Refill unit (installed on the pump skid)
e) Connecting pipe system including pipe supports and interface flange connections

f) a Cooling system cabling, excluded cabling to the outdoor coolers and the outdoor temperature sensor.
g) an outdoor temperature sensor
h) all necessary foundation bolts for the cooling system and piping
i) Junction boxes for termination of control cables

The water-cooling system shall be connected to:

- the heat exchangers of the synchronous condenser to evacuate the heat generated by the machine.
- (if applicable) the fly-wheel's heat extraction system

The use of the coolant shall be adapted on the environmental condition listed in this specification.

The coolant shall be a mixture of ethylene or propylene glycol and water (with corrosion inhibitors as additives). If ambient conditions allow (ambient air permanently above freezing point) water with corrosion inhibitors can be used.

8.14 Monitoring sub-systems

Following On-Line monitoring sub-systems shall be provided for Synchronous Condenser:

8.14.1 Vibration Monitoring System

A continuous on-line vibration monitoring system complete with sensors, input/output module, control/processor unit, relays, junction boxes, cabling and associated accessories for measuring, monitoring and data acquisition of shaft vibration/run-out shall be provided.

The systems should be fully integrated with control system (SCADA) to facilitate shutdown and alarming, trending the values in SCADA for diagnosis.

8.14.2 Shaft Current online Monitoring of Synchronous condenser

A low-voltage ring type current transformer in a parted form of construction shall be used for measurement of shaft current. The current transformers design shall be suitable for the intended installation location (i.e. ambient conditions). Thus, the shaft current relay shall detect a transient current in the synchronous condenser shaft.

8.15 Flywheel system (if applicable)

The flywheel shall be coupled to the synchronous condenser rotor.

The design shall enable a safe emergency run-down in case of total power loss (grid black-out). The required bearing lubrication during emergency run down shall be ensured by battery-powered DC pump, defined, and sized depending on unit specific parameters.

The main components of the flywheel assembly are the forged flywheel body and shall be coupled to synchronous condenser either directly or by means of attached shafts. The whole flywheel shall be supported by pedestal bearings.

The safe operation of the flywheel shall be covered by the standard protection concept for rotating power generation equipment, including overspeed, bearing temperatures and vibration limits.

8.16 Bearing and Shaft Vibration Measurement / Protection System

Two Proximity sensors (90º apart) and necessary provisions for the monitoring of shaft vibration amplitudes shall be installed on each bearing. The vibration measurement system for the bearing shall be integrated with the vibration system provided for SynCon.

At least two accelerometers per bearing shall be installed to monitor bearing casing vibration.

9. EXCITATION SYSTEM

9.1 General

Microprocessor based excitation system with thyristor control shall be provided to suit the Synchronous condenser characteristics. The excitation system shall comply with the requirements of IEC 60034-3 unless otherwise specified.

The excitation system may be offered as either:

- **Static Excitation System (SEE)** using controlled power electronic converters, **or**
- **Brushless Excitation System (BES)** using a shaft-mounted AC exciter and rotating rectifier assembly.

In case of SEE, the AC power required for the excitation shall be tapped from the SynCon terminal, stepped down by means of excitation transformers and rectified by fully controlled thyristor bridges and then fed to the SynCon field

thereby controlling the voltage output. In case of Brushless Excitation System, the excitation power shall be supplied by a shaft-mounted AC exciter after rectification through a rotating diode bridge. The offered excitation system shall be capable of delivering desired synchronous condenser terminal voltage and reactive power within the specified limits during all the steady-state and transient operating conditions. Any change in the SynCon terminal voltage shall be sensed by the voltage regulator which shall automatically control the field excitation to restore the setpoint. The temperature of the field shall be determined by the resistance method.

9.2 Static Excitation System (SEE)

In case of SEE, it shall consist of following:

a) Excitation transformer.
b) A Set of Thyristor converters (fully redundant Thyristor bridges) of suitable numbers shall be provided. Power thyristor converter shall be fully controlled three phase, full wave bridge type with fast and high ceiling performance. The converter shall have ‘N+1’ redundancy where N is the number of bridges required to deliver rated excitation current and the ceiling voltage or current and '+1' provides redundancy such that the failure of one power section does not lead to any operational limitations.
c) Facilities to ensure excitation power supply during starting
d) Field breaker and field discharge and suppression equipment.

9.3 Brushless Excitation System:

In case of BEE, it shall consist of following:

(a) Shaft-mounted three-phase AC exciter with stationary field and rotating armature
(b) Rotating rectifier assembly using high-reliability diodes with surge protection and with either complete bridge as redundant or at least one redundant parallel branch in each of the six arms of the bridge.
(c) No slip rings or brushes for main field current supply.
(d) Field flashing equipment shall be provided for voltage build-up and recovery under low residual conditions.
(e) Monitoring of rotating rectifier health via indirect measurement of exciter current, voltage, and unbalance detection.
(f) High ceiling performance with minimum 160% ceiling field voltage.

9.4 Regulator and sequencer

TSP shall provide Digital Controller and AVR having automatic voltage regulator mode (AVR) and field current regulator mode (Manual Mode), as well as the required sequencing and communication to the plant control system. It shall be according to following.

- Number of independent regulators: 2 (full N+1 redundancy, completely doubled hardware)
- Voltage Controller of PID-type/ PI type,
- Manual (field current) regulator, common hardware with AVR
- Bump less switch between voltage regulator and field current regulator
- Digital sequencer as part of the software
- Digital setpoint interface
- Synchronous condenser voltage and current sensing: 1 or 3-phase measurement.
- Reactive load compensation: raising/falling characteristic selectable
- Field current limitation including:

    + Maximum limiter undelayed

    + Maximum limiter delayed

    + Minimum limiter undelayed

- Stator current limitation
- Over fluxing (Volts/Hertz) limiter
- Reactive power regulator
- Automatic generator voltage
- Thyristor conduction supervision via AC thyristor current measurement or detection of field voltage shape
- Soft start-up (provides smooth SynCon voltage increase according to required ramp)
- Interface to control system via suitable protocol.
- Power System Stabilizer
- Provision to connect to LAN and NTP time server.
- All Alarms and messages with timestamp.
- Fault recorder which records and stores curves in case of alarms or trips.

Auxiliary power supply to excitation control and protection shall include suitable redundancy such that failure of one auxiliary source shall not affect excitation system operation.

***Operation and monitoring*:**

Following Local operation and monitoring shall be provided via touch panel integrated in the front door of the control cabinet. Local operation Touch panel shall be Password protected.

- excitation ON/OFF
- setpoint RAISE/LOWER
- AUTO, MANUAL selection
- Voltage-/reactive power regulator or power factor regulator selection
- Alarms acknowledgement
- Indication shall include:
  - Measurement Values (SynCon Voltage and Current, Field current, SynCon active power, SynCon reactive power, SynCon power factor, etc.)
  - Event and Alarm lists
  - Other local functions

All alarms of the excitation system are stored and indicated on SOE list in correct time sequence. Furthermore, the two alarms “Excitation Alarm” and “Excitation Trip” are wired to the terminal strip for external use.

Further included components:

- 1 precision Shunt for field current sensing
- All MCBs with supervision contact
- Real measuring, analogue Meters in regulators cabinet front door, for field current, field voltage, stator current and stator voltage
- 4-20 mA signal for remote indication of excitation current
- 4-20 mA signal for remote indication of excitation voltage

9.5 Closed-Loop Control

The set points will be adjusted via the automatic follow-up function.

Each automatic channel shall have its own manual controller for field current control and its own voltage and current transformer for the processing of the SynCon terminal voltage and terminal current.

The excitation system shall provide three modes of operation:

- Manual mode: the excitation current is modified locally via the Human Machine Interface (HMI) installed in the excitation panel, the automatic voltage control functions and the limiters are deactivated (test mode or commissioning mode).
- Automatic Mode local: The automatic voltage control is active and the control setpoint for the terminal voltage control shall be modified via the HMI screen installed in the excitation panel.
- Automatic Mode remote: The automatic voltage control is active and the control setpoint for the terminal voltage control shall be modified via plant operation and control interface.

The excitation system shall be electrically and thermally capable of delivering continuously up to 110 % of the rated field current required at design ambient temperature.

The initial response ceiling voltage of the excitation system shall be adequate to meet the step response conditions as verified by Contractor/TSP - Synchronous Condensers design. The SEE shall be able to deliver a ceiling field voltage of minimum *160*% of the rated field voltage (field voltage applicable at rated field current, rated SynCon terminal voltage and defined rated reactive power rating of the SynCon).

The limiting functions of the automatic channel ensure that the SynCon is operated within its capability limits during grid operation. The following limiting and control functions shall be included:

- Stator current limitation
- Maximum field current limitation (field forcing)
- Over excitation limitation (field current)
- Under excitation limitation
- V/f limitation

The excitation system shall be provided with strategic spare parts.

The Excitation System shall have following step response characteristics:

	Description	Time
Response time	The duration from a step change in control signal until the voltage	Minimum 1 sec

	changes by 90% of its final change, before any overshoot.	
Settling time	With the Syncol Unit unsynchronised following a disturbance equivalent to a 5% step change in the sensed Syncol Unit terminal voltage	Maximum 1.5 sec
	With the Syncol Unit	Maximum 2.5 sec
	Following any disturbance which causes an excitation limiter to operate.	Maximum 5sec

9.6 Power System Stabilizers

Power System Stabilizers (PSS) are used to enhance damping of power system oscillations through excitation control(s). TSP shall implement PSS controls in line with IEEE Standards 421. The PSS controller shall have configurable range of frequency (to damp) to have a flexibility during the operation phase.

9.7 Power Supply

In case of SEE, the excitation transformer shall be connected to SynCon isolated phase bus duct between generator circuit breaker and unit step up transformer or shall be supplied from the MV-busbar system. The excitation transformer shall be a three-phase, two-winding converter transformer. In the case of a Brushless Excitation System, the SynCon shall be provided with a shaft-mounted Permanent Magnet Generator (PMG) to supply independent power to the Excitation System, while the main rotor field excitation power shall be derived from the shaft-mounted AC exciter through rotating rectifiers.

9.8 Operating Aspects

The communication interface between the Excitation System and the plant operating control system shall have redundant connection.

Signal exchange to the Excitation System shall comprise all commands for Excitation System and SFC operation and the set-point values for different Excitation System closed loop controls. The opposite direction from the Excitation System to the Synchronous Condenser unit control system shall include the feedback signals, actual values, and several alarm signals.

An operator control panel shall be installed on the front door of the control cabinet. Local or remote operation can be selected by using the key switch at the control cabinet door.

The operator control panel shall provide all required software tools to configure, maintain, and troubleshoot the excitation systems.

10. STARTING SYSTEM

The machine starting system shall be supplied as a complete system including all equipment, control and power part, hardware and software, to perform, control and supervise the actual start-up process.

The static frequency converter (SFC) shall be provided to accelerate the synchronous condenser from any speed to the nominal speed, so as to allow the synchronous condenser units connection to the network. Specifically, if any synchronous condenser is freewheeling (e.g. following a trip), the synchronous condenser shall be able to be accelerated by the SFC, without the need of having the synchronous condenser come to a complete rest. In addition to this the drive shall have the capability to decelerate the synchronous condenser following GCB opening.

The synchronous condenser, the excitation system, the start-up system, the start supply transformer etc. shall not be overloaded in any respect; thermally, over fluxed, high currents / voltages or torque etc.

The normal start sequence duration shall be approximatively 30 min. (estimated time, required starting time< 30min) from the first rotation to required overspeed for successful synchronization.

At standstill, at the initialization of a sequence, the excitation shall be activated and supplying an excitation current to the rotor winding of the machine.

The SFC equipment will increase the frequency of the compensator until a running speed required for successful synchronization is achieved.

At this running speed of the SFC equipment, excitation is disconnected, and the exciting system of the compensator shall be activated.

The compensator achieves rated voltage and is synchronized into the grid.

If the synchronizing is unsuccessful, 2 further attempts shall be allowed.

11. Noise Levels

The overall noise level of the Synchronous Condensers Units yard shall be no greater than 85 dB(A) when measured at a distance of one metre and at a height of 1.5 metre from any equipment except SynCon. In case of SynCon, the noise level when measured at approximately 1 m distance from the Synchronous condenser surface during normal operation at rated ratings & ambient conditions shall not be more than 90 dB(A).

12. Step-up Power Transformer

The TSP shall provide single phase step-up transformers to operate as 3-phase bank with one unit as a common spare for stepping up the voltage from a suitable medium voltage value to 400 kV system as required for replacing any one of the faulty phase units. Alternatively equivalent 3-ph transformer can also be provided, in which case spare transformer of same rating shall also be provided.

TSP can have a common spare as mentioned above for all such SynCon Units whose Step up Transformer rating is same.

Step up Transformer 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.

The Transformer shall be designed with the aim to achieve operation according to the overall performance requirements of the SynCon Station. The transformer should be designed and rated to carry complete capacitive and inductive reactive loading as specified for SynCon Station as well as harmonic currents associated with the most onerous operating conditions of SynCon Station, without loss of life.

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

12.1 General Requirements

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

a) 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 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*.*

b) 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.

c) The transformer shall be capable of withstanding the mechanical stresses caused by symmetrical or asymmetrical faults on any winding.

d) All protection class Current Transformers in the 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 Transformer manufacturer.

e) 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.

f) 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

Table 3

Sl. No.	Description	Unit	Technical Parameters
1.1	Rated Capacity		
	HV	**MVA**	To meet the performance requirement and ratings of SynCon. The transformer shall be suitable for 100% reactive loading
	MV	**MVA**	
1.2	Voltage ratio (Line to Line)		XX (*)/400 kV
1.3	Single / Three Phase Design		Single phase/Three phase
1.4	Applicable Standard		IEC 60076
1.5	Rated Frequency	**Hz**	50

Sl. No.	Description	Unit	Technical Parameters
1.6	Cooling and Percentage Rating at different cooling		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 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		

Sl. No.	Description	Unit	Technical Parameters
i)	Top oil measured by thermometer	**0C**	50
ii)	Average winding measured by resistance Method	**0C**	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**	1425
	MV	**kVp**	*
	Neutral	**kVp**	170
iii)	Switching Impulse withstand Voltage		
	HV	**kVp**	1175
iv)	One Minute Power Frequency withstand Voltage		
	HV	**kVrms**	630
	MV	**kVrms**	*

Sl. No.	Description	Unit	Technical Parameters
	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		*
1.16	Bushing		
i)	Rated voltage		
	HV	**kV**	420
	MV	**kV**	*
	Neutral	**kV**	36
ii)	Rated current (Min.)		
	HV	**A**	*
	MV	**A**	*
	Neutral	**A**	*

Sl. No.	Description	Unit	Technical Parameters
iii)	Lightning Impulse withstand Voltage		
	HV	**kVp**	1550
	MV	**kVp**	*
	Neutral	**kVp**	170
iv)	Switching Impulse withstand Voltage		
	HV	**kVp**	1175
v)	One Minute Power Frequency withstand		
	Voltage		
	HV	**kVrms**	750
	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		

Sl. No.	Description	Unit	Technical Parameters
	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 * Ur /√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 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^{O} 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)".*

(*) marked parameters shall be decided based on SynCon manufacturer's requirement

13. Generator Circuit Breaker

The Circuit Breaker shall in general be of G2/M2 class and comply to IEC/IEEE
62271-37-013:2021. They shall satisfy the General Technical Requirements and shall be designed to operate in the environmental conditions specified in this specification.

14. Bus duct

(a) The generator bus duct shall comply with the requirements of the latest versions of relevant Indian Standards or International Electrotechnical Commission standards.
(b) The bus duct shall be designed to carry maximum continuous current under normal site conditions without exceeding temperature rise limits. Based on these requirements standard size of bus duct as per relevant Indian Standards or International Electrotechnical Commission standards shall be used.
(c) Generator bus duct shall be segregated or isolated phase type. Bus duct rated more than 3150 Amperes shall be isolated phase type. The isolated phase ducts shall be preferred over the segregated phase bus ducts. The bus duct rated more than 6000 Amp shall be continuous isolated phase type.
(d) A hot air blowing system or air pressurization system shall be provided to prevent moisture deposition in case of isolated phase busducts while space heaters may be provided in case of other bus ducts.

15. Selection of Insulation Levels

15.1 Surge Arrestors

Protective levels of arresters connected to the 400 kV AC Bus Bars of the SynCon Station shall be coordinated with the insulation and surge arrester Characteristics of the 400 kV AC systems to which the SynCon Station is to

be connected. The specification and characteristics of the surge arresters installed in 400 kV AC system is given in Substation specification. The front of wave (FWWL), lightning impulse (LIWL) and switching impulse (SIWL) withstand levels 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 above minimum basic requirement the various insulations level of 400 kV equipment shall be as below. The SynCon Station equipment, coupling transformers etc. shall be co- ordinated accordingly.

	SIWL	**LIWL**
All equipment other than Transformer Bushing and winding	1175 kVp	1550 kVp

15.2 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 SynCon Station to a target value of one flashover in 15 years.

15.3 Switchyard

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

15.4 Leakage distances

The Creepage/leakage distance across insulation shall be determined by the TSP and shall be adequate to ensure that under condition of heavy pollution, the probability of a flash over 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 25 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 10500 mm.

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

16. PROTECTION SYSTEM

The synchronous condenser unit shall have a protection system with necessary back-ups to protect the equipment from critical failures and faults. The protection systems shall be secure and reliable to minimize any damage due to faults in the system. Protection relays shall be numerical type.

The mechanical protection (overtemperature, vibration) should be implemented in SynCon control panel system.

16.1 General Protection Concept

The function of the protective equipment is the detection of faults and the minimization of further damages. The selected protective system must ensure that faults are detected fast, selectively acted upon, and announced to the owner of the station. The protection system must ensure correct behavior during normal operation of the synchronous condenser unit even in case of faults outside the protected zone. The protective systems shall be independent of other equipment according to the protection philosophy.

The protection equipment must be designed with a comprehensive monitoring function to provide a high level of reliability and to avoid unnecessary shutdowns due to protection equipment malfunction. The monitoring system must elicit an alarm and block protection in case of internal defects.

A redundancy concept of the protection system design shall apply to the SynCon and the machine transformer consistently throughout by duplicating all the essential components. All implemented protection functions shall be doubled in the main A and main B protection relays. The redundancy starts with separate instrument transformer cores and continues through the protection relays and trip signal, which must pass through separate DC voltage paths to switchgear with 2 circuit-breaker trip coils. All protection zones shall have overlapping zones by using different CT’s or CT cores. The protection relays shall be mounted in separate panels for A and B protection.

The auxiliary transformers shall be protected with overcurrent protection function.

16.2 Protection zones

The protection system for the synchronous condenser unit must be divided into various protection zones:

- Protection for the high voltage side of machine transformers
- Protection for the machine transformer included the isolated phase bus
- Protection for the synchronous condenser
- Protection for the MV/Auxiliary transformer

For the main protection zones common tripping relays must be used for protection A and B.

All types of faults that shall be detected by the protection system.

- Heavy short circuit faults (2 / 3 phase- and double earth fault) based on differential (ANSI 87) and overcurrent measuring (ANSI 50/51) principle.
- Single earth faults at the SynCon side of the transformer and IPB system by displacement voltage detection without selection where the fault happened.

16.3 Protection Functions

A. Minimum Synchronous Condenser Protection Functions

Function	Main A	Main B
Biased SynCon Differential Protection (87	Y	Y
95% Stator Earth Fault Protection (64 G1)	Y	N
100% Stator Earth Fault Protection (64 G2)	N	Y
Loss of Field Protection (40G)	Y	Y
Backup Impedance Protection (21G)	Y	Y
Overvoltage Protection (59G)	Y	Y
Negative Phase Sequence Current	Y	Y
Under Frequency Protection (81G)	Y	Y
Overload Protection for SynCon (51G)	Y	Y
Rotor Earth Fault Protection (64R)	Y	Y
Under Excitation Protection	Y	Y
Bearing Current Protection (50SC)	Y	Y
SynCon Pole slipping protection (98G)	Y	Y
Excitation System Overcurrent Protection (50/51 EXE)	Y	Y

Dead machine (27/50G)	Y	Y

B. Step Up Transformer Protection Functions

Function	Main A	Main B
Biased Differential	Y	Y
Overcurrent Protection	Y	Y
Over fluxing Protection	Y	Y
Low Side Neutral Voltage Displacement	Y	Y
Buchholz Protection	Y	N
Explosion Vent Protection	N	Y
LV Winding Temperature Protection	N	Y
HV Winding Temperature Protection	Y	N

C. Unit Transformer Protection Functions (Auxiliary Transformers)

Function	Main A	Main B
HV High set Overcurrent Protection	Y	Y
HV Overcurrent Protection	Y	Y
Over fluxing Protection	Y	Y
Buchholz Protection	Y	N
Explosion Vent Protection	N	Y
LV Winding Temperature Protection	Y	N
HV Winding Temperature Protection	N	Y

D. Pony Motor Protection Functions (if applicable)

Function	Main A	Main B
Overcurrent	Y	N

Overload / Thermal Protection	Y	N
Undercurrent Protection	Y	N
No of Starts Limiter	Y	N

E. Generator Circuit Breaker

Function	Main A	Main B
Current Checked Circuit Breaker Failure	Y	N
Trip Circuit Supervision	Y	Y
Synchronizing	Y	N

F. Breaker Failure Protection

a) High voltage circuit breaker

Each trip to the high voltage circuit breaker must simultaneously initiate a breaker failure start in the high voltage feeder protection system. This signal must be integrated in the high voltage feeder protection relay, which executes the breaker failure protection.

b) Generator circuit breaker

In case the generator circuit breaker does not open after a trip command, the breaker failure function in the SynCon protection relay must send an inter-trip signal to the high voltage circuit breaker.

The start of the breaker failure protection shall be realized over a signal from the trip relays to a binary input to the protection relays. This ensures that all trip signals will start the breaker failure function. The breaker failure protection supervises the current and the auxiliary contacts of the circuit breaker.

Generator Circuit Breaker Control

The control of the generator circuit breaker and the related disconnectors/earthing switches shall be implemented in synchronizing device.

Interlocking

The electrical interlocking shall be implemented in the software logic of the control device. The interlocking shall be realized with hardwired release signals. The release signal of the earthing switch and disconnector to and from the HV switchgear will be send as electrical signal. The earthing switch on the SynCon side must be interlocked with a release signal from the SynCon control system (it is only possible to close the earthing switch if the SynCon is stopped).

Synchronizing the SynCon

For the Synchronous condenser synchronizing a synchronizing relay shall be used. This synchronizing relay must work as a synchronizer. The synchronization of the SynCon to the grid shall be part of the start sequence of the SynCon control. In the synchronization step, synchronizing device monitor the voltage, the frequency, and the phase angle on both sides of the generator circuit breaker. The synchronization device will send increase or decrease commands to the excitation system until the Synchronous condenser voltage matches the grid voltage. If the voltage, frequency, and phase angle are within the set limits the close command to the generator circuit breaker will be issued by the synchronizing device.

16.4 Control and Protection SFC-MV Switchgear

The control of the medium voltage feeder for the SFC can be implemented in multifunctional control & protection relays.

16.5 Control of Auxiliary System

The control of the auxiliary system shall be implemented in the SynCon control panel.

16.6 Voltage Regulator for the Tap Changer

The control of the voltage regulator of the Main Transformer (On Load Tap-Changer) and monitor auxiliary transformer (Off Load Tap-Changer) shall be implemented in a SynCon control panel.

16.7 Communication and Time Synchronization

Communication to Control System

The protection and control devices shall be connected to the plant control system through an optical Ethernet communication network configured in a ring or other redundant topology. Communication shall be based on the IEC

61850 standard. All protection and control signals, including trip signals, shall be transmitted to and processed within the plant control system and shall be displayed and monitored through the HMI system.

Time synchronization must be realized over the same interface. Time synchronization to protection devices shall be over network time protocol. TSP shall follow CEA (Cyber Security in Power Sector) Guidelines, 2021.

16.8 Specific Requirement for Phasor Measurement Units (PMUs)

TSP shall supply, install and commission required No. of Phasor Measurement Units (PMUs) as per the "Guidelines on Unified Philosophy for placement of PMUs in Indian Grid" issued vide CEA letter No. CEA-PS-14-12/9/2024-PSETD Division dated 19.03.2025 for the SynCon. The PMUs shall be provided with LAN switch and shall connect with LAN switch of control room of respective substations/ generating stations with Fibre Optic cable. The 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.

16.9 Fault Recorder

Devices

The integral fault recorder function of the protection relay shall be used for recording of the current, the voltage and the trip signals during a fault in the electrical system.

If a trip occurs anywhere within the system, all fault recorders of all protection relays shall be triggered by a hardwired binary signal. This ensures that all relevant binary and analogue signals of the whole system will be recorded in case of a fault.

For testing and monitoring purpose, a manual trigger of the fault recorders must be foreseen.

Data Storage

The transfer of the fault/ disturbance records should be performed over the communication interface and the IEC61850 protocol.

Fault Analyses

Evaluation and analyses of the fault records take place on the engineering workstation.

16.10 Generator Disturbance Recorder (DR)

a) One No. microprocessor-based Disturbance Recorder (DR) shall be provided for each synchronous condenser to record graphic form of instantaneous values of voltage and current in all three phases and neutral, open and closed positions of relay contacts and breaker during disturbances.

b) It shall have the facility for slow and fast scan to record transient and dynamic performance of the system.

c) Both slow and fast scan facility shall have atleast 8 analog and 16 digital inputs.

d) The slow scan facility shall be provided with the following minimum features

- The input shall be MW, MVAR, field voltage, frequency and generator terminal voltage etc. Any transducers, if required for interfacing, shall be provided.
- It shall be suitable to record the frequency excursions and response of generator field and governor control on system fluctuations.
- It shall have options to select the scan rate in the range having a min. of 10Hz suitable to facilitate capture of low frequency waveforms in the range of 0.5 - 3Hz.
- The non-volatile memory shall be suitable for recording for a minimum of 15 minute at scan rate corresponding to selected pre-fault zone of recording.

e) The fast scan facility shall be provided with the following minimum features

- The input shall be voltages and current etc. Any transducers, if required for interfacing, shall be provided.
- It shall have scan rate of 1000 Hz or better for sampling each of the analog channel having fundamental frequency of 50 Hz. The frequency response for these channels shall be DC on the lower side to 500 Hz or better on the upper side. Any interposing devices provided shall be suitable for this frequency response.
- The pre and post fault recording time shall be atleast 200 ms and 5s respectively.

f) All external and internal faults in the DR equipment such as power supply fail, printer faults, paper exhausting, processor failure, memory failure etc. are to be indicated by means of light emitting diodes on the front of the panel of restitution unit. The DR shall be provided with a MMI (man machine interface) through a PC with VDU, keyboard and printer.

g) The internal clock of the system shall be synchronized through the GPS. The output shall be in IEEE/ COMTRADE format. The format shall be compatible for dynamic protection Relay Test Kit Necessary interfacing and software for analysis shall also be provided.

h) The amplitude resolution of the analog channels shall not be less than 16 bit and event resolution for digital channels shall be 1ms or better.

16.11 Metering

Operational Metering

The unit operational metering is measured by multifunction meter and linked to synchronous condenser control system for operation and control purposes.

16.12 SynCon Station Auxiliary Power Supply

The auxiliary supply of SynCon Station shall conform with the system requirements relating to reliability, availability, and redundancy, performing continuously to help ensure that the complete SynCon Station operates as per the requirements. SynCon 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 SynCon station shall be fed from this supply. The auxiliary supply provides power to the excitation system, starting system, controllers, cooling system, station supplies, and various other essential and non-essential loads. All essential loads are connected to the DC system of the SynCon 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 SynCon 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 SynCon Station during these transient events.

Auxiliary Supply System of SynCon Station shall be fed from two independent sources as per CEA (Technical Standards for Connectivity to the Grid) Regulations, 2007. In addition to this one emergency incomer from DG set shall also be there. DG set of SynCon Station shall be separate from DG set of Main Substation.

16.13 Power and control cables, and cabling

(i) For essential auxiliaries, the power and control cables shall be of fire survival type. All other Power and control cables shall be of flame retardant low smoke (FRLS) type.
(ii) Cables to be directly buried shall be essentially armoured type.
(iii) Flame retardant low smoke cables and fire survival cables shall meet test requirements as per relevant American Society of Testing and Materials, International Electrotechnical Commission, Institute of Electrical and Electronics Engineers and Swedish Standards.
(iv) Derating factors for site ambient and ground temperatures, grouping and soil resistivity shall be considered while determining the size of cables.
(v) Cable installation shall be carried out as per relevant IS and other applicable standards.
(vi) Power cables and control cables shall be laid on separate tiers. The laying of different voltage grade cables shall be on different tiers according to the voltage grade of the cables with higher voltage grade cables in topmost tier and control cables in bottommost tier.
(vii) All cables associated with one unit shall preferably be segregated from cables of other units.

(iv) Cable routes for one set of auxiliaries of same unit shall be segregated from the other set.

16.14 Fire Protection System for SynCon Station:

Necessary fire protection for SynCon units and Step-up Transformer shall be required. The main features of these protections are as under.

A) Fire Detection and Alarm System:

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

B) 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 SynCon Station equipment in the yard namely Step-up Transformers etc. as applicable for the station. Further suitable number of hydrants shall also be provided for SynCon Station building

HVW System:

HVW (High Velocity Water) Spray system shall be provided for Step-up transformers. 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.

17. VISUAL MONITORING SYSTEM FOR WATCH AND WARD OF SynCon STATION

Visual monitoring system (VMS) for effective watch and ward of SynCon station premises covering the areas of entire switchyard, SynCon 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.

System with Colour IP Cameras for VMS surveillance would be located at various locations including indoor areas and outdoor switchyard. The VMS data partly/completely shall be recorded (minimum for 15 days) and stored on network video recorder.

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) Step-up Transformers.
b) SynCon Cooling System, Electrical and Mechanical Auxiliary area.
c) Entrance to SynCon Station.
d) All other Major Equipments (such as CB, CT, VT, SA etc.)

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

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

18. Spares, Special Tools and Tackles

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

19. Losses

19.1 Calculation of losses

The TSP must guarantee total losses of less than 2% of highest reactive power output of SynCon Station at PCC for complete Synchronous Condenser Station, under the following conditions:

a) At 40^{o}C ambient temperature for specified Short Circuit Contribution at Point of Common Coupling
b) Specified rated frequency & voltage at Point of Common Coupling

The TSP shall calculate the total losses of the Synchronous Condenser Unit at each operating point specified below which must meet the guaranteed total losses mentioned above. The calculation of guarantee total losses shall include losses of all the components up to the PCC including losses of the synchronous condenser, flywheel (if applicable), IPB, transformer and the relevant auxiliary systems like pumps, fans, excitation system, building HVAC etc., whether conducting currents or not, based on the above assumptions.

The operating points shall be as follows:

i) Maximum Capacitive Output.

ii) Maximum Inductive Output; and
iii) Zero MVAr Output.

The actual losses shall be measured during SAT.

19.2 Loss measurement

Procedure according to IEC 60034-2-2 using the retardation method:

Losses will be determined by measurement of partial losses using retardation method according to the ITP and as specified in IEC 60034-2.1, chapter 7.1.1, method 2-1-2C: Summation of separate losses without a full load test. Short circuit test for the determination of the additional load losses to be applied for one type of synchronous machine per plant.

20. Availability and Reliability

20.1 Availability

The percentage availability of Synchronous Condenser is defined as follows:

$$\%\ Availability = \frac{Total\ time\ SynCon\ is\ able\ to\ Perfrom\ specified\ Duty}{Total\ time\ Period} x\ 100$$

Synchronous Condenser shall be considered to be available for service only if it is able to perform the whole of the specified duty. Operation with limited control functions or within a limited range of outputs (any parameters i.e. Inertia, Short Circuit MVA and Capacitive and Inductive MVAr) due to a subsystem failure shall be treated as unscheduled servicing downtime. The period basis for availability calculation shall be 12 months (365 days).

The total time period during which the SynCon Station is not able to perform the specified duty shall include Planned Outage hours (POH), Maintenance Outage Hours (MOH) and Forced Outage Hours (FOH).

Planned Outage (POH = Planned Outage Hours) is the state where the Equipment is unavailable due to Planned Maintenance activities (Scheduled Routine Maintenance, Scheduled Annual and Biennial Maintenance, Small Revisions and Major Revisions) that require the shutdown of the Equipment. Such activities leading to a Planned Outage.

Unplanned Outage

Unplanned Outage is the state where the Equipment is unavailable but is not in the Planned Outage state.

The Unplanned Outage can be due to **Forced Outage Hours** (FOH = Forced Outage Hours) or due to **Maintenance Outage Hours** (MOH = Maintenance Outage Hours)

Forced Outage is considered as an outage that requires removal of the Equipment from the Available State **immediately** or **within 7 days maximum**.

Maintenance Outage is considered an outage that **does not require immediate removal** from the Available State but requires the Equipment to be removed from the Available State **before the next Planned Outage**. This is scheduled **at least 7 days in advance** (otherwise it's classified as FOH).

20.2 Reliability

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

i) A SynCon Station shut down.

ii) A reduction of SynCon Station capacity (any parameters i.e. Inertia, Short Circuit MVA and Capacitive and Inductive MVAr) due to an outage of any component of SynCon Station

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

	Design target for SynCon Station	Max acceptable Guaranteed value for SynCon Station
Total Number of Forced Outages	3	5

Here definition of Forced Outage shall be considered as same as given in the "20.1 Availability".

The period basis for availability calculation shall be 12 months (365 days).

21. Training on Synchronous Condenser

As a part of project, it shall be under the scope of TSP to provide the training regarding design, manufacturing, construction, testing, control & protection aspects of Synchronous Condenser at Manufacturer's works and training on

operation & maintenance at some commissioned Project of the manufacturer for atleast 10 man-months to officials from CEA/CTU/Grid India in addition to its own manpower for the project.

Annexure D

Contingency Cases for Barmer-II SYNCON

A) N-1 Contingency

Contingency at 765 kV level

1. Three Phase Fault close to 765 kV bus of Barmer-I PS followed by tripping of one circuit of Barmer-I PS–Merta-II 765 kV D/c line (fault persist for 100 ms)
2. Single Phase to Ground Fault close to 765 kV bus of Barmer-I PS 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 of one circuit of Barmer-I PS–Merta-II 765 kV D/c line
3. Three Phase Fault close to 765 kV bus of Merta-II S/s followed by tripping of one circuit of Barmer-I PS–Merta-II 765 kV D/c line (fault persist for 100 ms)
4. Single Phase to Ground Fault close to 765 kV bus of Merta-II S/s 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 of one circuit of Barmer-I PS–Merta-II 765 kV D/c line
5. Three Phase Fault close to 765 kV bus of Barmer-I PS followed by tripping of one circuit of Barmer-I PS–Sirohi PS 765 kV D/c line (fault persist for 100 ms)
6. Single Phase to Ground Fault close to 765 kV bus of Barmer-I PS 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 of one circuit of Barmer-I PS–Sirohi PS 765 kV D/c line
7. Three Phase Fault close to 765 kV bus of Sirohi PS followed by tripping of one circuit of Barmer-I PS–Sirohi PS 765 kV D/c line (fault persist for 100 ms)
8. Single Phase to Ground Fault close to 765 kV bus of Sirohi PS 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 of one circuit of Barmer-I PS–Sirohi PS 765 kV D/c line

9. Three Phase Fault close to 765 kV bus of Fatehgarh-IV PS (Sec-2) followed by tripping of one circuit of Fatehgarh-IV PS (Sec-2) - Beawar 765 kV D/c line (fault persist for 100 ms)
10. Single Phase to Ground Fault close to 765 kV bus of Fatehgarh-IV PS (Sec-2) 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 of one circuit of Fatehgarh-IV PS (Sec-2) - Beawar 765 kV D/c line
11. Three Phase Fault close to 765 kV bus of Beawar S/s followed by tripping of one circuit of Fatehgarh-IV PS (Sec-2) - Beawar 765 kV D/c line (fault persist for 100 ms)
12. Single Phase to Ground Fault close to 765 kV bus of Beawar S/s 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 of one circuit of Fatehgarh-IV PS (Sec-2) - Beawar 765 kV D/c line
13. Three Phase Fault close to 765 kV bus of Sirohi PS followed by tripping of one circuit of Sirohi PS-Fatehgarh-IV PS (Sec-2) 765 kV D/c line (fault persist for 100 ms)
14. Single Phase to Ground Fault close to 765 kV bus of Sirohi PS 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 of one circuit of Sirohi PS-Fatehgarh-IV PS (Sec-2) 765 kV D/c line
15. Three Phase Fault close to 765 kV bus of Fatehgarh-IV PS (Sec-2) followed by tripping of one circuit of Sirohi PS-Fatehgarh-IV PS (Sec-2) 765kV D/c line (fault persist for 100 ms)
16. Single Phase to Ground Fault close to 765 kV bus of Fatehgarh-IV PS (Sec-2) 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 of one circuit of Sirohi PS-Fatehgarh-IV PS (Sec-2) 765kV D/c line

Contingency at 400 kV level

17. Three Phase Fault close to 400 kV bus of Barmer-II PS followed by tripping of one circuit of Barmer-II PS –Fatehgarh-IV PS (Sec-2) 400kV D/c line (fault persist for 100 ms)
18. Single Phase to Ground Fault close to 400 kV bus of Barmer-II PS-IV PS 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 of one circuit of Barmer-II PS – Fatehgarh-IV PS (Sec-2) 400kV D/c line
19. Three Phase Fault close to 400 kV bus of Fatehgarh-IV PS (Sec-2) followed by tripping of one circuit of Barmer-II PS –Fatehgarh-IV PS (Sec-2) 400kV D/c line (fault persist for 100 ms)
20. Single Phase to Ground Fault close to 400 kV bus of Fatehgarh-IV PS(Sec-2) 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 of one circuit of Barmer-II PS – Fatehgarh-IV PS (Sec-2) 400kV D/c line
21. Three Phase Fault close to 400 kV bus of Barmer-II PS followed by tripping of one circuit of Barmer-I PS –Barmer-II PS 400 kV D/c line (fault persist for 100 ms)
22. Single Phase to Ground Fault close to 400 kV bus of Barmer-II PS-IV PS 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 of one circuit of Barmer-I PS –Barmer-II PS 400 kV D/c line
23. Three Phase Fault close to 400 kV bus of Barmer-I PS followed by tripping of one circuit of Barmer-I PS –Barmer-II PS 400 kV D/c line (fault persist for 100 ms)
24. Single Phase to Ground Fault close to 400 kV bus of Barmer-I PS 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 of one circuit of Barmer-I PS –Barmer-II PS 400 kV D/c line

25. Three Phase Fault close to 400 kV bus of Barmer-I PS followed by tripping of one circuit of Barmer-I PS –Fatehgarh-III PS (Sec-2) 400 kV D/c line (fault persist for 100 ms)
26. Single Phase to Ground Fault close to 400 kV bus of Barmer-I PS 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 of one circuit of Barmer-I PS –Fatehgarh-III PS (Sec-2) 400 kV D/c line
27. Three Phase Fault close to 400 kV bus of Fatehgarh-III PS (Sec-2) followed by tripping of one circuit of Barmer-I PS –Fatehgarh-III PS (Sec-2) 400 kV D/c line (fault persist for 100 ms)
28. Single Phase to Ground Fault close to 400 kV bus of Fatehgarh-III PS(Sec-2) 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 of one circuit of Barmer-I PS – Fatehgarh-III PS (Sec-2) 400 kV D/c line
29. Three Phase Fault close to 400 kV bus of Fatehgarh-IV PS (Sec-2) followed by tripping of one circuit of Fatehgarh-IV PS (Sec-2) –Bhinmal S/s 400 kV D/c line (fault persist for 100 ms)
30. Single Phase to Ground Fault close to 400 kV bus of Fatehgarh-IV PS (Sec-2) 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 of one circuit of Fatehgarh-IV PS (Sec-2) –Bhinmal S/s 400 kV D/c line
31. Three Phase Fault close to 400 kV bus of Bhinmal S/s followed by tripping of one circuit of Fatehgarh-IV PS (Sec-2) –Bhinmal S/s 400 kV D/c line (fault persist for 100 ms)
32. Single Phase to Ground Fault close to 400 kV bus of Bhinmal S/s 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 of one circuit of Fatehgarh-IV PS (Sec-2) –Bhinmal S/s 400 kV D/c line

B) N-1-1 Contingency

Contingency at 765 kV level

33. Case 1 + Single Phase Fault close to 765 kV bus of Barmer-I PS followed by single pole opening (100 ms) of the faulted phase and successful re-closure (dead time 1 second) of 2nd circuit of Barmer-I PS–Merta-II 765 kV D/c line
34. Case 3 + Single Phase Fault close to 765 kV bus of Merta-II S/s followed by single pole opening (100 ms) of the faulted phase and successful re-closure (dead time 1 second) of 2nd circuit of Barmer-I PS–Merta-II 765 kV D/c line
35. Case 5 + Single Phase Fault close to 765 kV bus of Barmer-I PS followed by single pole opening (100 ms) of the faulted phase and successful re-closure (dead time 1 second) of 2nd circuit of Barmer-I PS–Sirohi PS 765 kV D/c line
36. Case 7 + Single Phase Fault close to 765 kV bus of Sirohi PS followed by single pole opening (100 ms) of the faulted phase and successful re-closure (dead time 1 second) of 2nd circuit of Barmer-I PS–Sirohi PS 765 kV D/c line
37. Case 9 + Single Phase Fault close to 765 kV bus of Fatehgarh-IV PS (Sec-2) followed by single pole opening (100 ms) of the faulted phase and successful re-closure (dead time 1 second) of 2nd circuit of Fatehgarh-IV PS (Sec-2) - Beawar 765 kV D/c line
38. Case 11 + Single Phase Fault close to 765 kV bus of Beawar S/s followed by single pole opening (100 ms) of the faulted phase and successful re-closure (dead time 1 second) of 2nd circuit of Fatehgarh-IV PS (Sec-2) - Beawar 765 kV D/c line
39. Case 13 + Single Phase Fault close to 765 kV bus of Sirohi PS followed by single pole opening (100 ms) of the faulted phase and successful re-closure (dead time 1 second) of 2nd circuit of Sirohi PS-Fatehgarh-IV PS (Sec-2) line
40. Case 15 + Single Phase Fault close to 765 kV bus of Fatehgarh-IV PS (Sec-2) followed by single pole opening (100 ms) of the faulted phase and successful re-closure (dead time 1 second) of 2nd circuit of Sirohi PS-Fatehgarh-IV PS (Sec-2) line

Contingency at 400 kV level

41. Case 17+ Single Phase Fault close to 400 kV bus of Barmer-II PS 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. 2nd circuit of Barmer-II PS –Fatehgarh-IV PS (Sec-2) 400 kV D/c line
42. Case 19+ Single Phase Fault close to 400 kV bus of Fatehgarh-IV PS(Sec-2) 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. 2nd circuit of Barmer-II PS –Fatehgarh-IV PS (Sec-2) 400 kV D/c line
43. Case 21+ Single Phase Fault close to 400 kV bus of Barmer-II PS 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. 2nd circuit of Barmer-I PS –Barmer-II PS 400 kV D/c line
44. Case 23+ Single Phase Fault close to 400 kV bus of Barmer-I PS 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. 2nd circuit of Barmer-I PS –Barmer-II PS 400 kV D/c line
45. Case 25+ Single Phase Fault close to 400 kV bus of Barmer-I PS 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. 2nd circuit of Barmer-I PS –Fatehgarh-III PS (Sec-2) 400 kV D/c line
46. Case 27+ Single Phase Fault close to 400 kV bus of Fatehgarh-III PS (Sec-2) 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. 2nd circuit of Barmer-I PS –Fatehgarh-III PS (Sec-2) 400 kV D/c line
47. Case 29+ Single Phase Fault close to 400 kV bus of Fatehgarh-IV PS (Sec-2) 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. 2nd circuit of Fatehgarh-IV PS (Sec-2) – Bhinmal S/s 400 kV D/c line

48. Case 31+ Single Phase Fault close to 400 kV bus of Bhinmal S/s 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. 2nd circuit of Fatehgarh-IV PS (Sec-2) –Bhinmal S/s 400 kV D/c line

Contingency at 220kV level

49. Three phase fault close to 220 kV Barmer-II PS bus with Tripping of 400 MW generation at 220KV Barmer-II PS bus
50. Three phase fault close to 400 kV Barmer-II PS bus, with Tripping of 1195 MW generation at 400 kV Barmer-II PS bus

Contingency at HVDC level

51. Outage of one pole of HVDC Bipole of ±800 kV HVDC Bipole line (Hexa lapwing) between Barmer-II (HVDC) & South Kalamb (HVDC) (under forward mode of operation)
52. Outage of one pole of HVDC Bipole of ±800 kV HVDC Bipole line (Hexa lapwing) between Barmer-II (HVDC) & South Kalamb (HVDC) (under 50 % & 100% reversal mode of operation)

Note:

1. In the 'N-1-1' as stated above, if there is a temporary fault, the system shall not lose the second element after clearing of fault but shall successfully survive the disturbance.
2. In case of permanent fault, the system shall lose the second element as a result of fault clearing and thereafter, shall asymptotically reach to a new steady state without losing synchronism. In this new state, the system parameters (i.e. voltages and line loadings) shall not exceed emergency limits, however, there may be requirement of load shedding / rescheduling of generation so as to bring system parameters within normal limits.
3. All contingency cases to be performed in all study files provided by BPC to respective TSP.

Simulation tests to demonstrate the LVRT & HVRT compliance of other requirements of Syncon

Test No.	**PCC Target Voltage (pu)**	Duration of voltage dip (sec)	Pre - fault Reactive Power dispatch (pu)	Nature of voltage dip	To be done in PSCAD (Generic & UDM)	To be done in PSS/E (Generic & UDM)
1	1	No	1.0 (Under excited)	Flat run (60s)	Yes	Yes
2	1	No	0.1 (Under excited)	Flat run (60s)	Yes	Yes
3	1	No	1.0 (Over excited)	Flat run (60s)	Yes	Yes
4	1	No	0.1 (Over excited)	Flat run (60s)	Yes	Yes
LVRT						
5	0.85	3.0	1.0 (Under excited)	Balanced Three phase	Yes	Yes
6	0.5	1.65			Yes	Yes
7	0.15	0.3			Yes	Yes
8	0.85	3.0		Unbalanced (LL)	Yes	No
9	0.5	1.65			Yes	No
10	0.15	0.3			Yes	No

Test No.	**PCC Target Voltage (pu)**	Duration of voltage dip (sec)	Pre - fault Reactive Power dispatch (pu)	Nature of voltage dip	To be done in PSCAD (Generic & UDM)	To be done in PSS/E (Generic & UDM)
11	0.85	3.0		Unbalanced (LG)	Yes	No
12	0.5	1.65			Yes	No
13	0.15	0.3			Yes	No
14	0.85	3.0	0.5 (Under excited)	Balanced Three phase	Yes	Yes
15	0.5	1.65			Yes	Yes
16	0.15	0.3			Yes	Yes
17	0.85	3.0		Unbalanced (LLG)	Yes	No
18	0.5	1.65			Yes	No
19	0.15	0.3			Yes	No
20	0.85	3.0		Unbalanced (LG)	Yes	No
21	0.5	1.65			Yes	No
22	0.15	0.3			Yes	No
23	0.85	3.0	0.25 (Under excited)	Balanced Three phase	Yes	Yes
24	0.5	1.65			Yes	Yes
25	0.15	0.3			Yes	Yes
26	0.85	3.0			Yes	No

Test No.	**PCC Target Voltage (pu)**	Duration of voltage dip (sec)	Pre - fault Reactive Power dispatch (pu)	Nature of voltage dip	To be done in PSCAD (Generic & UDM)	To be done in PSS/E (Generic & UDM)
27	0.5	1.65		Unbalanced (LLG)	Yes	No
28	0.15	0.3			Yes	No
29	0.85	3.0		Unbalanced (LG)	Yes	No
30	0.5	1.65			Yes	No
31	0.15	0.3			Yes	No
32	0.85	3.0	1.0 (Over excited)	Balanced Three phase	Yes	Yes
33	0.5	1.65			Yes	Yes
34	0.15	0.3			Yes	Yes
35	0.85	3.0		Unbalanced (LL)	Yes	No
35	0.5	1.65			Yes	No
36	0.15	0.3			Yes	No
37	0.85	3.0		Unbalanced (LG)	Yes	No
38	0.5	1.65			Yes	No
39	0.15	0.3			Yes	No
40	0.85	3.0	0.5 (Over excited)		Yes	Yes
41	0.5	1.65			Yes	Yes

Test No.	**PCC Target Voltage (pu)**	Duration of voltage dip (sec)	Pre - fault Reactive Power dispatch (pu)	Nature of voltage dip	To be done in PSCAD (Generic & UDM)	To be done in PSS/E (Generic & UDM)
42	0.15	0.3		Balanced Three phase	Yes	Yes
43	0.85	3.0			Yes	No
44	0.5	1.65		Unbalanced (LL)	Yes	No
44	0.15	0.3			Yes	No
45	0.85	3.0			Yes	No
46	0.5	1.65		Unbalanced (LG)	Yes	No
47	0.15	0.3			Yes	No
48	0.85	3.0			Yes	Yes
49	0.5	1.65		Balanced Three phase	Yes	Yes
50	0.15	0.3			Yes	Yes
51	0.85	3.0			Yes	No
52	0.5	1.65	0.25 (Over excited)	Unbalanced (LLG)	Yes	No
53	0.15	0.3			Yes	No
54	0.85	3.0			Yes	No
55	0.5	1.65		Unbalanced (LG)	Yes	No
56	0.15	0.3			Yes	No

Test No.	**PCC Target Voltage (pu)**	Duration of voltage dip (sec)	Pre - fault Reactive Power dispatch (pu)	Nature of voltage dip	To be done in PSCAD (Generic & UDM)	To be done in PSS/E (Generic & UDM)
HVRT						
Test No.	**PCC Target Voltage (pu)**	Duration of voltage swel (sec)	Pre - fault Reactive Power dispatch (pu)	Nature of voltage dip	To be done in PSCAD (Generic & UDM)	To be done in PSS/E (Generic & UDM)
57	1.5	0.1	1.0 (Under excited)	Balanced Three phase	Yes	Yes
58	1.3	10			Yes	Yes
59	1.1	Continuous			Yes	Yes
60	1.5	0.1		Single phase	Yes	No
61	1.3	10			Yes	No
62	1.1	Continuous			Yes	No
63	1.5	0.1	0.5 (Over excited)	Balanced Three phase	Yes	Yes
64	1.3	10			Yes	Yes
65	1.1	Continuous			Yes	Yes
66	1.5	0.1		Single phase	Yes	No
67	1.3	10			Yes	No
68	1.1	Continuous			Yes	No

Test No.	**PCC Target Voltage (pu)**	Duration of voltage dip (sec)	Pre - fault Reactive Power dispatch (pu)	Nature of voltage dip	To be done in PSCAD (Generic & UDM)	To be done in PSS/E (Generic & UDM)
69	1.5	0.1	0.25 (Over excited)	Balanced Three phase	Yes	Yes
70	1.3	10			Yes	Yes
71	1.1	Continuous			Yes	Yes
72	1.5	0.1		Single phase	Yes	No
73	1.3	10			Yes	No
74	1.1	Continuous			Yes	No
75	1.5	0.1	1.0 (Under excited)	Balanced Three phase	Yes	Yes
76	1.3	10			Yes	Yes
77	1.1	Continuous			Yes	Yes
78	1.5	0.1		Single phase	Yes	No
79	1.3	10			Yes	No
80	1.1	Continuous			Yes	No
81	1.5	0.1	0.5 (Under excited)	Balanced Three phase	Yes	Yes
82	1.3	10			Yes	Yes
83	1.1	Continuous			Yes	Yes
84	1.5	0.1		Single phase	Yes	No

Test No.	**PCC Target Voltage (pu)**	Duration of voltage dip (sec)	Pre - fault Reactive Power dispatch (pu)	Nature of voltage dip	To be done in PSCAD (Generic & UDM)	To be done in PSS/E (Generic & UDM)
85	1.3	10			Yes	No
86	1.1	Continuous			Yes	No
87	1.5	0.1	0.25 (Under excited)	Balanced Three phase	Yes	Yes
88	1.3	10			Yes	Yes
89	1.1	Continuous			Yes	Yes
90	1.5	0.1		Single phase	Yes	No
91	1.3	10			Yes	No
92	1.1	Continuous			Yes	No
Effectiveness of PSS						
Test No.	Pre - fault Reactive Power dispatch (pu)	Nature of fault		PSS (In service/Wo service)	To be done in PSCAD (Generic & UDM)	To be done in PSS/E (Generic & UDM)
93	1.0 (Under excited)	3-phase bolted		With PSS	Yes	Yes
94				W/o PSS	Yes	Yes
95	1.0 (Over excited)			With PSS	Yes	Yes
96				W/o PSS	Yes	Yes

Test No.	**PCC Target Voltage (pu)**	Duration of voltage dip (sec)	Pre - fault Reactive Power dispatch (pu)	Nature of voltage dip	To be done in PSCAD (Generic & UDM)	To be done in PSS/E (Generic & UDM)
Excitation System Limiter Testing						
Test No.	**Target Voltage (pu)**	Pre - fault Reactive Power dispatch (pu)		Description		
97	-5% step of Vref	0.1 (Under excited) (Within the generator's capability curve)		OEL & UEL models to be considered		
98	+5% step of Vref	0.1 (Over excited) (Within the generator's capability curve)		OEL & UEL models to be considered		
99. Excitation System Step Response Testing (Open & close loop)						
100. RoCof Testing (ROCOF) up to 4 Hz/second for 0.25 seconds						
101. RoCof Testing (ROCOF) up to 3 Hz/second for 1 second						
102. Impedance/frequency scan for a frequency range of 0-2500Hz (on SMIB)						
103. Oscillation Rejection Test (on SMIB) for 0.1, 0.3, 0.6, 0.9, 1.0 & 2.0, 3.0, 4.0, 8.0, 10.0 Hz						

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 requirements for grid management and operation of substations, Transmission Service Provider (TSP) shall provide the following:

For smooth operation of the HVDC system, communication network with high reliability and availability shall be provided for transmission of control and protection signals between the two or more (in case of multi-terminal DC) HVDC terminals. The communication system design shall be as follows:

- Main-I
- Main-II (as hot standby to Main-I)
- Back-up communication

The TSP shall supply, install and commission SDH equipment required for the converter stations at Barmer-II and South Kalamb and the necessary repeater stations. The repeater stations for fibre optic communication are also included in the scope of the TSP. The number and locations of repeaters shall be finalized after a survey by TSP.

COMMUNICATION SYSTEMS GENERAL

Duplicated (2X100%) main communication systems (Main-I and Main-II) at Barmer-II and South Kalamb terminal and its repeaters comprise first cubicle of Main Fibre Optic Terminal equipment (FOTE) and second cubicle of Standby FOTE to be provided to meet the requirements of the control, protection, data transfer and telephone systems. The system shall be based on the fiber optic communication between the converter stations through ± 800 kV DC lines. Each Main and Standby FOTE system shall be independent of each other. TSP to design the optical fiber Communication system between the converter stations in such a way that communication is available even when there is complete failure of one FOTE system. All repeater stations required for the communication system shall be provided by TSP. The TSP shall provide all required equipment, accessories, routers, modems and facilities etc. as required, for successful commissioning and use of the communication channels at Barmer-II and South Kalamb HVDC Bipole terminal.

The backup communication link shall also be provided through OPGW on parallel AC Lines. Necessary support shall be provided by the TSP to other TSP/s whose existing communication network is required to be configured for backup communication. Configuration work shall be done by the backup communication system owner/s for the Barmer-II – South Kalamb HVDC link in coordination with the TSP. TSP shall be responsible for all interface requirements with the Communication system of the other TSP(s) whose OPGW/Communication equipment are required for successful commissioning of the backup communication link including hardware/accessories etc.

C.1.0 ±800 kV HVDC Bipole line between Barmer-II (HVDC) & South Kalamb (HVDC)

On Barmer-II (HVDC) – South Kalamb (HVDC) ±800kV HVDC line, TSP shall supply, install & commission One (1) No. OPGW cable containing 48 Fibres (48F) on one E/W peak and conventional earth wire on other E/W peak. OPGW diameter shall be inline with earthwire parameters mentioned in *'Specific technical requirements for HVDC transmission line'*.

The TSP shall install this OPGW from the gantry of Barmer-II (HVDC) up to the gantry of South Kalamb (HVDC) S/s 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 900 kms (approx.) where repeaters are required to meet link budget requirement of Barmer-II (HVDC) – South Kalamb (HVDC).

TSP shall finalize the location and number of repeater stations depending upon the actual site conditions. Further TSP shall comply to the requirements mentioned as per **Appendix-F.1**.

C.2.0 LILO of both circuits of 400 kV Fatehgarh-IV PS - Barmer-I PS at Barmer-II PS

On LILO of both circuits of 400 kV Fatehgarh-IV PS - Barmer-I PS at Barmer-II PS, TSP to supply, install and commission OPGW and earth wire as per Tower Configurations:

(i) Loop-In and Loop out Ckt on Single Towers: Two (2) No. OPGW cable containing 24 Fibres (24F) to be installed and commissioned by the TSP on both Earthwire peaks

(ii) Loop-In and Loop out Ckt on Two separate Towers: One (1) No. OPGW cable containing 24 Fibres (24F) on one earthwire peak and conventional earthwire on other E/W peak for both Loop In and Loop Out Lines.

Note**:** On the 400 kV Fatehgarh-IV PS - Barmer-I PS line, 24 Fiber OPGW is proposed therefore on LILO portion 24 Fiber OPGW is considered (TSP need to do the site survey before installing OPGW).
The TSP shall install OPGW cables from Gantry of Barmer-II PS up to the LILO tower with all associated hardware including Vibration Dampers, LILO Tower, mid-way and gantry Joint Boxes (called **OPGW Hardware** hereafter) and finally terminate in Joint Boxes at Barmer-II PS. The transmission line length of LILO portion is 10 kms (approx.). After LILO, if fiber length for links **Barmer-I to Barmer-II PS** and **Fatehgarh-IV PS to Barmer-II PS** is above 225 kms then repeater shall be envisaged, otherwise line can be managed as a repeater less link.

TSP shall finalize the location of repeater station depending upon the actual site conditions. Further TSP shall comply to the requirements mentioned as per **Appendix-F.1**.

Maintenance of OPGW Cable and **OPGW Hardware** shall be the responsibility of TSP.

Note**:** Necessary optical interfaces shall be provided by TSP in the FOTE of Fatehgarh-IV PS and Barmer-I PS as per link budget requirement after change of fiber link length due to LILO.

C.3.0 Barmer-II PS – Barmer-I PS D/C line

(i) On Barmer-II PS – Barmer-I PS 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 Barmer-II PS up to the gantry of Barmer-I PS with all associated hardware including Vibration Dampers, mid-way & gantry Joint Boxes (called OPGW Hardware hereafter) and finally terminate in Joint Boxes at end Substations. The transmission line length is 30 kms (approx.), where repeater may not be required to meet the link budget requirement of Barmer-II PS – Barmer-I PS link.

(iii) Maintenance of OPGW Cable and OPGW Hardware shall be the responsibility of TSP.

C.4.0 FOTE requirement at Barmer-I S/s.

(i) TSP shall supply, install and commission FODP with minimum 144 Fiber capacity alongwith panel and required Approach Cable (48F) with all associated hardware fittings from gantry tower to Bay Kiosk and from the Bay Kiosk to Control room.

(ii) TSP shall supply, install & commission One 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 Barmer-I S/s, Barmer -II 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 Barmer-I S/s 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 including FOTE, FODP, approach cable, PMU, DCPS alongwith Battery Bank shall be the responsibility of TSP.

C.5.0 FOTE Requirement at ±800KV Barmer-II (HVDC) terminal station

(i) TSP shall supply install and commission one or more. FODP (with minimum 2x144F) alongwith 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 2x STM-16 (FOTE) equipment (in redundant mode connected with separate fibre pairs of same OPGW) alongwith panel/s supporting minimum Five (5) directions with MSP (Multiplex Section Protection – 1+1) at Barmer-II (HVDC) S/s with necessary interfaces to meet the voice and data communication requirement among Barmer-II (AC), Barmer -II (HVDC), South Kalamb (HVDC)/ Repeater Stations. The suitable DC Power Supply and backup to be provided for each communication equipment operational in redundant mode.

(iii) FODP and FOTE equipment with panels shall be provided in the Control Room of Barmer-II (HVDC) S/s. FOTE & FODP Eq can be accommodated in the same panel to optimize space.

(iv) The new communication equipment under the present scope shall be compatible for integration with existing regional level centralized NMS. The local configuration of the new communication equipment shall be the responsibility of TSP. The configuration work in the existing centralized NMS for integration of new Communication equipment shall be done by Regional ULDC Team, however all the necessary support in this regard shall be ensured by TSP.

(v) TSP shall deploy Cyber Security System in compliance with CEA (Cyber Security in Power Sector) Guidelines, 2021 and CEA (Cyber Security in Power Sector) Regulation, from its date of publication/ notification and their amendments thereof.

(vi) The maintenance of all the communication equipment and software thereof including FOTE, FODP, approach cable, Repeater Station, DCPS alongwith Battery Bank & Cyber Security System shall be the responsibility of TSP.

C.6.0 FOTE Requirement at ±800KV South Kalamb (HVDC) terminal station

(i) TSP shall supply, install & commission one or more. FODP (with minimum 2x144F) 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 & commission 2x STM-16 (FOTE) equipment (in redundant mode connected with separate fibre pairs of same OPGW) along with panel/s supporting minimum Five (5) directions with MSP (Multiplex Section Protection – 1+1) at South Kalamb (HVDC) S/s with necessary interfaces to meet the voice and data communication requirement among South Kalamb (HVDC), Barmer-II (HVDC)/ Repeater Stations. The suitable DC Power Supply and backup to be provided for each communication equipment operational in redundant mode.

(iii) FODP and FOTE equipment with panels shall be provided in Control Room of South Kalamb (HVDC) S/s. FOTE & FODP Eq can be accommodated in the same panel to optimize space.

(iv) The new communication equipment under the present scope shall be compatible for integration with existing regional level centralized NMS. The local configuration of the new communication equipment shall be the responsibility of TSP. The configuration work in the existing centralized NMS for integration of new Communication equipment shall be done by Regional ULDC Team, however all the necessary support in this regard shall be ensured by TSP.

(v) TSP shall deploy Cyber Security System in compliance with CEA (Cyber Security in Power Sector) Guidelines, 2021 and CEA (Cyber Security in Power Sector) Regulation, from its date of publication/ notification and their amendments thereof.

(vi) The maintenance of all the communication equipment and software thereof including FOTE, FODP, approach cable, Repeater Station, DCPS along with Battery Bank & Cyber Security System shall be the responsibility of TSP.

C.7.0 FOTE requirement at Barmer -II S/s (400/220kV AC)

(4 No. of 400 kV line bays for REs, 7 No. of 220 kV line bays for REs, 4 No. of 400 kV line bays for LILO and 2 No. of 400 kV line bays for Barmer-I to Barmer-II D/C line)

(i) TSP shall supply, install and commission one or more FODP to accommodate minimum 768 Fibers alongwith panel and required Approach Cable (48F/24F) 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 One or more STM-16 (FOTE) equipment alongwith panel/s supporting minimum Seventeen (17) directions with MSP (Multiplex Section Protection – 1+1) with necessary interfaces to meet the voice and data communication requirement between Barmer-I PS, Fatehgarh-IV PS, 4 No. of 400 kV REs, 7 No. of 220 kV REs, Barmer-II (HVDC). These directions shall exclude the local patching among equipment (if any). 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 South Kalamb (HVDC) S/s. FOTE & FODP can be accommodated in same panel to optimize space.

(iv) The new communication equipment under the present scope shall be compatible for integration with existing regional level centralized NMS. The local configuration of the new communication equipment shall be the responsibility of TSP. The configuration work in the existing centralized NMS for integration of new Communication equipment shall be done by Regional ULDC Team, however all the necessary support in this regard shall be ensured by TSP.

(v) TSP shall deploy Cyber Security System in compliance with CEA (Cyber Security in Power Sector) Guidelines, 2021 and CEA (Cyber Security in Power Sector) Regulation, from its date of publication/ notification and their amendments thereof.

(vi) The maintenance of all the communication equipment and software thereof including FOTE, FODP, approach cable, DCPS along with Battery Bank shall be the responsibility of TSP.

C.8.0 Specific Requirement for Phasor Measurement Units (PMUs)

TSP shall supply, install and commission required No. of Phasor Measurement Units (PMUs) as per the "Guidelines on Unified Philosophy for placement of PMUs in Indian Grid" issued vide CEA letter No. CEA-PS-14-12/9/2024-PSETD Division dated 19.03.2025 for the scope of this RFP. The PMUs shall be provided with LAN switch and shall connect with LAN switch of control room of respective substations/ generating stations with Fibre Optic cable. The 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.

C.9.0 Specific Requirement for UNMS Integration of FOTE

Communication system integration in UNMS/CSMS

TSP is to ensure integration of communication system into UNMS/CSMS as per following:

"The new communication equipment/ system under the present scope shall be compatible for integration with existing regional level NMS system/ Centralized Supervision & Monitoring System (CSMS) i.e. Regional UNMS. The local configuration of the new communication equipment/ system at the station end shall be the responsibility of TSP as per the following. The configuration work in the existing centralized NMS/ UNMS 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.

Requirement for integration of Communication Equipment/ system 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 & periodic, Performance KPI parameters (E-1, STM, Ethernet), Remote Configuration, Cross Connects, Trails & Circuits, Services Provisioning (NE), E-1, STM, Ethernet, TX & RX 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 & 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."

Appendix-F.1

Repeater Requirements

FOTE to be provided by TSP in repeater station/s shall be 2x STM-16 (FOTE) equipment (in redundant mode connected with separate fibre pairs of same OPGW/UGFO/Approach Cable)

- If the repeater location is finalized in the Control Room of a nearby substation, TSP shall provide OPGW to accommodate all the fibers in main transmission line on a single Earthwire peak with OPGW Hardware & mid-way Joint Boxes etc. of the line crossing the main line and required approach Cable to accommodate all the OPGW fibers with all associated hardware fittings, to establish connectivity between crossing point of main transmission line up to the repeater equipment in substation control room.
  TSP shall co-ordinate for Space and DC power supply sharing for repeater equipment.

  TSP shall provide FODP, FOTE (with STM-16 capacity) with suitable interfaces required for link budget of respective link.

OR

- If the repeater location is finalized in the nearby substation premises, the TSP shall identify the Space for repeater shelter in consultation with station owner. Further TSP shall provide OPGW to accommodate all the fibers in main transmission line on a single Earthwire peak with OPGW Hardware & mid-way Joint Boxes etc. of the line crossing the main line and required approach Cable/UGFO to accommodate all the OPGW fibers with all associated hardware fittings, to establish connectivity between crossing point of main transmission line up to the substation where the repeater shelter is to be housed.
  TSP shall provide repeater shelter along with FODP, FOTE (with STM-16 capacity) with suitable interfaces require for link budget of respective link, reliable power supply provisioning for AC and DC supply, battery bank, Air Conditioner and other associated systems.

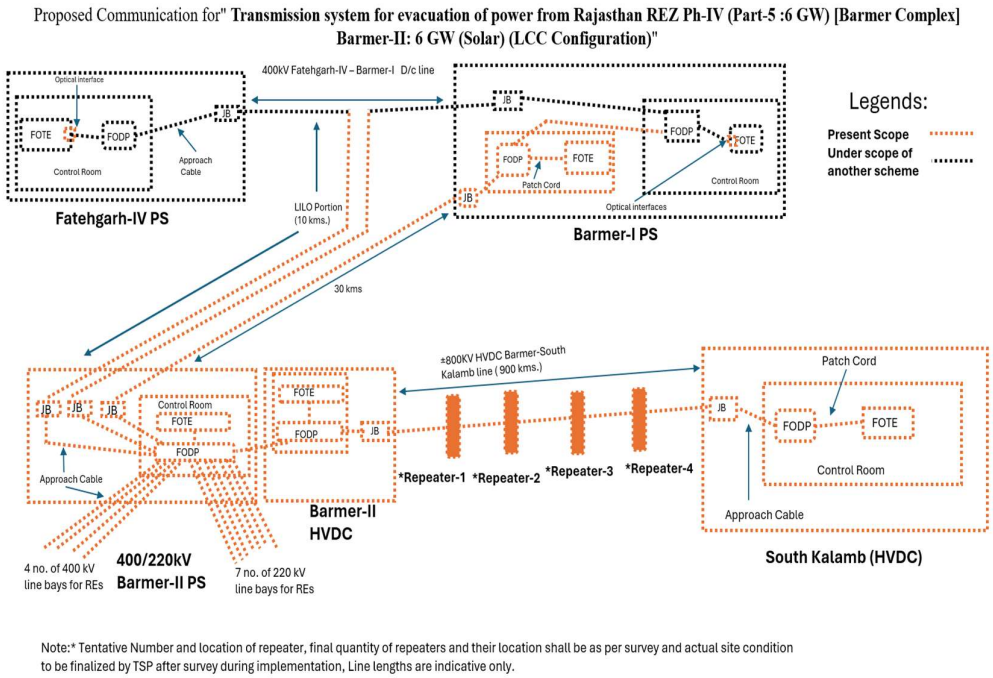
OR

- If the repeater location is finalized on land near the transmission tower. TSP shall make the provisions for Land at nearby tower for repeater shelter. Further TSP shall provide required approach Cable to accommodate all the OPGW fibers with all associated hardware fittings to establish connectivity up to the location of repeater shelter.

TSP shall provide repeater shelter along with FODP, FOTE (with STM-16 capacity) with suitable interfaces require for link budget of respective link, reliable power supply provisioning for AC and DC supply, battery bank, Air Conditioner and other associated systems

Maintenance of OPGW Cable and OPGW Hardware, repeater equipment & items associated with repeater shelter shall be 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.



Note:* Tentative Number and location of repeater, final quantity of repeaters and their location shall be as per survey and actual site condition to be finalized by TSP after survey during implementation, Line lengths are indicative only.

Figure F.1

Note: In the proposed scheme Figure F.1, only one STM-16 (FOTE) is shown at Barmer-II (HVDC) and South Kalamb (HVDC). However, as per the requirement, the TSP shall supply, install and commission two (2) STM-16 (FOTE) equipment (in redundant mode, each connected with separate fibre pairs of the same OPGW) along with panels supporting a minimum of five (5) directions with MSP (1+1).

C.10.0 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 protections for transmission line and the line compensating equipment shall have hundred percent back up communication channels i.e. two channels for tele-protection in addition to one channel for speech plus data for each direction. The PLCC equipment shall in brief include the following:

i. Coupling device, Coupling filters line traps, carrier terminals, protection couplers, HF cables, PABX (if applicable) and maintenance and testing instruments.

ii. 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 centers (RLDC/SLDC) etc.

iii. 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.

iv. 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.

v. 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.

vi. PLCC equipment for all the transmission lines covered under the scheme shall be provided by TSP as per following configuration. PLCC to be provided for following lines under present scopeTSP shall provide new set of PLCC as per the following configuration:

Sl. No	Line name	PLCC configuration
1.	Fatehgarh-IV PS - Barmer-II PS [formed after LILO]	1 set Analog PLCC + 1 set Digital Protection Coupler for each circuit at both ends. Existing PLCC panel may also be utilized.
2.	Barmer-I PS - Barmer-II PS [formed after LILO]	1 set Analog PLCC + 1 set Digital Protection Coupler for each circuit at both ends. Existing PLCC panel may also be utilized.
3.	400 kV Barmer-II PS - Barmer-I PS D/C line	1 set Analog PLCC + 1 set Digital Protection Coupler for each circuit at both ends.
4.	800 kV HVDC Bipole line between Barmer-II (HVDC) and South Kalamb (HVDC)	2 sets Digital Protection Coupler for each circuit at both ends.

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

vii. TSP shall provide/ undertake necessary addition/ modification/ shifting/ re-commissioning etc. of PLCC equipment due to LILO of transmission lines (wherever applicable).

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

Frequently Asked Queries:

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 & 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 the 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 keeping in mind further increase in pollution during life of the line. It shall be as per CEA regulations and relevant standards. However, the tower shall be designed considering the porcelain insulators with creepage factor of 31 mm/kV irrespective of type of insulator used.

Substation:

2.1 We understand that space for storage of O&M spare shall be provided by the 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 the responsibility of the TSP. . TSP shall follow CEA's " Operation and Maintenance (O&M) guidelines and Standard Format for Memorandum of Understating 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 be 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 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 a 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 the respective substation owner for construction of new bays.

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

2.8 It is understood that the 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 the 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 & CVT is required for Line/feeders. Further, we understood that requisite Energy meters for various 765 kV, 400 kV & 220 kV Feeders shall be provided & 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 matches 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 765kV single phase Reactor unit for Bus reactor shall be provided with 1ph 765kV 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 has 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 the 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, the control room shall be augmented as per requirement.

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. & 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 Kisok/ 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 the 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 2x24F OPGW shall be required to install by TSP on both earthwire peak on 400 kV & 765 kV lines where two E/W peaks are available. On 220 & 132 kV lines where only one E/W peak is available TSP to install one No. 48F OPGW.
Incase 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 1x24F 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 & 765 kV lines. On 220 kV &132 kV lines where only one E/W peak is available TSP to install one No. 24F OPGW in place of conventional earthwire.

3.4 How is the OPGW laying done in the case of 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 & 400 kV lines.
Incase 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 are PMUs 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/NavIC clock and LAN switch and shall connect with LAN switch of control room of respective substations with Fibre Optic cable. Further the “Guidelines on Unified Philosophy for placement of PMUs in Indian Grid” issued vide letter No. CEA-PS-14-12/9/2024-PSETD Division dated 19.03.2025 shall be followed.

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 in compliance of the “Guidelines on Unified Philosophy for placement of PMUs in Indian Grid” issued vide letter No. CEA-PS-14-12/9/2024-PSETD Division dated 19.03.2025.

Planning:

4.1 Whether the Project/ Elements are eligible for early commissioning incentive as per MoP, GoI 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.

Schedule: 2

Scheduled COD

[Note: As referred to in the definition of "Element", "Scheduled COD", and in Articles 3.1.3 (c), 4.1 (b) and 4.3 (a) of this Agreement]

Sl. No.	Name of the Transmission Element	Scheduled COD	Percentage of Quoted Transmission Charges recoverable on Scheduled COD of the Element of the Project	Element(s) which are pre-required for declaring the commercial operation (COD) of the respective Element
1.	Establishment of 400/220 kV, 6x500 MVA S/s at suitable location near Barmer (Barmer-II Substation) along with 2x125 MVAr bus reactor	54 months from allocation of project (Bipole-1: 48 months, Bipole-2: 54 months)	100%	All the elements of the scheme are required to be commissioned simultaneously as their utilization is dependent on each other.
2.	LILO of both circuits of 400 kV Fatehgarh-IV PS - Barmer-I PS D/C line at Barmer-II PS			
3.	400 kV Barmer-II PS - Barmer-I PS D/C line (Quad)			
4.	Establishment of 6000 MW, ± 800 kV Barmer-II (HVDC) [LCC] terminal station (4x1500 MW) at a suitable location near Barmer-II substation			

Sl. No.	Name of the Transmission Element	Scheduled COD	Percentage of Quoted Transmission Charges recoverable on Scheduled COD of the Element of the Project	Element(s) which are pre-required for declaring the commercial operation (COD) of the respective Element
5.	Establishment of 6000 MW, ± 800 kV South Kalamb S/s (HVDC) [LCC] terminal station (4x1500 MW) at a suitable location near South of Kalamb			
6.	±800 kV HVDC Bipole line (Hexa lapwing) between Barmer-II (HVDC) & South Kalamb (HVDC) (with parallel Dedicated Metallic Return) (capable to evacuate 6000 MW) [with 100% reverse power capability]			
7.	Augmentation of South Kalamb S/s by 4x1500 MVA, 765/400 kV ICTs (3 Nos 400 kV & 765 kV Section-II & 1 No. on 400 kV & 765 kV Section-I) along with 2x330 MVAR, 765 kV bus reactor & 2x125 MVAR, 420 kV bus reactor on Section-II. The Section-II will be established under a different network expansion scheme in WR (2x1500 MW HVDC Bipole-I to be terminated			

Sl. No.	Name of the Transmission Element	Scheduled COD	Percentage of Quoted Transmission Charges recoverable on Scheduled COD of the Element of the Project	Element(s) which are pre-required for declaring the commercial operation (COD) of the respective Element
	on 400 kV Section-I & 2x1500 MW HVDC Bipole-II to be terminated on 400 kV Section-II of South Kalamb S/s & 765 kV bus sectionalizer to be kept normally closed & 400 kV bus sectionalizer to be kept normally open)			
8.	2 Nos. of Syncon units at 400 kV level of Barmer-II PS (1 No. of SynCon unit comprises dynamic support of +300 MVAr/-200 MVAr (Minimum) & Short circuit contribution at PCC of 1200 MVA (Minimum))			

The payment of Transmission Charges for any Element, irrespective of its successful commissioning on or before its Scheduled COD, shall only be considered after successful commissioning of the Element(s), which are pre-required for declaring the commercial operation of such Element as mentioned in the above table.

Scheduled COD for overall Project: 54 months from allocation of project (Bipole-1: 48 months, Bipole-2: 54 months)

[Note: List of Element(s) along with the critical Element(s) to be provided by CEA]

Schedule: 3

Safety Rules and Procedures

[Note: As referred to in Articles 5.6 of this Agreement]

1: **Site Regulations and Safety:**

The TSP shall establish Site regulations within sixty (60) days from fulfilment of conditions subsequent, as per Prudent Utility Practices setting out the rules to be observed till expiry of the Agreement at the Site and shall comply therewith.

Such Site regulations shall include, but shall not be limited to, rules in respect of security, safety of the Project, gate control, sanitation, medical care, and fire prevention, public health, environment protection, security of public life, etc.

Copies of such Site regulations shall be provided to the Nodal Agency and the CEA for the purpose of monitoring of the Project.

2: **Emergency Work:**

In cases of any emergency, the TSP shall carry out all necessary remedial work as may be necessary.

If the work done or caused to be done by any entity , other than the TSP, the TSP shall, reimburse the actual costs incurred, to the other Party carrying out such remedial works.

3: **Site Clearance:**

In the course of execution of the Agreement, the TSP shall keep the Site reasonably free from all unnecessary obstruction, storage, remove any surplus materials, clear away any wreckage, rubbish and temporary works from the Site, and remove any equipment no longer required for execution of the Agreement. After completion of all Elements of the Project, the TSP shall clear away and remove all wreckage, rubbish and debris of any kind from the Site, and shall leave the Site clean and safe.

4: **Watching and Lighting:**

The TSP shall provide and maintain at its own expense all lighting, fencing, and watching when and where necessary for the proper construction, operation, maintenance / repair of any of the Elements of the Project, or for the safety of the owners and occupiers of adjacent property and for the safety of the public, during such maintenance / repair.

Schedule: 4

Computation of Transmission Charges

1.1 General

The Monthly Transmission Charges to be paid to the TSP for providing Transmission Service for any Contract Year during the term of the Agreement shall be computed in accordance with this Schedule and paid as per Sharing Regulations.

Illustration regarding payment of Transmission Charges under various scenarios (considering definitions of Contract Year, Expiry Date & Monthly Transmission Charges above) is as below: -

Illustration-1: In case the Project Elements achieve COD as per Schedule

Quoted Transmission Charges: **Rs. 140 Million**

Completion Schedule:

Element No.	Completion Schedule in Months	Scheduled CoD of the Element	Actual CoD of the Element	% Charges recoverable on Scheduled CoD of the Element
Element 1	28	1-Feb-2018	1-Feb-2018	25%
Element 2	38	1-Dec-2018	1-Dec-2018	75%

Tariff Payable as follows:

Transmission Charges for Element 1			**Transmission Charges for Element 2**		
1-Feb-18 to 31-Mar-18	140 X 25% X ((28+31)/365)	5.65		--	0.00
1-Apr-18 to 30-Nov-18	140 X 25% X (244/365)	23.39		--	0.00
1-Dec-18 to 31-Mar-19	140 X 100% X (121/365)				46.41
2	140 X 100% X 1				140
3	140 X 100% X 1				140
4	140 X 100% X 1				140
5	140 X 100% X 1				140
…….					
……..					
36 (1-Apr to 30-Nov)	140 X 100% X (244/365)				93.59

Illustration-2: In case of extension of Scheduled COD as per Article 4.4.1 & 4.4.2 of this Agreement

Quoted Transmission Charges: **Rs. 140 Million**

Completion Schedule:

Element No.	Completion Schedule in Months	Scheduled CoD of the Element	Actual CoD of the Element	% Charges recoverable on Scheduled CoD of the Element
Element 1	20	1-Feb-2018	1-Jul-2018	25%
Element 2	28	1-Oct-2018	1-Dec-2018	75%

Tariff Payable as follows:

Transmission Charges for Element 1			**Transmission Charges for Element 2**		
1-Feb-18 to 31-Mar-18	--	0.00		--	0.00
1-Apr-18 to 30-Jun-18	--	0.00		--	0.00
1-Jul-18 to 30-Nov-18	140 X 25% X (153/365)	14.67		--	0.00
1-Dec-18 to 31-Mar-19	140 X 100% X (121/365)				46.41
2	140 X 100% X 1				140
3	140 X 100% X 1				140
4	140 X 100% X 1				140
5	140 X 100% X 1				140
…….					
……..					
36 (1-Apr to 30-Nov)	140 X 100% X (244/365)				93.59

Illustration-3: In case of delay in achieving COD of Project & all individual Elements (COD of the Project achieved in Contract Year 1)

Quoted Transmission Charges: **Rs. 140 Million**

Completion Schedule:

Element No.	Completion Schedule in Months	Scheduled CoD of the Element	Actual CoD of the Element	% Charges recoverable on Scheduled CoD of the Element
Element 1	20	1-Feb-2018	1-Dec-2018	25%
Element 2	28	1-Oct-2018	1-Dec-2018	75%

Tariff Payable as follows:

Transmission Charges for Element 1			**Transmission Charges for Element 2**		
1-Feb-18 to 31-Mar-18	--	0.00		--	0.00
1-Apr-18 to 30-Sept-18	--	0.00		--	0.00
1-Oct-18 to 30-Nov-18	--	0.00	1-Oct-18 to 30-Nov-18	--	0.00
1-Dec-18 to 31-Mar-19	140 X 100% X (121/365)				46.41
2	140 X 100% X 1				140
3	140 X 100% X 1				140
4	140 X 100% X 1				140
5	140 X 100% X 1				140
…….					
……..					
36 (1-Apr to 30-Nov)	140 X 100% X (244/365)				93.59

Illustration-4: In case of delay in achieving COD of Project & all individual Elements (COD of the Project achieved in Contract Year other than Contact Year 1)

Quoted Transmission Charges: **Rs. 140 Million**

Completion Schedule:

Element No.	Completion Schedule in Months	Scheduled CoD of the Element	Actual CoD of the Element	% Charges recoverable on Scheduled CoD of the Element
Element 1	38	1-Oct-2019	1-May-2020	25%
Element 2	38	1-Oct-2019	1-May-2020	75%

Tariff Payment to be paid as:

Transmission Charges for Element 1			**Transmission Charges for Element 2**		
1-Oct-19 to 31-Mar-20	--	0.00	1-Oct-19 to 31-Mar-20	--	0.00
1-Apr-20 to 30-Apr-20	-	0.00	1-Apr-20 to 30-Apr-20	-	0.00
1-May-20 to 31-Mar-21	140 X 100% X (335/365)				128.49
2	140 X 100% X 1				140
3	140 X 100% X 1				140
4	140 X 100% X 1				140
5	140 X 100% X 1				140
…….					
……..					
36 (1-Apr to 30-Apr)	140 X 100% X (30/ 365)				11.51

Illustration5: In case of delay in achieving COD of Element but Project COD achieved on time

Quoted Transmission Charges: **Rs. 140 Million**

Completion Schedule:

Element No.	Completion Schedule in Months	Scheduled CoD of the Element	Actual CoD of the Element	% Charges recoverable on Scheduled CoD of the Element
Element 1	20	1-Feb-2018	1-Jul-2018	25%
Element 2	30	1-Dec-2018	1-Dec-2018	75%

Tariff Payable as follows:

Transmission Charges for Element 1			Transmission Charges for Element 2		
1-Feb-18 to 31-Mar-18	--	0.00		--	0.00
1-Apr-18 to 30-Jun-18	--	0.00		--	0.00
1-Jul-18 to 30-Nov-18	140 X 25% X (153/365)	14.67		--	0.00
1-Dec-18 to 31-Mar-19	140 X 100% X (121/365)				46.41
2	140 X 100% X 1				140
3	140 X 100% X 1				140
4	140 X 100% X 1				140
5	140 X 100% X 1				140
…….					
……..					
36 (1-Apr to 30-Nov)	140 X 100% X (244/365)				93.59

Illustration-6: In case of early commissioning of Project

Quoted Transmission Charges: **Rs. 140 Million**

Completion Schedule:

Element No.	Completion Schedule in Months	Scheduled CoD of the Element	Actual CoD of the Element	% Charges recoverable on Scheduled CoD of the Element
Element 1	38	1-Oct-2019	1-Jul-2019	25%
Element 2	38	1-Oct-2019	1-Jul-2019	75%

Tariff Payment to be paid as:

Transmission Charges for Element 1	**Transmission Charges for Element 2**	
1-July-19 to 31-Mar-20	140 X 100% X (274/365)	105.09
2	140 X 100% X 1	140
3	140 X 100% X 1	140
4	140 X 100% X 1	140
5	140 X 100% X 1	140
…….		
……..		
36 (1-Apr to 30-Jun)	140 X 100% X (91/365)	34.91

Illustration-7: In case of early commissioning of an element

Quoted Transmission Charges: **Rs. 140 Million**
Completion Schedule:

Element No.	Completion Schedule in Months	Scheduled CoD of the Element	Actual CoD of the Element	% Charges recoverable on Scheduled CoD of the Element
Element 1	38	1-Oct-2019	1-Apr-2019	25%
Element 2	38	1-Jul-2019	1-Jul-2019	75%

Tariff Payment to be paid as:

Transmission Charges for Element 1			**Transmission Charges for Element 2**		
1-Apr-2019 to 30-Jun-19	140 X 25% X (91/365)	8.72	1-Apr-2019 to 30-Jun-19	--	0.00
1-July-19 to 31-Mar-20	140 X 100% X (274/ 365)				105.09
2	140 X 100% X 1				140
3	140 X 100% X 1				140
4	140 X 100% X 1				140
5	140 X 100% X 1				140
…….					
……..					
36 (1-Apr-30-Jun)	140 X 100% X (91/365)				34.91

The Transmission Charges shall be payable on monthly basis as computed above.

1.2 Computation of Monthly Transmission Charges

The Monthly Transmission Charges for any month m in a Contract Year n shall be calculated as below:

For AC System:

a. If Actual Transmission System Availability for the month m of contract year n is greater than or equal to 98% and less than or equal to 98.5%;

Monthly Transmission Charges MTC(m) = Tmn *1

a. If Actual Transmission System Availability for the month m of contract year n exceeds 98.5% and less than or equal to 99.75%;

Monthly Transmission Charges MTC(m) = Tmn * (AA/ 98.5%)

c. If Actual Transmission System Availability for the month m of contract year n is greater than 99.75%;

Monthly Transmission Charges MTC(m) = Tmn * (99.75% / 98.5%)

d. If Actual Transmission System Availability for the month m of contract year n is less than 98%and greater than or equal to 95.00%;

Monthly Transmission Charges MTC(m) = Tmn * (AA/ 98%)

e. If Actual Transmission System Availability for the month m of contract year falls below 95%;

Monthly Transmission Charges MTC(m) = Tmn * (AA/ 98%) - 0.02 * (Tmn * (AA/ 95%)

For DC System:

a. If Actual Transmission System Availability for the month m of contract year n is greater than or equal to 95% and less than or equal to 96%;

Monthly Transmission Charges MTC(m) = Tmn *1

b. If Actual Transmission System Availability for the month m of contract year n exceeds 96% and less than or equal to 99.75%;

Monthly Transmission Charges MTC(m) = Tmn * (AA/ 96%)

c. If Actual Transmission System Availability for the month m of contract year n is greater than 99.75%;

Monthly Transmission Charges MTC(m) = Tmn * (99.75% / 96%)

d. If Actual Transmission System Availability for the month m of contract year n is less than 95% and greater than or equal to 92.00%;

Monthly Transmission Charges MTC(m) = Tmn * (AA/ 95%)

e. If Actual Transmission System Availability for the month m of contract year falls below 92%;

Monthly Transmission Charges MTC(m) = Tmn * (AA/ 95%) - 0.02 * (Tmn * (AA/ 92%)

where:

- AA is the actual Availability, as certified by RPC, as per procedure provided in Schedule 6.
- m is the month in Contract Year 'n'
- Tmn= Transmission Charges for the month 'm' in Contract Year 'n' = (=Transmission Charge/ no. of days in the Year n)* no. of days in month m

Provided, no Transmission Charges shall be paid during the period for which the RLDC has not allowed the operation of the Element/Project due to the failure of the TSP to operate it as per the provisions of the Grid Code.

1.3 RLDC Fee & Charges

The payment of RLDC fee & charges, in accordance with relevant regulations of CERC, shall be the responsibility of the TSP.

Schedule: 5

Quoted Transmission Charges

[Quoted Transmission Charges from Annexure - 21 of the RFP of the Selected Bidder to be inserted here]

[To be incorporated from the Bid of the Selected Bidder submitted during the e-reverse auction after its selection]

Quoted Transmission Charges: Rs. …… Million

Proportionate Transmission Charges payable for each Element of the Project:

Sl. No.	Name of the Transmission Element	Scheduled COD	Percentage of Quoted Transmission Charges recoverable on Scheduled COD of the Element of the Project	Element(s) which are pre-required for declaring the commercial operation (COD) of the respective Element
1.	Establishment of 400/220 kV, 6x500 MVA S/s at suitable location near Barmer (Barmer-II Substation) along with 2x125 MVAr bus reactor	54 months from allocation of project (Bipole-1: 48 months, Bipole-2: 54 months)	100%	All the elements of the scheme are required to be commissioned simultaneously as their utilization is dependent on each other.
2.	LILO of both circuits of 400 kV Fatehgarh-IV PS - Barmer-I PS D/C line at Barmer-II PS			
3.	400 kV Barmer-II PS - Barmer-I PS D/C line (Quad)			
4.	Establishment of 6000 MW, ± 800 kV Barmer-II (HVDC) [LCC] terminal station (4x1500 MW) at a suitable location near Barmer-II substation			
5.	Establishment of 6000 MW, ± 800 kV South			

Sl. No.	Name of the Transmission Element	Scheduled COD	Percentage of Quoted Transmission Charges recoverable on Scheduled COD of the Element of the Project	Element(s) which are pre-required for declaring the commercial operation (COD) of the respective Element
	Kalamb S/s (HVDC) [LCC] terminal station (4x1500 MW) at a suitable location near South of Kalamb			
6.	±800 kV HVDC Bipole line (Hexa lapwing) between Barmer-II (HVDC) & South Kalamb (HVDC) (with parallel Dedicated Metallic Return) (capable to evacuate 6000 MW) [with 100% reverse power capability]			
7.	Augmentation of South Kalamb S/s by 4x1500 MVA, 765/400 kV ICTs (3 Nos 400 kV & 765 kV Section-II & 1 No. on 400 kV & 765 kV Section-I) along with 2x330 MVAR, 765 kV bus reactor & 2x125 MVAR, 420 kV bus reactor on Section-II. The Section-II will be established under a different network expansion scheme in WR (2x1500 MW HVDC Bipole-I to be terminated on 400 kV Section-I & 2x1500 MW HVDC Bipole-II to be terminated on 400 kV Section-II of South Kalamb S/s & 765 kV bus			

Sl. No.	Name of the Transmission Element	Scheduled COD	Percentage of Quoted Transmission Charges recoverable on Scheduled COD of the Element of the Project	Element(s) which are pre-required for declaring the commercial operation (COD) of the respective Element
	sectionalizer to be kept normally closed & 400 kV bus sectionalizer to be kept normally open)			
8.	2 Nos. of Syncon units at 400 kV level of Barmer-II PS (1 No. of SynCon unit comprises dynamic support of +300 MVAr/-200 MVAr (Minimum) & Short circuit contribution at PCC of 1200 MVA (Minimum))			

Schedule: 6

Appendix IV of the Central Electricity Regulatory Commission (Terms and Conditions of Tariff) Regulations 2024

Procedure for Calculation of Transmission System Availability Factor for a Month

1. Transmission system availability factor for nth calendar month ("TAFPn") shall be calculated by the respective transmission licensee, verified by the concerned Regional Load Dispatch Centre (RLDC) and certified by the Member-Secretary, Regional Power Committee of the region concerned, separately for each AC and HVDC transmission system and grouped according to sharing of transmission charges. In the case of the AC system, transmission System Availability shall be calculated separately for each Regional Transmission System and inter-regional transmission system. In the case of the HVDC system, transmission System Availability shall be calculated on a consolidated basis for all inter-state HVDC systems.

2. Transmission system availability factor for nth calendar month ("TAFPn") shall be calculated by considering the following:

    i) **AC transmission lines**: Each circuit of AC transmission line shall be considered as one element;

    ii) **Inter-Connecting Transformers (ICTs):** Each ICT bank (three single-phase transformers together) shall form one element;

    iii) **Static VAR Compensator (SVC):** SVC, along with SVC transformer, shall form one element;

    iv) **Bus Reactors or Switchable line reactors:** Each Bus Reactors or Switchable line reactors shall be considered as one element;

    v) **HVDC Bi-pole links:** Each pole of the HVDC link, along with associated equipment at both ends, shall be considered as one element;

    vi) **HVDC back-to-back station:** Each block of the HVDC back-to-back station shall be considered as one element. If the associated AC line (necessary for the transfer of inter-regional power through the HVDC back-to-back station) is not available, the HVDC back-to-back station block shall also be considered unavailable;

vii) **Static Synchronous Compensation ("STATCOM"):** Each STATCOM shall be considered as a separate element.

3. The Availability of the AC and HVDC portion of the Transmission system shall be calculated by considering each category of transmission elements as under:

TAFPn (in %) for AC system:

$$= \frac{(o \text{ X } AVo)+(p \text{ X } AVp) + (q \text{ X } AVq) + (r \text{ X } AVr)+(u \text{ X } AVu)}{(o + p + q + r+u)} \text{x100}$$

Where,

o	=	Total number of AC lines.
AVo	=	Availability of o number of AC lines
p	=	Total number of bus reactors/switchable line reactors
AVp	=	Availability of p number of bus reactors/switchable line reactors
q1	=	Total number of ICTs
AVq	=	Availability of q number of ICTs
r	=	Total number of SVCs
AVr	=	Availability of r number of SVCs
u	=	Total number of STATCOM
AVu	=	Availability of u number of STATCOM

TAFMn (in %) for HVDC System:

$$= \frac{\sum_{x=1}^{s} Cxbp\ (act) \text{ X } AVxbp + \sum_{y=1}^{t} Cy\ (act)btb \text{ X } AVybtb}{\sum_{x=1}^{s} Cxbp + \sum_{y=1}^{t} Cy\ btb} \text{x100}$$

Where

Cxbp(act)	=	Total actual operated capacity of x^{th} HVDC pole
Cxbp	=	Total rated capacity of x^{th} HVDC pole
AVxbp	=	Availability of x^{th} HVDC pole
Cybtb(act)	=	Total actual operated capacity of y^{th} HVDC back-to-back station block
Cybtb	=	Total rated capacity of y^{th} HVDC back-to-back station block
AVybtb	=	Availability of y^{th} HVDC back-to-back station block
s	=	Total no of HVDC poles
t	=	Total no of HVDC Back to Back blocks

4. The availability for each category of transmission elements shall be calculated based on the weightage factor, total hours under consideration and non-available hours for each element of that category. The formulae for calculation of the Availability of each category of the transmission elements are as per **Appendix-V**. The weightage factor for each category of transmission elements shall be considered as under:

    (a) For each circuit of the AC line – The number of sub-conductors in the line multiplied by ckt-km;

    (b) For each HVDC pole- The rated MW capacity x ckt-km;

    (c) For each ICT bank – The rated MVA capacity;

    (d) For SVC- The rated MVAR capacity (inductive and capacitive);

    (e) For Bus Reactor/switchable line reactors – The rated MVAR capacity;

    (f) For HVDC back-to-back stations connecting two Regional grids- Rated MW capacity of each block; and

    (g) For STATCOM – Total rated MVAR Capacity.

5. The transmission elements under outage due to the following reasons shall be deemed to be available:

    i. Shut down availed for maintenance of another transmission scheme or construction of new element or renovation/upgradation/additional capitalization in an existing system approved by the Commission. If the other transmission scheme belongs to the transmission licensee, the Member Secretary, RPC may restrict the deemed availability period to that considered reasonable by him for the work involved. In case of a dispute regarding deemed availability, the matter may be referred to the Chairperson, CEA, within 30 days.

    ii. Switching off of a transmission line to restrict over-voltage and manual tripping of switched reactors as per the directions of the concerned RLDC.

    iii. Shut down of a transmission line due to the Project(s) of NHAI, Railways and Border Road Organization, including for shifting or modification of such transmission line or any other infrastructure project approved by Ministry of Power. Member Secretary, RPC may restrict the deemed availability period to that considered reasonable by him for the work involved; Provided that apart from the deemed

availability, any other costs involved in the process of such shutdown of transmission line shall not be borne by the DICs.

Provided that such deemed availability shall be considered only for the period for which DICs are not affected by the shutdown of such transmission line.

6. For the following contingencies, the outage period of transmission elements, as certified by the Member Secretary, RPC, shall be excluded from the total time of the element under the period of consideration for the following contingencies:

   i) Outage of elements due to force majeure events beyond the control of the transmission licensee. However, whether the same outage is due to force majeure (not design failure) will be verified by the Member Secretary, RPC. A reasonable restoration time for the element shall be considered by the Member Secretary, RPC, and any additional time taken by the transmission licensee for restoration of the element beyond the reasonable time shall be treated as outage time attributable to the transmission licensee. Member Secretary, RPC may consult the transmission licensee or any expert for estimation of reasonable restoration time. Circuits restored through ERS (Emergency Restoration System) shall be considered as available;

   ii) Outage caused by grid incident/disturbance not attributable to the transmission licensee, e.g. faults in a substation or bays owned by another agency causing an outage of the transmission licensee's elements, and tripping of lines, ICTs, HVDC, etc., due to grid disturbance. However, if the element is not restored on receipt of direction from RLDC while normalizing the system following grid incident/disturbance within reasonable time, the element will be considered not available for the period of outage after issuance of RLDC's direction for restoration;

   iii) The outage period which can be excluded for the purpose of sub-clause (i) and (ii) of this clause shall be declared as under:

      a. Maximum up to one month by the Member Secretary, RPC;

      b. Beyond one month and up to three months after the decision at RPC;

      c. Beyond three months by the Commission for which the transmission license shall approach the Commission along with

reasons and steps taken to mitigate the outage and restoration timeline.

7. Time frame for certification of transmission system availability: (1) The following schedule shall be followed for certification of availability by the Member Secretary of the concerned RPC:
    - Submission of outage data along with documentary proof (if any) and TAFPn calculation by Transmission Licensees to RLDC/ constituents

      – By the 5th of the following month;

    - Review of the outage data by RLDC / constituents and forward the same to respective RPC – by 20th of the month;
    - Issue of availability certificate by respective RPC – by the 3rd of the next month.

Appendix-V

FORMULAE FOR CALCULATION OF AVAILABILITY OF EACH CATEGORY OF TRANSMISSION ELEMENTS

For AC transmission system

AVo(Availability of o no. of AC lines) = $\frac{\sum_{i=1}^{o} Wi(Ti - TNAi)/Ti}{\sum_{i=1}^{o} Wi}$

AVq(Availability of q no. of ICTs) = $\frac{\sum_{k=1}^{q} Wk(Tk - TNAk)/Tk}{\sum_{k=1}^{q} Wk}$

AVr(Availability of r no. of SVCs) = $\frac{\sum_{l=1}^{r=1} Wl(Tl - TNAl)/Tl}{\sum_{l=1}^{r} Wl}$

AVp(Availability of p no. of Switched Bus reactors) = $\frac{\sum_{m=1}^{p} Wm(Tm - TNAm)/Tm}{\sum_{m=1}^{p} Wm}$

AVu(Availability of u no. of STATCOMs) = $\frac{\sum_{n=1}^{u} Wn(Tn - TNAn)/Tn}{\sum_{n=1}^{u} Wn}$

AV_{xbp}(Availability of an individual HVDC pole) = $\frac{(Tx - TN)}{Tx}$

AV_{ybtb} (Availability of an individual HVDC Back-to-back Blocks) = $\frac{(Ty - TNAy)}{Ty}$

For the HVDC transmission system

For the new HVDC commissioned but not completed twelve months;

For first 12 months: [(AV_{xbp} or AV_{ybtb})x95%/85%], subject to a ceiling of 95%.

Where,

o	=	Total number of AC lines;
AVo	=	Availability of o number of AC lines;
p	=	Total number of bus reactors/switchable line reactors;
AVp	=	Availability of p number of bus reactors/switchable line reactors;
q	=	Total number of ICTs;
AVq	=	Availability of q number of ICTs;
r	=	Total number of SVCs;
AVr	=	Availability of r number of SVCs;.
U	=	Total number of STATCOM;
AVu	=	Availability of u number of STATCOMs;
W*i*	=	Weightage factor for *i*th transmission line;
W*k*	=	Weightage factor for *k*th ICT;
W*l*	=	Weightage factors for inductive & capacitive operation of *l*th SVC;
Wm	=	Weightage factor for mth bus reactor;
Wn	=	Weightage factor for nth STATCOM.
T*i*, , T*k*, T*l*, ,	-	The total hours of ith AC line, kth ICT, lth SVC, *m*th Switched Bus Reactor
T*m*, T*n*, T*x*, T*y*		& nth STATCOM, xth HVDC pole, yth HVDC back-to-back blocks during the period under consideration (excluding time period for outages not attributed to transmission licensee for the reasons given in Para 5 of the procedure)
$T_{NA}i$, $T_{NA}k$ $T_{NA}l$, $T_{NA}m$,		The non-availability hours (excluding the time period for outages not attributable to transmission licensee taken as deemed availability as $T_{NA}n$, T_{NAn}, $T_{NA}x$, $T_{NA}y$ per Para 5 of the procedure) for ith AC line, *k*th ICT, lth SVC , *m*th Switched Bus Reactor, nth STATCOM, xth HVDC pole and ythHVDC back-to-back block.

Schedule: 7

Entire Bid (both financial bid and technical bid) of the Selected Bidder to be attached here

Schedule: 8

Contract Performance Guarantee

(To be on non-judicial stamp paper of appropriate value as per Stamp Act relevant to place of execution. Foreign entities submitting Bids are required to follow the applicable law in their country.)

In consideration of the ……..[Insert name of the SPV or Selected Bidder on behalf of the TSP, or Lead Member in case of the Consortium, with address] agreeing to undertake the obligations under the Transmission Service Agreement dated …….and the other RFP Project Documents and the Nodal Agency and the ……..[Insert the name of the BPC], agreeing to execute the *RFP Project Documents* with the Selected Bidder, regarding setting up the Project, the ……. [Insert name and address of the bank issuing the guarantee and address of the head office] (hereinafter referred to as "Guarantor Bank") hereby agrees unequivocally, irrevocably and unconditionally to pay to ……. (being the Nodal Agency) at ……[Insert the Place from the address of the Nodal Agency indicated in the TSA] forthwith on demand in writing from the Nodal Agency or any Officer authorized by it in this behalf, any amount up to and not exceeding Rupees …….. Crores (Rs. …….) only [Insert the amount of the bank guarantee] on behalf of M/s. ……. [Insert name of the Selected Bidder or SPV].

This guarantee shall be valid and binding on the Guarantor Bank up to and including ……and shall not be terminable by notice or any change in the constitution of the Bank or the term of the Transmission Service Agreement or by any other reasons whatsoever and our liability hereunder shall not be impaired or discharged by any extension of time or variations or alternations made, given, or agreed with or without our knowledge or consent, by or between parties to the respective agreement.

Our liability under this Guarantee is restricted to Rs. …….. Crores (Rs. ……..) only. Our Guarantee shall remain in force until …….. [Insert the date of validity of the

Guarantee as per Article 3.1.2 of this Agreement]. The Nodal Agency, shall be entitled to invoke this Guarantee up to three hundred sixty five (365) days of the last date of the validity of this Guarantee.

The Guarantor Bank hereby expressly agrees that it shall not require any proof in addition to the written demand from …… (in its roles as the Nodal Agency), made in any format, raised at the above mentioned address of the Guarantor Bank, in order to make the said payment to Nodal Agency.

The Guarantor Bank shall make payment hereunder on first demand without restriction or conditions and notwithstanding any objection by ..... [Insert name of the Selected Bidder], …….. [Insert name of the TSP] and / or any other person. The Guarantor Bank shall not require Nodal Agency to justify the invocation of this BANK GUARANTEE, nor shall the Guarantor Bank have any recourse against Nodal Agency in respect of any payment made hereunder.

THIS BANK GUARANTEE shall be interpreted in accordance with the laws of India.

The Guarantor Bank represents that this BANK GUARANTEE has been established in such form and with such content that it is fully enforceable in accordance with its terms as against the Guarantor Bank in the manner provided herein.

THIS BANK GUARANTEE shall not be affected in any manner by reason of merger, amalgamation, restructuring, liquidation, winding up, dissolution or any other change in the constitution of the Guarantor Bank.

THIS BANK GUARANTEE shall be a primary obligation of the Guarantor Bank and accordingly Nodal Agency shall not be obliged before enforcing this BANK GUARANTEE to take any action in any court or arbitral proceedings against …… [Insert name of the SPV] or the Selected Bidder, as the case may be, to make any claim against or any demand on …… [Insert name of the SPV] or the Selected Bidder, as the case may be, or to give any notice to …… [Insert name of the SPV] or the Selected Bidder, as the case may be, or to enforce any security held by the Nodal Agency or to exercise, levy or enforce any distress, diligence or other process against …… [Insert name of the SPV] or the Selected Bidder, as the case may be.

The Guarantor Bank acknowledges that this BANK GUARANTEE is not personal to Nodal Agency and may be assigned, in whole or in part, (whether absolutely or by way of security) by Nodal Agency to any entity to whom the Nodal Agency is entitled to assign its rights and obligations under the Transmission Service Agreement.

The Guarantor Bank hereby agrees and acknowledges that Nodal Agency shall have a right to invoke this Bank Guarantee either in part or in full, as it may deem fit.

Notwithstanding anything contained hereinabove, our liability under this Guarantee is restricted to Rs. …….. Crores (Rs. ……..) only and it shall remain in force until ……[Date to be inserted on the basis of Article 3.1.2of the Transmission Service Agreement], with an additional claim period of three hundred sixty five (365) days thereafter. This BANK GUARANTEE shall be extended from time to time for such period, as may be desired by …….. [Insert name of the Selected Bidder or Lead Member in case of the Consortium or SPV]. We are liable to pay the guaranteed amount or any part thereof under this Bank Guarantee only if Nodal Agency serves upon us a written claim or demand.

In witness where of:

Signature .....

Name: .....

Power of attorney No.: ……

For:

…….. [Insert Name of the Bank]

Banker's Seal and Full Address, including mailing address of the Head Office

Schedule: 8A

(ISB for CPG)

FORMAT FOR SURETY INSURANCE CONTRACT

(To be on non-judicial stamp paper of appropriate value as per Stamp Act relevant to place of execution.

Foreign entities submitting Bids are required to follow the applicable law of India)

In consideration of the ..... [Insert name of the SPV or Selected Bidder on behalf of SPV or Lead Member in case of the Consortium, with address] (hereinafter referred to as the **'Principal Debtor'** for the purposes of this Surety Insurance Contract as provided in Section 126 of the Indian Contract Act, 1872) having been selected to undertake the Transmission Project on the terms and conditions contained in the Transmission Service Agreement dated ...../ to be executed as per the Model Transmission Service Agreement provided along with the Request for Proposal **('RFP')** and other RFP Project Documents, subject to the condition of providing a Performance Bank Guarantee or a Surety Insurance Contract guaranteeing/insuring the due performance of the obligations under the Transmission Service Agreement, to the Central Transmission Utility of India Limited **('CTUIL')** [herein after referred to as the Nodal Agency], the [Insert name and address of the Insurance Company issuing the Surety Insurance Contract and address of the head office] (hereinafter referred to as **"Surety")** hereby agrees unequivocally, irrevocably, absolutely and unconditionally, without demur, to pay to the Nodal Agency at _____ [Insert Place and Address of the Nodal Agency indicated in Transmission Service Agreement, or to the designated Bank Account of the Nodal Agency, namely.....] forthwith on demand in writing from the Nodal Agency, or any Officer authorized by it in this behalf, intimated to the Surety at the address mentioned above, any amount as may be decided by the Nodal Agency not exceeding Rupees .....Crores (Rs.....) only [Insert the amount of the Surety Insurance Contract]

The Surety hereby acknowledges, accepts and confirms that the Surety has received from the Principal Debtor, by way of premium the entire consideration for the Surety to execute, in favour of the Nodal Agency, this Surety Insurance Contract, as extended by the Surety from time to time and assuming the obligation to pay to the Nodal Agency the amount in terms hereof, without any requirement for payment of any other consideration to the Surety by the Principal Debtor, or otherwise.

This Surety Insurance Contract shall be valid and binding on the Surety, as the principal obligation of the Surety to pay on demand by the Nodal Agency, and shall

not be terminable by notice or any change in the constitution of the Surety or the term of the Transmission Service Agreement or by any other reasons whatsoever and the liability hereunder of the Surety shall not be impaired or discharged by any extension of time or variations or alternations made, given, or agreed (with or without the knowledge or consent of the Surety) by or between the Principal Debtor and the Nodal Agency.

The liability of the Surety under this Surety Insurance Contract is restricted to Rupees ..... Crores (Rs) only. The Surety Insurance Contract shall remain in force until [Insert the date of validity of the Surety Insurance Contract]. The Nodal Agency shall be entitled to invoke this Surety Insurance Contract up to three hundred sixty five (365) days after the last date of the validity of this Surety Insurance Contract.

The Surety hereby expressly agrees that it shall not require any proof except for the written demand from the Nodal Agency, containing the statement that the contractor has failed to meet its contractual obligations raised at the above mentioned address of the Surety (address of Surety office should be a place in NCR only) and the Surety shall pay the amount without reference to the Principal Debtor.

Any such demand made by the Nodal Agency on the Surety shall be conclusive and binding not withstanding any difference between the Nodal Agency and the Principal Debtor or any dispute pending before any Court, Tribunal, Arbitrator or any other authority. The Surety undertakes not to revoke this guarantee during its currency without previous consent of the Nodal Agency and further agrees that the Surety Insurance Contract herein contained shall continue to be enforceable till the Nodal Agency discharges this contract or till the expiry of tenor (including Claim period) whichever is earlier.

The Surety shall make payment hereunder within two (02) working days on first demand without restriction or conditions and notwithstanding any objection by the Principal Debtor, namely, ... [Insert name of SPV], or ..... [Insert name of the Selected Bidder], or ..... [Insert name of the TSP] and/or any other person. The Surety shall not require the Nodal Agency to justify the invocation of this Surety Insurance Contract, nor shall the Surety have any recourse against the Nodal Agency in respect of any payment made hereunder.

This SURETY INSURANCE CONTRACT shall be interpreted in accordance with the laws of India.

This SURETY INSURANCE CONTRACT is being executed by the Surety in terms of the IRDAI (Surety Insurance Contract) Guidelines, 2022 and the Surety hereby acknowledges, accepts and confirms that this Surety Insurance Contract shall be a Contract of Guarantee as provided under Section 126 of the Indian Contract Act, 1872

and further shall be covered by Section 14(3)(b) of the Insolvency and Bankruptcy Code, 2016 (as amended) shall be enforceable as such.

The Surety represents that this Surety Insurance Contract has been established in such form and with such content that it is fully enforceable in accordance with its terms as against the Surety in the manner provided herein.

This SURETY INSURANCE CONTRACT shall not be affected in any manner by reason of merger, amalgamation, restructuring, liquidation, winding up, dissolution or any other change in the constitution of the Surety.

In order to give effect to this surety Bond, the Nodal Agency shall be entitled to act as if the surety insurer were the principal debtor and any change in the constitution of the contractor and/or the surety insurer, whether by their absorption with any other body or corporation or otherwise, shall not in any way or manner affect the liability or obligation of the surety insurer under this surety Bond.

This SURETY INSURANCE CONTRACT shall be a primary obligation of the Surety as a Principal to pay on demand by the Nodal Agency and the Nodal Agency shall not be obliged before enforcing this Surety Insurance Contract to take any action in any court or arbitral proceedings against the Principal Debtor, namely, ... [Insert name of SPV], or ... ...[Insert name of the Selected Bidder], or ....[Insert name of the TSP] and/or any other person, as the case may be, to make any claim against or any demand on the Principal Debtor, namely, ... [Insert name of SPV], or ..... [Insert name of the Selected Bidder], or..... [Insert name of the TSP] and/or any other person, as the case may be, or to give any notice to Principal Debtor, namely..... [Insert name of SPV], or ..... [Insert name of the Selected Bidder], or ..... [Insert name of the TSP] and/or any other person, as the case may be, or to enforce any security held by the Nodal Agency or to exercise, levy or enforce any distress, diligence or other process against the Principal Debtor, namely, ... [Insert name of SPV], or ..... [Insert name of the Selected Bidder], or ..... [Insert name of the TSP] and/or any other person, as the case may be.

The Surety acknowledges that this Surety Insurance Contract is not personal to the Nodal Agency and may be assigned, in whole or in part, (whether absolutely or by way of security) by Nodal Agency to any entity to whom the Nodal Agency is entitled to assign its rights and obligations under the Transmission Service Agreement Provided that any such assignment shall be in compliance with the relevant provisions of the Insurance Act 1938

The Surety hereby agrees and acknowledges that the Nodal Agency shall have a right to invoke this Surety Insurance Contract either in part or in full, as it may deem fit. In

case of invocation of this Surety Insurance Contract in part, besides making payment for the part of Surety Insurance Contract invoked, surety at the request of nodal agency shall amend the value of Surety Insurance Contract to the extent of balance amount.

The Surety undertakes not to revoke this Surety Contract during its currency, except with the previous express consent of the Nodal Agency in writing and declares and warrants that it has the power to issue this Surety Contract and the undersigned has full powers to do so on behalf of the Surety

In witness where of:

Signature.....

Name: .....

Power of attorney No/ Employee No. as applicable.: ……

For:

. ..... [Insert Name of the Surety-Insurance Company]

Banker's Seal and Full Address, including mailing address of the Head Office

Notes: 1. The Stamp Paper should be in the name of the Executing Insurance Company.

Schedule: 8B

(POI for CPG)

Format for Issuance of Payment on Order Instrument

Dear Sir,

1. Indian Renewable Energy Development Agency Limited ('IREDA")/PFC/REC has sanctioned a non-fund based limit loan of Rs. (Rupees..... Only) to M/s. .... [Insert name of SPV or selected Bidder] under the Loan Agreement executed on ..... to execute Transmission System Projects.

2. In consideration of the .....[Insert name of the SPV or Selected Bidder on behalf of SPV or Lead Member in case of the Consortium, with address] for the purposes of this Payment on Order Instrument ("POI") having been selected to undertake the Transmission Project on the terms and conditions contained in the Transmission Service Agreement dated ...../ to be executed as per the draft of the Model Transmission Service Agreement provided along with the Request for Proposal (,,RFP") and other RFP Project Documents, subject to the condition of providing a POI guaranteeing the due performance of the obligations under the Transmission Service Agreement to the Nodal Agency/Central Transmission Utility of India Limited (,,CTUIL"), the.....[Insert name and address of the non-banking financial institutions(IREDA/PFC/REC) issuing the POI and address of the head office] (hereinafter referred to as "**Guarantor**") hereby agrees unequivocally, irrevocably, absolutely and unconditionally, without demur, to pay to the Nodal Agency at ..... [Insert Place and Address of the Nodal Agency indicated in Transmission Service Agreement, or to the designated Bank Account of the Nodal Agency, namely …….] forthwith on demand in writing from the Nodal Agency, or any Officer authorized by it in this behalf, intimated to the Guarantor at the address mentioned above, any amount as may be decided by the Nodal Agency not exceeding Rupees ..... Crores (Rs) only [Insert the amount of Payment on Order Instrument]

3. At the request of .....and ....., [Insert name of on behalf of M/s. SPV or selected Bidder] this Payment on Order Instrument (POI) for an amount of Rs. ..... (Rupees .....) is being issued with IREDA/PFC/REC assuming the obligations to remit such amount to CTUIL from the sanctioned loan.

4. This Payment on Order Instrument comes into force immediately and IREDA/PFC/REC confirms that it has sufficient amount out of the sanctioned loan and shall maintain the required amount to pay under this Payment on Order Instrument, during the validity and claim period of this Payment on Order Instrument.

5. This POI has been issued by IREDA/PFC/REC utilizing the credit limit of M/s.....[Insert name of SPV or selected Bidder] IREDA/PFC/REC confirms that its liability to pay under this Payment on Order Instrument shall be primary and independent of whether at the time of invocation of Payment on Order Instrument, the sanctioned funds are available or not and notwithstanding, the status of M/s ..... [Insert name of SPV or selected Bidder] at the relevant time and to whether IREDA/PFC/REC is able to recover the amount advanced by it to the said developer.

6. IREDA/PFC/REC and M/s. …….[Insert name of SPV or selected Bidder] hereby acknowledges, accepts and confirms that this Payment on Order Instrument shall be a Contract of Guarantee as provided under Section 126 of the Indian Contract Act, 1872 and further shall be covered by Section 14(3)(b) of the Insolvency and Bankruptcy Code, 2016 (as amended) shall be enforceable as such.

7. IREDA/PFC/REC liability under this POI is restricted to Rupees Crores (Rs.....) only. This POI shall remain in force until..... [Insert the date of validity of the POI]. The Nodal Agency shall be entitled to invoke this POI up to three hundred sixty-five (365) days after the last date of the validity of this POI. This POI shall be extended from time to time for such period, as may be desired by the TSP.

8. The Guarantor hereby expressly agrees that it shall not require any proof except for the written demand from the Nodal Agency, raised at the above- mentioned address of the Guarantor (address of Guarantor office should be in NCR only) and the Guarantor shall pay the amount to the Nodal Agency without reference to the TSP.

9. Any such demand made by the Nodal Agency on the Guarantor shall be conclusive and binding not withstanding any difference between the Nodal Agency and the TSP or any dispute pending before any Court, Tribunal, Arbitrator or any other authority. The Guarantor undertakes not to revoke this guarantee during its currency without previous consent of the Nodal Agency and further agrees that the POI herein contained shall continue to be enforceable till the Nodal Agency discharges this contract or till the expiry of tenure or (including Claim period) whichever is earlier.

10. The Guarantor shall make payment hereunder within two (02) working days on first demand without restriction or conditions and notwithstanding any objection or disputes raised by the TSP, namely, ... [Insert name of SPV], or [Insert name of the Selected Bidder], or ..... [Insert name of the TSP] and/or any other person. The Guarantor shall not require the Nodal Agency to justify the invocation of this POI, nor shall the Guarantor have any recourse against the Nodal Agency in respect of any payment made hereunder.

11. This POI shall be interpreted in accordance with the laws of India.

12. The Guarantor represents that this POI Contract has been established in such form and with such content that it is fully enforceable in accordance with its terms as against the Guarantor in the manner provided herein.

13. This POI shall not be affected in any manner by reason of merger, amalgamation, restructuring, liquidation, winding up, dissolution or any other change in the constitution of the Guarantor.

14. This POI Contract shall be a primary obligation of the Guarantor as a Principal to pay on demand by the Nodal Agency and the Nodal Agency shall not be obliged before enforcing this POI Contract to take any action in any court or arbitral proceedings against the TSP, namely, … … … [Insert name of SPV], or..... [Insert name of the Selected Bidder], or ..... [Insert name of the TSP] and/or any other person, as the case may be to make any claim against or any demand on the TSP, namely, ... [Insert name of SPV], or ..... [Insert name of the Selected Bidder], or ..... [Insert name of the TSP] and/or any other person, as the case may be, or to give any notice to TSP, namely..... [Insert name of SPV], or ..... [Insert name of the Selected Bidder], or ..... [Insert name of the TSP] and/or any other person, as the case may be, or to enforce any security held by the Nodal Agency or to exercise, levy or enforce any distress, diligence or other process against the TSP, namely, ... [Insert name of SPV], or ……. [Insert name of the Selected Bidder], or ..... [Insert name of the TSP] and/or any other person, as the case may be.

15. The Guarantor acknowledges that this POI Contract is not personal to the Nodal Agency and may be assigned, in whole or in part, (whether absolutely or by way of security) by Nodal Agency to any entity to whom the Nodal Agency is entitled to assign its rights and obligations under the Transmission Service Agreement.

16. The Guarantor hereby agrees and acknowledges that the Nodal Agency shall have a right to invoke this POI Contract either in part or in full, as it may deem fit. In case of invocation of this POI Contract in part, besides making payment for the part of POI Contract invoked, Guarantor at the request of Nodal Agency shall amend the value of POI Contract to the extent of balance amount.

IN WITNESS WHERE OF the non- banking financial institutions through its authorized officer, has set its hand and stamp on this..... day of.....at.....

Signature .....

Name:

Power of attorney No.: .....

For: ..... [Insert Name of the non- banking financial institutions Company]

Seal and Full Address, including mailing address of the Head Office

Schedule: 9

Methodology for determining the Relief Under Force Majeure Event & Change in Law during Construction Period

The relief in the form of revision in tariff due to Force Majeure Event leading to extension of Scheduled COD for a period beyond one hundred eighty (180) days and/ or Change in Law during the construction period shall be as under:

$\Delta T = [(P \times d)] \div [1-(1+ d)^{(-n)}]$

Where,

ΔT = Change in Transmission Charges for each year

P = Sum of cumulative increase or decrease in the cost of the Project due to Change in Law and interest cost during construction corresponding to the period exceeding one hundred eighty (180) due to Force Majeure Event leading to extension of Scheduled COD for a period beyond one hundred eighty (180) days

n = number of years over which the Transmission Charges has to be paid

d = Discount rate as notified by the CERC, applicable on the Bid Deadline

The increase in Transmission Charges as stated above shall be applicable only if the value of increase in Transmission Charges as calculated above exceeds 0.30% (zero point three percent) of the quoted Transmission Charges of the TSP.