VOLUME – II

PART – 2

SCOPE OF WORK & TECHNICAL SPECIFICATIONS

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SCHDULE – III EPC TECHNICAL SPECIFICATION

AC SYSTEM

B1 – INVERTER DUTY TRANSFORMER

1.0 Inverter Duty Transformer

The design, manufacture, delivery, factory testing and inspection, delivery to site, installation, testing and commissioning of Continuous Solar Inverter application and Inverter duty (Outdoor) Transformers as per latest applicable standards. The equipment shall be designed, engineered and manufactured to achieve high availability and reliability.

The supplier shall arrange all specialized equipment / services necessary for proper erection, commissioning, and performance testing of all items of the equipment covered under this contract. The cost of the same shall be included in the contract price.

All routine and acceptance tests at Factory and Site acceptance tests shall be conducted as part of the contract with prior notice to Owner.

2.0 Codes & Standards

Codes	Description
IS:2026	Specification for Power Transformers
IEC:60076	Power Transformers
IEC 61378-1	Converter duty Transformers
IS 3639	Fittings and Accessories for Power Transformers
IS 2099	Specification of HV Porcelain Bushing
IS 7421	Specification of LV Porcelain Bushing
IS 10028	Practice for selection, installation & maintenance of transformers
IS 335	New Insulating oils
CBIP	Manual on Transformers
IEC:60296	Fluids for electro technical applications – Unused mineral insulating oils for transformers and switchgear
IEC:60354	Loading guide for oil-immersed power transformers
IS 3637	Buchholz Relay

Codes	Description
IS 5561	Specification for terminal connector
IS 6600	Specification for overloading of Transformers
IS 2147	Marshalling Box
IEC-60137	Transformer bushings
IS-2705	Specification for Current Transformers
IEC-61869	Bushing CT
IS 4257	Porcelain Bushings for Transformers
IS 10561/IS 8478	Application Guide for on load tap changer & Power Transformers
IS 1893	Criteria for earthquake resistant design of structures.
IS 5	Painting
Indian Electricity Act and rules framed there-under	
Regulations laid by the office of the Chief Electrical Inspector to Government.	
BEE Guidelines	
CEA Regulation on Technical Standards for Construction of Electrical Plants and Electric Lines, 2022.	
Latest additions of (as applicable as on date of bid submission) NFPA, HEI, ANSI, ASME, ISI, TEMA, AWS, NEMA, IEC, EJMA, codes and standards shall also apply, Unless covered otherwise by Indian codes & standards and in case nothing to the contrary is specifically mentioned elsewhere in the specifications	

3.0 Design Criteria

3.1 Inverter step up transformer shall be able to step up the inverter output voltage to 33kV. The voltage ratio and kVA rating shall be decided by the Bidder based on the system offered.

3.2 The transformers shall be of Converter Duty, two / multi winding, three phases, 50Hz, mineral oil filled, ONAN cooled, with off-circuit taps of ±5% in steps of 2.5% on the HV side.

3.3 Transformers should be provided with separate galvanically isolated low voltage windings for each inverter.

3.4 Transformers shall be suitable for operation with pulsed inverters.

3.5 Inverter Transformers with winding material of electrolytic grade copper / electrolytic grade Aluminum shall be acceptable subjected to proven and of successfully type tested design with service warrantee of 5 years after commissioning.

3.6 The thermal design of Inverter Transformer needs to consider the temperature dependent performance of the Inverter. It is to in accordance with Inverter output and under worst condition it should not limit Inverter output.

3.7 The design ambient temperature for the transformer shall be 50ºC or as per CEA Guidelines / Working committee report.

3.8 The transformer shall be designed for exceptional circumstances arising due to sudden fluctuation in power and supply voltage and shall be capable of operating at approximately 25% above normal rated voltage for a period of not exceeding one minute and 40% above normal rated voltage for a period of 5 seconds

3.9 The transformer shall be designed to deliver rated MVA continuously even at the lowest tap without exceeding specified temperature rise. The transformer and accessories shall be designed taking into account site conditions and other relevant project data indicated in Project Information.

3.10 All Transformers should be rated for a maximum temperature rise of 50°C by oil temperature and 55°C by winding temperature with a daily average ambient temperature of 50°C. Hot spot temperature based on maximum yearly weighted average temperature shall not exceed as per IEC standard recommendation

3.11 Transformers and accessories shall be designed to withstand the expected fault levels. Dynamic ability and thermal ability to withstand the short circuit forces shall be demonstrated by tests / calculations.

3.12 Transformer Differential protection shall be provided as per CBIP manual of transformer and or as per CEA regulation / statutory requirements.

3.13 The percentage impedance of transformer shall be as per Inverter manufacturer recommendation.

3.14 The transformer shall be capable of continuous operation at rated MVA on any tap with voltage variation of ±10% corresponding to the voltage of the tap as well as in accordance with IEC 60354 or other relevant standard. The transformer shall be capable of operating at rated output at any tap position, provided the voltage corresponding to that tap does not vary by more than ±10% of rated voltage. The winding including the tapping arrangement shall be designed such that the electromagnetic balance is maintained between HV and LV windings at all voltage ratios.

3.15 The transformer shall be provided with windings (all) and oil temperature indicators and double float type Buchholz relay (conforming to IS:3637) with gas collecting device & pipe and potential free contacts for remote alarm and trip purpose. The transformer shall be provided with minimum two numbers of spring-operated PRD (with trip contacts) with suitable discharge arrangement for oil.

3.16 For multi winding transformer, it is recommended to have close coupling and equal impedances on each of LV winding to HV winding and to have high enough impedance between two LV windings in order to decouple these windings. The multi-winding transformer needs to be designed for long term operating conditions with asymmetrical load on LV side i.e., in case three winding design, the transformer needs to operate reliable with only one Inverter supplying power to only one LV winding.

3.17 All tank gaskets used shall be of NBR (Acrylonitrile butadiene Rubber generally known as NBR) and properties of all the above gaskets / O-Rings shall comply with the requirements of IS-11149 (Grade IV) and manufacturer shall provide 5 years leakage free Warranty.

3.18 2mm Thick CRCA sheet steel, vermin and dust proof marshalling box (minimum IP55) shall be furnished with each transformer to accommodate winding and oil temperature indicators, Buchholz relay, MOG, PRD contacts, Transducers and other contacts terminal blocks for control cables etc. Marshalling Box of all transformers shall be preferably Tank Mounted. One dummy terminal block in between each trip wire terminal shall be provided. At least 20% spare terminals shall be provided on each panel. The gasket used shall be of neoprene rubber. Also Marshalling Box, shall be at least 450 mm above ground level. Wiring scheme (TB details) shall be engraved in a stainless-steel plate with viewable font size and the same shall be fixed inside the Marshalling Box door

3.19 Transformer Neutral Earthing shall be done as per system requirement. In case of solidly earthed neutral of Transformers, it shall be brought through insulated support from tank to the ground level at a convenient point with 2 nos. copper flat, for connection to ground network (as applicable). The transformer neutrals shall be brought out in a separate cable box. If the same cable box is used for neutral side, then a metallic partition between phases and neutral shall be provided.

3.20 Neutral of Transformer if not used should be taken out through bushing and covered by insulating cap.

3.21 The tank shall be of conventional / bell type with bolted cover on top. In case the joint is welded it shall be provided with flanges suitable for repeated welding. The joint shall be provided with a suitable gasket to prevent weld splatter inside the tank. Proper tank shielding shall be done to prevent excessive temperature rise of the joint.

3.22 The Inverter duty transformer shall be suitable for cable connection on HV and LV sides. In case of single core cable termination, cable box gland plate shall be of non-magnetic material.

3.23 The inverter transformer shall be provided with shield earthing.

3.24 The transformer shall be capable of being loaded in accordance with IEC 60354 / IEC 60076-7 upto a load of 150%. There shall be no limitation imposed by bushings or any other associated equipment.

3.25 **Bushing CTs**

a) Bushing CTs of adequate rating for protection (differential and others if any) as required, WTI etc shall be provided. All CTs (except WTI) shall be mounted in the turret of bushings, mounting inside the tank is not permitted.

b) For 33kV side PS Class CT for Transformer differential protection shall be provided in HV Turret of Transformer respective 33kV Panel.

c) All CT terminals shall be provided as fixed type terminals on the M. Box to avoid any hazard due to loose connection leading to CT opening. In no circumstances Plug In type connectors shall be used for CT.

3.26 The transformers shall be suitable for outdoor installation in a hot, saline, humid and tropical climate (This shall be decided based on actual site offered by the Bidder). They shall be capable of operating continuously at their rated outputs without exceeding specified temperature limits.

3.27 Harmonic Factor as per Inverter manufacturer recommendation must be taken into account while designing the transformer. The extra no load loss due to voltage harmonics and load and stray load loss due to current harmonics (as applicable) and must be taken into consideration in transformer design. In addition, the dc bias component of 0.5% of rated Inverter output current is to be accounted for its effect on the transformer design.

3.28 The maximum flux density in any part of the core and yoke at the rated MVA, voltage and frequency shall be 1.76 Tesla and under 110 % continuous overvoltage condition it shall be 1.9 Tesla at all tap positions.

3.29 The line terminals of the windings of a three-phase power transformer shall be denoted by reference letter 1U, 1V, 1W for HV side and 2u, 2v, 2w, 3u, 3v, 3w and so on for LV sides. The neutral terminal shall be denoted as 1N for high voltage and 2n, 3n and so on for low voltage winding. If several windings have the same rated voltage, their respective numbering shall be agreed between the manufacturer and the purchaser. The numbering shall commence at the tapping nearest to the end marked 1. The marking of tapped windings which may be reversed shall be based on that connection which gives the highest effective number of turns for the winding connected to the tap-changer.

3.30 The noise level of transformer, when energized at normal voltage and frequency shall not exceed, when measured under standard conditions, the values specified in NEMA standard publication TR-1.

3.31 Transformer shall be suitable for oil filling by full vacuum.

3.32 The adverse effect on life of transformer due to cloud intermittency and solar generation loading cycle must be compensated through suitable design (as applicable).

3.33 Bushing turrets, covers of inspection openings, thermometer pockets etc. shall be designed to prevent ingress of water into or leakage of oil from the tank.

3.34 All bolted connections shall be fitted with weather proof, hot oil resistant, resilient gasket in between for complete oil tightness and shall give satisfactory service under the operating conditions for complete life of the transformer if not opened for maintenance at site. If gasket is compressible, metallic stops/other suitable means shall be provided to prevent over-compression.

3.35 All seams and joints which are not required to be opened at site, shall be factory welded, and shall be double welded [i.e. with a continuous cord on both sides of the plate (inside and outside of the tank), bottom & cover of the tank, turrets, flanges, etc.] to ensure adequate strength. Butt welds on parts that are mechanically stressed or under pressure must have full penetration. Welding shall conform to IS 9595. The requirement of post weld heat treatment of tank/stress relieving shall be based on recommendation of IS 10801.

3.36 Drain valves, shut off valves, oil sampling valves and filter valves shall be provided. A ladder with hand rail shall be provided to approach Buchholz relay, PRD, etc. Ladder shall start from 100mm above gravel level to Top of the transformer tank. The ladder shall have pad lockable cover right from start to avoid unauthorized climbing in transformer charged condition and with top hand rail.

3.37 The core shall be constructed from high permeability grade, non-ageing, cold rolled, grain oriented, silicon steel laminations. CRGO Silicon steel shall be M4 grade or better. The construction core shall comply to IS 3024. Core material shall be BIS certified.

3.38 The manufacturer shall ensure that windings of all transformers are made in clean, dust proof (Cleanroom class ISO 9 or better as per ISO 14644-1), humidity-controlled environment with positive atmospheric pressure.

3.39 Conductors shall be of electrolytic grade Copper / electrolytic grade Aluminum (of proven and of successfully type tested design with service warrantee of 5 years after commissioning) free from scales and burrs. Oxygen content shall be as per IS 12444.

3.40 Inverter Transformer shall have copper/Aluminum Shield winding between LV & HV windings. Each LV winding must be capable of handling non-sinusoidal voltage with voltage gradient as per relevant applicable standards and Inverter manufacturer recommendation. Also, each shield winding shall be taken out to tank with two separate connection from shield to bushing with proper support with 2 nos. 3.6 kV

shield bushings and same shall be brought down along with support insulator from tank & copper flat up to the bottom of the tank for independent grounding.

3.41 Main conservator shall have air cell type constant oil pressure system to prevent oxidation and contamination of oil due to contact with moisture and shall be fitted with magnetic oil level gauge with low oil level potential free contacts at one side and prismatic oil level gauge at other side. Air cell used shall be made of nitrile rubber reinforced with nylon cloth suitable for operating continuously at 100°C. Pressure gauge shall be provided for Air cell to monitor air cell pressure.

3.42 The MOG and prismatic oil level gauge should not be obstructed with radiator bank, and it should be clearly visible from ground.

3.43 The conservator shall be fitted with lifting lugs in such a position so that it can be removed for cleaning purposes. Suitable provision shall be kept to replace air cell and cleaning of the conservator as applicable.

3.44 Suitable oil topping arrangement shall be provided at conservator top.

3.45 Suitable air venting arrangement shall be provided at over Tank, conservator tank, radiators, etc..

3.46 The Transformer tank conservator shall be fitted with cobalt free Silica gel Breather (in transparent enclosure with maximum height 1400mm above ground). Silica gel shall be isolated from atmosphere by an oil seal

3.47 Suitable extended SS304 canopy / Rain hood shall be provided for Buchholz relay, PRD/PRV, MK, JBs, Panel, cubicles, TCIV, NIFPS Fire detectors, etc. to prevent ingress of rain water.

3.48 Transformers shall be provided with a 150 mm dial type thermometer for top oil temperature indication with angular sweep of 270°. Range of temperature should be 0-150°C.

3.49 Temperature indicator dials shall have linear gradations to clearly read at least every 2°C. Accuracy class of OTI shall be 1.5% or better. OTI shall be with mercury free switches, (Ref: Precimeasure Type: 1005A or, equivalent of approved vendor).

3.50 150 mm dia with angular sweep of 270° local winding temp. indicating instrument with maximum reading pointer and two adjustable electrically independent, ungrounded contacts (one for high winding temperature alarm and one for trip) besides that required for SCADA monitoring system shall be provided for HV and each LV windings. Temperature indicator dials shall have linear gradations to clearly read at least every 2°C. Range of temperature should be 0- 150°C. Accuracy class of WTIs shall be 1.5% or better. WTIs shall be with mercury free switches preferably of Type: 1005A or, better; Make: Precimeasure or equivalent of approved make.

3.51 The WTIs shall also be provided with in built variable resistor for connecting it to transducers for remote monitoring of the temperature. The transducers shall be provided with dual outputs of 4-20mA signal and shall be mounted in the cooler control cubicle / marshaling box. This is applicable to all windings.

3.52 Transducer Temperature Sensors for OTIs & WTIs: Temperature transducer with PT100 sensor RTD shall be provided with PT100 temperature sensor having nominal resistance of 100 ohms at 0°C. The PT100 temperature sensor shall have three wire ungrounded system. The calibration shall be as per IS 2848 or equivalent. The PT100 sensor may be placed in the pocket containing temperature sensing element. RTD shall include image coil for OTI system and shall provide dual output 4-20mA for SCADA. The transducer shall be installed in the Individual Marshalling Box. Any special cable required for shielding purpose, for connection between PT100 temperature sensor and transducer, shall be in the scope of manufacturer. 4-20mA signal shall be wired to SCADA through IEC 61850 compliant communications.

3.53 The transformers shall be provided with flanged bi-directional wheels and axles. This set of wheels and axles shall be suitable for fixing to the under carriage of transformer to facilitate its movement on rail track. Suitable locking arrangement along with foundation bolts shall be provided for the wheels to prevent accidental movement of transformer.

3.54 To prevent transformer movement during earthquake, suitable clamping devices shall be provided for fixing the transformer to the foundation. All Wheels shall be detachable and shall be made of cast iron and steel as required.

3.55 Suitable rating HV Bushings porcelain type with creepage – 31 mm/kV and LV Bushing below 3.6 kV used within transformer cable box, epoxy type bushing with creepage – 31 mm/kV confirming to IS 2099/IEC 60137 also allowed as alternate to porcelain type. Creepage distance shall be 31 mm/kV for all type of Bushings.

3.56 Inverter Transformer HV & LV bushings palms shall be silver/tin plated

3.57 The Step-up transformer shall be suitable for cable connection on HV side and LV sides. Suitable cable terminating arrangements shall be provided. In case of single core cable termination, cable box gland plate shall be of non-magnetic material

3.58 Air insulated dry Cable box for HT/LT XLPE cable shall be provided on HV & LV Sides. Cable Box (Bolted design) with Disconnecting Chamber and cover with Handle shall be provided for cables terminations for HV & LV sides. Cable boxes shall be of phase segregated air insulated type & shall be of sufficient size to accommodate cable & termination and allow proper heat dissipation due to high current. Adequate measures to be applied to take-care of heat dissipation. Phase segregation shall be achieved by insulating barriers

3.59 For each terminal shall be brought out through bushings with suitable rated Copper Bus bars / terminal connectors of sufficient size, copper flexible jumpers, supporting

insulators, and bolt holes to accommodate cable & termination and allow proper heat dissipation due to high current.

3.60 Cable boxes shall be of 3mm sheet for load bearing member and 2mm for other parts with degree of protection as IP:55 or better as per IS:13974

3.61 Proper two-point earthing and two nos. GI supports shall be provided to each cable boxes.

3.62 Cable boxes shall have removable top cover with handle & ample clearance shall be provided to enable either transformer or each cable to be subjected separately to high voltage test.

3.63 The creepage distances of 31mm/kV and clearances for phase to earth and between phases shall not be less than those specified in standards.

3.64 Where cable boxes are provided for three core cables, the seating sockets on the two outer phases shall preferably be inclined towards the center to minimize bending of the cable cores. Where there is more than one core per phase, the socket block shall be so designed as to minimize bending of the cable cores.

3.65 Suitable size detachable type Gland plate of non-magnetic material shall be provided. The clear spacing of 900mm shall be provided between gland plate to terminals.

3.66 Cable boxes shall be designed such that it shall be possible to move away the transformer without disturbing the cable terminations, leaving the cable box on external supports (as applicable).

3.67 Cable boxes shall be suitable for withstanding fault current 31.5 kA for 1 Sec & 50 kA for 1 Sec for HV & LV respectively.

3.68 All joints shall be provided with weatherproof gasket and earthing link.

3.69 All joints shall be provided with canopy. Drain plug shall be provided.

3.70 The insulating oil shall be new, unused mineral oil, conforming to IEC-60296-2020/ IEC 61099 / IS 16081 / IS335. NO inhibitors shall be used in the transformer oil & conform to parameters specified at Annexure– E attached of Standard Technical Specifications of Transformer(s), while tested at Bidder's premises. The transformer shall and all associated oil filled equipment shall normally be supplied along with the first filling of oil and excess quantity of oil as per standard mentioned above. The Bidder shall furnish test certificates from the Bidder against their acceptance norms, prior to dispatch of oil from refinery to site.

3.71 The final coat shall be of a glossy oil and weather resisting non-fading paint of shade number RAL 7035 of IS:5. The paint shall be suitable for heavily polluted atmosphere. Primer paint shall be ready made zinc chrome as per IS: 104; intermediate and final

coats of paint shall be as per IS: 2932. Color shade of final coat shall be RAL 7035. The final thickness of paint film on steel shall not be less than 150 microns. Sufficient quantity of touch-up paint shall be furnished for application at site.

3.72 The painting of all structures & equipment shall be considering as per "ISO-12944". Painting process shall be approved by the Owner.

3.73 The Bidder shall arrange transportation of all equipment from the point of manufacture to the Site. The arrangements shall include, but not be limited to, hiring adequate capacity of Wagon, determination of routes, determination of required permits, payment of required taxes and duties, and notification to the Owner. If transformer transported without oil, then shall be transported with filling Nitrogen gas / dry air at a positive pressure.

3.74 Radiators shall be detachable type, mounted on the tank with shut off valve at each point of connection to the tank, lifting lugs, along with drain plug/valve at the bottom and air release plug at the top.

3.75 Name plates shall be SS 304 or better. The transformer shall be provided with a rating plate of weatherproof material, fitted in a visible position, showing the appropriate items indicated below. The entries on the plate shall be in English in indelibly marked.

3.76 Cable glands shall be weather proof Double compression type made of heavy duty brass machine finished and nickel chrome plated of suitable size. Thickness of plating shall not be less than 10 micron. Cable glands shall conform to BS:6121.

3.77 All Cable lugs for power cables shall be Heavy duty Long barrel tinned copper ring type / bimetallic solderless crimping type of suitable size. Cable lugs for control cables shall be tinned copper ring type with insulated sleeve.

3.78 All control terminal shall be of Stud type (screw drive operated) and control wiring shall be terminated with tinned copper ring type lugs with insulated sleeve. Disconnecting stud type terminal shall be provided for CT circuits. 20% spare terminal shall be provided of each type. Printed single tube ferrules marked to correspond with panel wiring diagram shall be fitted at both ends of each wire. The wire identification marking shall be in accordance with IS:375. Red Ferrules should be provided on trip circuit wiring.

3.79 All wiring shall be carried out with wires of 1.1 KV grade, stranded copper conductors. The insulation shall be halogen free and flame retardant. Power circuits shall be wired with stranded copper conductors of adequate sizes to suit the rated current, the minimum size shall be 2.5 sq. mm. Unless otherwise specified, control alarm and indication circuits shall be wired with stranded, tinned copper conductors of sizes not smaller than 1.5 sq. mm. Space heater circuits, CT and VT circuits shall be wired with stranded copper conductor of size not smaller than 2.5 sq. mm.

3.80 All metallic hardware such as nuts, bolts, screws, washers etc. shall be of Hot dip galvanized to minimum 110microns.

3.81 All cable entries shall be located at bottom side of the panels / Junction boxes / MKs /DBs etc to prevent any possibility of water ingress into the box. All panels/Junction boxes/MKs /DBs etc shall be min. 450mm above finished floor level for cable connections.

3.82 Outdoor panels / JBs / MKs /DBs / Buchholz relay / PRD / all cubicle etc shall be completely weather-proof with a sloping extended SS304 canopy for protection against rain and providing a degree of protection of IP 55.

3.83 Painting of all metallic enclosed electrical equipment / panels / JBs / MKs /DBs etc. shall be of paint shade RAL -7035 and as per ISO 12944-5.

3.84 Unless noted otherwise, all steel structures exposed to environment would be painted to meet the requirements of corrosion category or would be galvanized as specified in Project Information section.

3.85 Design shall be as per Seismic Zone of IS 1893. The entire Plant design shall be as per relevant IS code for wind and seismic zone.

4.0 Transformer Fire Protection System

Transformer Fire protection system to be provided by bidder as per CEA Central Electricity Authority Regulations, CBIP manual of transformer standard /TAC/IS10028/IS 1646and applicable regulations/guidelines/circulars/norms etc amended from time to time.

4.1 In case of Nitrogen Injection Fire Protection system (NIFPS) system is selected by the Bidder the specifications are as under

4.1.1 The bidder shall be responsible for the design of the complete system and shall submit the drawings and design calculations for the number of fire detectors, pipe sizing of drainpipe and Nitrogen injection pipe, Nitrogen cylinder capacity, number of injection points, etc. and get approval from Owner.

4.1.2 Facility shall be provided to test the system when the transformer is in service, without actually draining the oil and injecting Nitrogen.

4.1.3 The Nitrogen regulator valve shall be designed in such a way that the Nitrogen shall not enter the transformer tank even in case of passing/ leakage of valve

Each Inverter duty transformer shall be provided with a dedicated Nitrogen Injection system. It shall act as a fast and effective fire fighter without employing water or

carbon dioxide. Fire shall be extinguished within 3 minutes of system activation and within 30 seconds of commencement of nitrogen injection. Nitrogen Injection system shall consist of the following components.

4.1.4 Fire Extinguishing Cubicle placed on a plinth at a distance of about 5 m away from transformer. NIFPS shall be suitable for outdoor installation. Only Cubical mounting foundation may be required. considering ease of approach for manual operation in case of fire. The cubicle should house a pressurized nitrogen cylinder, connected to the oil tank of transformer. The Transformer Conservator Isolation Valve (TCIV) shall be fitted between the conservator tank and Buchholz relay. The Cubicle shall be made of CRCA sheet of 2 mm (minimum) thick complete with the base frame, painted inside and outside with post office red colour (shade 538 of IS -5. The degree of protection shall be IP55 or better.

The following items shall be provided in the Cubicle.

a) Nitrogen gas cylinder with regulator and falling pressure electrical contact manometer.
b) Oil drain assembly including Oil drainpipe with mechanical quick drain valve.
c) Electromechanical control equipment for draining of oil of pre-determined volume and injecting regulated volume of nitrogen gas.
d) Pressure monitoring switch for back-up protection for nitrogen release.
e) Limit switches for monitoring of the system.
f) Butterfly valve with flanges on the top of panel for connecting oil drain pipe and nitrogen injection pipes for transformer.
g) Oil drain pipe extension of suitable sizes for connecting pipes to oil pit.
h) Panel lighting and Space heater.
i) Pressure indicators for Nitrogen pressure of the cylinder and actual injection through Nitrogen regulator.
j) Fire Extinguishing Cubicle shall have oil leakage detection arrangement for detecting oil leakage from drain valve. In case of any oil leakages, alarm to be provided.

4.1.5 Specifications for oil tank shall be as per below:

a) Minimum Oil Tank cover Size: 750X 750 mm
b) Material: Cast Iron
c) Type: Heavy duty Air tight
d) Painting inside and outside of the tank
e) Capacity of the tank as per CEA regulations and or Statutory requirement.
f) Air venting mechanism
g) Method to avoid rain Water or drain water entering the tank

4.1.6 A pit / sump of appropriate size in a corner of the tank shall be provided by Bidder with adequate slope to facilitate suction of the pump for complete emptying of the tank.

4.1.7 A Control box shall be placed in the inverter station for monitoring system operation, automatic control and remote operation. Separate control box for each transformer is to be provided. Enclosure of control box shall be of Rittal or equivalent. Two or more transformer control box in one enclose shall not be acceptable. Potential Free contacts shall be available for alarm troubles for input to . A separate hooter & emergency trip provision shall be provided in inverter station. Control box shall also to be connected to relay panel in inverter station for receiving system activation signals. Control supply voltage shall be of 110V DC. The following alarms, indications, switches, push buttons, audio signal etc. shall be provided. Only DIN mounted auxiliary contactors (of approved vendor) with or without add-on block are to be provided for signaling / contact multiplication etc. Use of miniature relays / plug-in relays are not acceptable.

i) System ON.
ii) TCIV open.
iii) TCIV closed
iv) Oil drain valve closed.
v) Gas inlet valve closed.
vi) Detector trip.
vii) Buchholz relay trip.
viii) Oil drain valve open.
ix) Extinction in progress.
x) Cylinder pressure low.
xi) Differential relay trip.
xii) PRD / RPRR trip.
xiii) Transformer trip.
xiv) System out of service.
xv) Fault in cable connecting fault detector.
xvi) Fault in cable connecting differential relay.
xvii) Fault in cable connecting Buchholz relay
xviii) Fault in cable connecting transformer reactor trip.
xix) Fault in cable connecting PRD.
xx) Fault in cable connecting TCIV.
xxi) Auto / Manual / Off
xxii) Extinction release on / off
xxiii) Lamp test.
xxiv) Visual / Audio alarm for AC supply fail.
xxv) Visual / Audio alarm for DC supply fail.

4.1.8 Alternatively, redundant supply can be provided

a) One feeder from UPS
b) One feeder from ACDB

4.1.9 If DC power is required for NIFPS the power converter shall be included in the NIFPS system. Power supply monitoring shall be provided in any supply fail it shall be recorded and alarmed in SCADA.

4.1.10 NIFPS shall be able to tolerate +/- 10 to 15 % voltage fluctuation.

4.1.11 Transformer conservator isolation valve (TCIV) shall be fitted in the conservator pipeline, between conservator and buchholz relay which shall operate for isolating the conservator during abnormal flow of oil due to rupture / explosion of tank or bursting of bushing. The valve shall be flow sensitive and shut off when the flow in the pipe is more than the flow expected in the permissible normal operating conditions. The valve shall not isolate conservator during normal flow of oil during filtration or filling or refilling, locking plates to be provided with handle for pad locking. It shall have proximity switch for remote alarm, indication with visual position indicator. The TCIV should be of the best quality as malfunctioning of TCIV could lead to serious consequence. The closing of TCIV means stoppage of breathing of transformer. A suitable platform and ladder shall be provided to approach Buchholz relay and the TCIV valve for manual reset. The ladder shall be pad lockable cover right from FGL to avoid unauthorized climbing in transformer charged condition and with top handrail.

4.1.12 The system shall be complete with adequate number of detectors (quartz bulb) fitted on the top cover of the transformer oil tank. Detectors shall be connected in parallel to the signal box by Fire survival cables. Fire survival cables (capable to withstand 750 deg C.) shall conform to BS 7629-1, BS 8434-1, BS 7629-1 and BS 5839-1, BS EN 50267-2-1 or relevant Indian standards.

4.1.13 Signal box shall be mounted away from transformer main tank, preferably near the transformer marshalling box, for terminating cable connections from TCIV & detectors and for further connection to be control box. The degree of protection shall be IP55.

4.1.14 Fire Retardant Low Smoke Minimum FRLS or As per CEA regulation cable shall be used for connection between control box to DC & AC supply source, FEC to AC supply source, signal box / marshalling box to transformer conservator isolation valve connection on transformer. Separate cables for AC supply & DC supply shall be used.

4.1.15 Pipes complete with connections, flanges, bends and tees etc. shall be supplied along with the system.

a) Oil drain and nitrogen injection openings with gate valves on transformer tank at suitable locations.
b) Flanges between Buchholz relay and conservator tank for fixing TCIV.
c) Pipe connections between transformer and FEC and between FEC and oil pit required for collecting top oil.
d) Butterfly valves / Gate valves on oil drainpipe and nitrogen injection pipe which should be able to withstand full vacuum.

4.1.16 On receipt of all activating signals, the system shall drain - pre-determined volume of hot oil from the top of tank (i.e., top oil layer), through outlet valve, to reduce tank pressure by removing top oil and simultaneously injecting nitrogen gas at high

pressure for stirring the oil at pre-fixed rate and thus bringing the temperature of top oil layer down. Transformer conservator isolation valve blocks the flow of oil from conservator tank in case of tank rupture / explosion or bushing bursting. Nitrogen occupies the space created by oil drained out and acts as an insulating layer over oil in the tank and thus preventing aggravation of fire.

4.1.17 Besides automatic control, remote electrical push button control at Control box and local manual control in the cubicle shall also be provided. Tripping of all circuit breakers (on HV & LV side) associated transformer is the pre-requisite for activation of system.

4.1.18 The following electrical signals shall be used for activating the system under prevention mode/fire extinguishing mode.

For prevention:

a) Differential relay operation.
b) Buchholz relay paralleled with pressure relief Rise Relay

For extinguishing:

a) Fire Detector (Type tested and calibrated)
b) Buchholz relay paralleled with pressure relief Relay.

4.1.19 The system shall be designed to be operated manually in case of failure of power supply to the system. It shall be ensured that once the system gets activated manually or in auto mode, all the connected breakers shall not close until the system is actually put in OFF mode. Also, PRD shall get closed only if all the connected breakers are open.

4.1.20 The supplier shall demonstrate the entire functional test associated with the following as Factory Acceptance Tests:

a) FEC, Control Box
b) Fire Detector
c) Transformer Conservator Isolation Valve

4.1.21 The performance test of the complete system shall be carried out after erection of the system with transformer at site.

5.0 Technical Parameters

Sl. No.	Item Description	Unit	Technical requirement
1.	Rating	kVA	To be decided based on Inverter rating and at least match with the PQ capability of Inverter at minimum ambient temperature 50 degree centigrade or as per CEA guidelines / Working committee report
2.	Voltage ratio	kV	33 **
3.	Type	-	Oil filled Type
4.	Type of Cooling	-	ONAN
5.	Cooling Oil type	-	Mineral oil
6.	Frequency	Hz	50±5%
7.	No. of windings of each transformer	-	Two / Multiwinding
8.	Impedance @ base MVA	-	As per Standard and fault current limitation on LV side / as per inverter manufacturer's recommendation
9.	Maximum current density		
	a) LV Winding	A/ mm^2	3.0 – 3.5
	b) HV Winding	A/ mm^2	3.0 – 3.5
10.	Maximum flux density	Wb/m^2	1.76
11.	Winding connection and vector group	-	As per Inverter manufacturer's recommendation
12.	System earthing (a) HV (b) LV	- -	As per Inverter manufacturer's recommendation

Sl. No.	Item Description	Unit	Technical requirement
13.	Type of tap changer	-	Off load-OCTC on HV side
14.	Tapping range and number of steps	%	±5 % in steps of 2.5 %
15.	Loading Capability		Continuous operation at rated MVA on any tap with voltage variation of +/-10%, also transformer shall be capable of being loaded in accordance with IS:6600/IEC60076-7. As min. requirement, Transformers shall be designed with 110% continuous thermal overloading capability.
16.	Over fluxing capability	%	110% continuous 125% for 1 minute 140% for 5 seconds
17.	Core	-	
	a) Material	-	CRGO silicon steel laminations of M4 or better grade
	b) Thickness of lamination	mm	0.27 or better
18.	Winding	-	LV – Electrolytic Copper / Aluminium HV - Electrolytic Copper / Aluminium
19.	Tank		
	a) Material	-	As per Standard
	b) Thickness of sides	mm	As per Standard
	c) Thickness of top and bottom	mm	As per Standard
	d) Thickness of cover	mm	As per Standard

Sl. No.	Item Description	Unit	Technical requirement
	e) Radiator Thickness	mm	Minimum 1 mm
20.	Impulse withstand voltage of HV winding	kVpeak	170
21.	Power frequency withstand voltage of winding HV/LV	kVrms	33 kV - 70 LV - 3
22.	System Fault level for 1 sec. (a) HV Side (b) LV Side	 kA kA	 31.5 As per Short circuit study
23.	Permissible Temperature rise over an ambient of 50 deg C (irrespective of tap)		
	a) Top Oil	Deg. C	50 Deg. C
	b) Each Individual Winding	Deg.C	55 Deg. C
24.	Short circuit withstand time		
	a) Three phase dead short Circuit at terminal with Rated voltage maintained on the other side.	Secs.	2
	b) Single phase short circuit at terminal with rated Voltage maintained on other side	Secs.	2
25.	Clearances in air a) Between Phases	 mm mm	 HV – 350, LV-25 HV – 320, LV-25

Sl. No.	Item Description	Unit	Technical requirement
	b) Between Phase & Earth		
26.	Creepage distance	mm / kV	31
27.	Noise level	-	As per NEMA TR-1
28.	Guaranteed Losses	%	Maximum 1.1%
	a) No Load Loss	%	Bidder to specify
	b) Load Loss	%	Bidder to specify
29.	Terminal Connection		
	a) 33 kV side	-	Phase segregated Cable box type
	b) LV side	-	Cable box
30.	Painting	-	Shade RAL 7035 as per ISO 12944-5
31.	Winding Temperature Indicator (Local and Remote – to be integrated with SCADA)	-	On HV and each LV Windings
32.	Oil Temperature Indicator (Local and Remote – to be integrated with SCADA)	Yes / No	Yes
33.	Marshalling Box	-	Yes, outdoor type
	a) Degree of protection	-	IP 55

Note : "*" – Indicates the data shall be as per Inverter Model chosen

Annexure – E (Specification of Transformer Oil)

Sr No	Property	Permissible Value
1	Kinematic Viscosity, mm2 /s	≤ 12 at 40 ° C ≤ 1800.0 at (-)30 ° C
2	Flash Point, ° C	≥ 140° C
3	Pour point, ° C ≤ (-)40 ° C	Pour point, ° C ≤ (-)40 ° C
4	Appearance	Appearance Clear, free from sediment and suspended matter
5	Density kg/dm3 at 20 ° C	≤ 0.895
6	Interfacial Tension N/m at 25° C	≥ 0.04
7	Neutralisation value, mgKOH/g	≤ 0.01
8	Corrosive sulphur	Non-Corrosive
	Presence of oxidation Inhibitor according to IS 13631 / IEC 60666, %	Not Detectable (< 0.01 %)
	Metal Passivator additives, mg/kg	Not Detectable (< 5 mg/kg)
	Other Additives	Does not contain any additives
9	Water content mg/kg	≤ 30 in bulk supply ≤ 40 in drum supply
10	Anti-oxidants additives	Not detectable
11	Oxidation Stability • Neutralization value, mgKOH/g • Sludge, % by mass	 ≤ 1.2 ≤ 0.8
12	Breakdown voltage • As delivered, kV • After treatment, kV	 ≥ 30 ≥ 70
13	Dissipation factor, at 90° C And 40 Hz to 60 Hz	≤ 0.005
14	PCA content	≤1%
15	PCB content	Not Detectable (< 2mg /kg)
16	Impulse withstand Level, kVp	≥ 145
17	Gassing tendency at 50 Hz after 120 min, mm3 /min	≤ 5

6.0 Tests:

6.1 Following type tests shall be conducted on one transformer of each rating and each Make as per IS: 2026/ IEC-60076/CBIP Manual:

a) Temperature rise Test with dissolved gas analysis test before and after.

b) Dielectric tests (As per IEC 60076)

c) Vacuum and pressure tests on Transformer tank, conservator, cooler units, pipe and other fittings.
d) Degree of protection for Cooler control cabinet / Marshaling box
e) Measurement of acoustic noise level as per NEMA TR-1 (special test)
f) Testing of PRV / PRD

6.2 Following minimum routine tests shall be performed on the Inverter Transformers as per IEC:60076 / IS:2026:

a) Measurement of winding resistance-at all tap position
b) Insulation resistance test
c) Measurement of voltage ratio and check for vector relationship-at all tap position
d) Measurement of no load current with 415 V, 50 Hz AC supply
e) Measurement of Impedance Voltage & short Circuit Impedance
f) Measurement of No-Load Losses & current at 90%, 100% & 110% of rated voltage
g) Measurement of Load Losses
h) Induced Over voltage Withstand test
i) Magnetic Balance and magnetising current Test
j) Separate Source Voltage withstand test
k) Oil BDV test
l) Insulation Resistance & Polarization Index
m) Measurement of capacitance & tan delta
n) SFRA test
o) Oil leakage test
p) Calculation of Efficiency & Regulation
q) Functional and continuity checking for marshalling box and auxiliary relays
r) Shield earth connectivity
s) Jacking test on oil filed transformer

6.3 **Special Test**

Short Circuit Test: In case short circuit test has not been conducted or the test report not meeting the specification requirement for the offered transformer manufacturer, Bidder /Sub-vendor shall establish" Ability to withstand the dynamic effects of short circuit" for the offered transformer as per latest IEC 60076-5. The ability to withstand the dynamic effects of short circuit can be established either by performing actual short circuit test or by method of calculation with reference to short circuit tested reference transformer as per IEC-60076- 5 Bidder shall choose any one the two options mentioned below

a) Option-1: Performing actual short circuit test as Type Test. In order to meet project schedule, Bidder/Sub vendor shall take suitable steps quite in advance to ensure successful conduction of short circuit test.

b) Option-2: By theoretical evaluation of the ability to withstand dynamic effect of short circuit based on Calculation and Design and Manufacture Consideration. In this regard

the guidelines given in Annexure-A with applicable tables of the IEC 60076-5 is to be followed.

7.0 Data to be furnished by vendor after award of contract

7.1 **Drawing / Document for Approval:**

a) Detailed technical data sheet
b) Efficiency at full load and 75% load at unity power factor
c) General outline drawings showing plan, front elevation, and side elevation, with all fittings and accessories, earthing terminals, foundation/floor fixing details, jacking pads and weights of the following:
   i. Marshalling box
   ii. Cable boxes & disconnecting links
   iii. Terminals details
d) Bushings: Plan, elevation, terminal details, mounting details, make and type number, current and voltage rating, creepage distance, etc.
e) Rating and diagram plates drawing
f) Valve schedule
g) Type test certificate validity as per CEA
h) Fire protection system OGA, drawing and documents with O&M manuals
i) All accessories drawings like, OTI, WTI, breather, Buchholz Relay, PRD, Conservator, Radiator bank, etc along with catalogue with O&M manuals
j) QAP and MQAP as per CEA regulations /standard/guideline
k) Any other drawings / documents required by Owner during detail engineering

7.2 **Drawings / Documents for information:**

a) Quality assurance plan, FAT/SAT procedure
b) Field Quality Plan
c) Product warranty document
d) Schedule of manufacturing and delivery
e) Detailed erection, testing & commissioning manuals
f) Detailed operation and maintenance manuals
g) Overloading Curve with time duration
h) Recommended spare parts list for 5 years
i) Printed instructions to receive, store and handle at site
j) Any other drawings / documents required by Owner during detail engineering

B2 - 33 KV HT / MV SWITCHGEAR

1.0 33/11 kV Sub-Pooling Switchboard / MCR (Main Control Room) and 33kV ICOG Panel

1.1 The purpose of these panels is to provide necessary protection to Inverter duty transformers at the block level, aggregation of power and onward transmission to the 33kV pooling switchgear. The design, manufacture, delivery, factory testing and inspection, delivery to site, installation, testing and commissioning of these panels shall comply with latest applicable standards. The equipment shall be designed, engineered, and manufactured to achieve high availability and reliability.

1.2 The supplier shall arrange all specialized equipment / services necessary for proper erection, commissioning, and performance testing of all items of the equipment covered under this contract. The cost of the same shall be included in the contract price.

1.3 All routine and acceptance tests at Factory and Site acceptance tests shall be conducted as part of the contract with prior notice to Purchaser.

2.0 Codes & Standards

Codes	Description
IEC 60298	A.C. metal-enclosed switchgear and control gear for rated voltages above 1 kV and up to and including 52 kV
IEC 62271-100/200	High-voltage switchgear and control-gear
IS: 9921	A.C. disconnectors (isolators) and Earthing switches for voltages above 1000 V
IS: 9431	Specification for indoor post insulators of organic material for system with nominal voltages greater than 1000 volts up to and including 300 kV
IS: 2705	Current Transformers
IS: 3156	Voltage Transformers
IEC 60529	Degree of protection provided by enclosures (IP Code)
IS: 6005	Code of practice for phosphating of iron and steel
IEC: 61850	Communication Standard for Numerical relays
IEC: 61131-3	Automation Standard for Numerical relays
IS :513 (2008)	Cold Rolled Low Carbon Steel Sheets and Strips
IS: 9046	AC contactors for voltages above 1000 volts and up to and including 11000 Volts.

3.0 Design Criteria

3.1 The Switchgear shall be of single tier, fully compartmentalized, metal enclosed construction type.

3.2 The switchgear shall have an internal arc test classification corresponding to system fault current and as per ICE62271-200.

3.3 The service class continuity of switchgear shall be LSC2B-PM as per IS/IEC 622771-200.

3.4 The Switchgear assembly shall be dust, moisture, rodent and vermin proof, with the truck in any position Service, Test / Isolated or removed and with all doors and covers closed. All doors, removable covers and glass windows shall have gaskets all round with synthetic rubber or neoprene gaskets

3.5 Cooling of Switchgear Panel shall by natural air flow.

3.6 Switchgear shall have a degree of protection of IP: 42 (minimum) for indoor application. Switchgears shall be provided with IP55 enclosure or better for Outdoor application with continuous ambient temperature of 50º C or as per CEA guidelines / Working committee report and shall be resistant to water & ultraviolet radiation further for outdoor duty, it shall be placed over extended shed, plinth and working platform, ingress protection specified above is minimum requirement, however IP protection shall be as per OEM recommendation.

3.7 33kV ICOG Panel shall be consisted of one VCB the isolation and protection device. Indoor ICOG panel with Containerized solution or PEB building or outdoor ICOG panel with proper extended shed, plinth and working platform shall also be acceptable. Separate ICOG panel is also not mandatory in case distance between IDT and 33kV sub pooling station / MCR (Main Control Room) is less than 50 meters subject to compliance of electrical inspector's requirements, safety regulation and any other applicable rules, norms, act, regulations etc. However additional hard wired EPB (Emergency Push Button) to be provided at strategic location in invertor station to trip the HT Breaker.

3.8 33kV Sub-pooling switchboard shall consists of VCB for the Inverter transformer incomers and VCB for the 33kV transmission line to the MGVCL/GETCO Substation as applicable. The number of incoming feeders shall be decided based on the block configuration adopted for the project. Space provision for future panel (one no) shall be provided. 33kV Sub-pooling switchboard shall be provided with RCC cum PEB building.

3.9 For each 33kV panel / board, minimum clear distances of 2500MM at panel front, minimum 1500 mm left and right side and 1750MM at back of the panel board shall be provided or clear distances recommended by OEM whichever is higher shall be

provided for proper installation, panel /part replacement and O&M activities. Minimum clear distances of 150 mm on each side (Right & left) for future panels shall be provided for proper installation, panel /part replacement and O&M activities.

3.10 The circuit breakers and VTs shall be mounted on withdrawable trucks which shall roll out horizontally from service position to isolated position. Withdrawable bus VT's shall be preferably on front side of the panel board. For complete withdrawal from the panel, the truck shall rollout on the floor or shall roll out on telescopic rails. In case the later arrangement is offered, suitable trollies shall be provided for each ICOG / Sub pooling stations (for each type of breaker) by the Bidder for withdrawal and insertion of the truck from and into the panel. Testing of the breaker shall be possible in isolated position by keeping the control plug connected

3.11 The ICOG panels shall consist of VCB for the incomer from Inverter Duty transformer.

3.12 Enclosure shall be constructed with rolled steel / Aluzinc / Stainless Steel sections and sheets metal of at least 2.5 mm thick. Detachable Gland plates of minimum 3 mm thick, shall be made out of hot rolled or cold rolled, for single core cables, it shall be nonmagnetic material.

3.13 Total height of the switchgear panels shall not generally exceed 2700 mm. The height of switches, push buttons and other hand operated devices shall not exceed 1800 mm and shall not be less than 700 mm from bottom of the panel base. All relays, meters, indicating lamps, switches etc. shall be flush mounted on the respective cubicle front door.

3.14 The VT/ relay compartments shall have degree of protection not less than IP:52 in accordance with IS:13947. However, remaining compartments of 33kV Switchgear shall have a degree of protection of IP: 42 (minimum) for indoor application. No louvers/opening shall be provided on the top of the panel. All other louvers if provided, shall have very fine brass or GI mesh screen. Tight fitting gourmet/gaskets are to be provided at all openings in relay compartment.

3.15 All VCB shall be motorized type.

3.16 Circuit breaker shall be restrike free, stored energy operated and trip free type. Motor wound closing spring charging shall only be acceptable. An anti-pumping relay shall be provided for each breaker. Spring charging motor winding shall be provided with Class -E or better insulation.

3.17 The closing coil and spring charging motor shall operate satisfactorily at all values of control supply voltage between 85% to 110% rated DC voltage. The shunt trip coils shall operate satisfactorily under all operating conditions of the circuit breaker

up to its rated short circuit breaking current at all values of control supply voltage between 70% to 110% of rated DC voltage.

3.18 Breakers Operation Class shall be E2, M2 & C2 and Rated Operating Duty shall be O - 0.3Sec- CO-3MIN-CO.

3.19 In case, control supply availability is must for movement of breaker from service to test to isolate and vice versa, than dedicated MCB (other than protection and other control MCB's) shall be provided for locking magnet / solenoid / similar device used for such interlock.

3.20 Each DC circuits (e.g. DC main sources, closing circuit, tripping circuit, indication circuit, spring charging motor circuit, auxiliary supply to indicating instrument etc.) shall have dedicated MCBs of required rating.

3.21 All AC Auxiliaries / control circuits shall have dedicated MCBs of required rating.

3.22 VCB shall have mechanically latched separate lock out relay (ABB PSU14X or VAJC or equivalent), trip circuit supervision of lock out relay and VCB in open and close condition, DC supervision and AC supervision (this can be a part of annunciator also). 2 NO and 2 NC spare contacts wired up to the TB shall be provided.

3.23 Breaker auxiliary contacts shall be used directly. In case contact multiplication is inevitable (only if OEM is not supporting number of auxiliary contacts required) then mechanically latched electrically operated contact multiplication relays (e.g VAJC / PSU14X) shall be provided. 2NO + 2 NC spare breaker auxiliary contacts wire up to TB for future use shall be provided.

3.24 Only DIN mounted auxiliary contactors (of approved vendor) with or without add-on block are to be provided for signaling / contact multiplication etc. Use of miniature relays / plug in relay are not acceptable.

3.25 The switchgear shall be fully integrated with SCADA and with IEC 61850. All feeders shall be controlled from SCADA / respective control system and from the switchgear. All the protection and safety interlocks shall be hardwired in the Switchgear itself. Bidder shall consider adequate number of digital inputs and outputs for integration with SCADA. Number of DI and DO will finalized during detail engineering without any extra cost to the owner. DI and DO shall be from numerical relay only (Additional RIO is not acceptable).

3.26 Mimic diagram with description of function to represent the single line diagram, shall be made available on the panel.

3.27 Suitable explosion vents to ensure safety of operating personnel shall be provided.

3.28 The switchgear shall be provided with emergency push buttons for emergency operations.

3.29 The panels shall be provided with internal illumination arrangement along with utility power socket.

3.30 All working parts of the mechanism shall be of corrosion resisting material.

3.31 The circuit breaker shall normally be controlled from SCADA and local operation shall also be provided.

3.32 All circuit breakers shall be provided with communicable numerical relays with IEC 61850 protocol.

3.33 All control terminals shall be of Stud type (screw drive operated) and control wiring shall be terminated with tinned copper ring type lugs. Disconnecting stud type terminal shall be provided for CT circuits. Printed single tube ferrules marked to correspond with panel wiring diagram shall be fitted at both ends of each wire. The wire identification marking shall be in accordance with IS:375. Red Ferrules should be provided on trip circuit wiring. 20% of terminals of each type and rating in each feeder shall be provided as spare subject to a minimum of 2 terminals of each type and rating.

3.34 110V DC Supply shall be used for control and protection system of switchgear. In case UPS AC supply is considered for auxiliary control and protection supply for ICOG switchgear, then suitably rated AC/DC converter/power pack arrangement with redundancies shall be used to meet the DC control supply requirement of switchgear panels.

3.35 The Cable glands shall be weatherproof Double compression type made of heavy-duty brass machine finished, and nickel chrome plated of suitable size. Thickness of plating shall not be less than 10 microns. Cable glands shall conform to BS:6121.

3.36 All Cable lugs for power cables shall be Heavy duty long barrel tinned copper ring type / bimetallic solderless crimping type of suitable size. Cable lugs for control cables shall be tinned copper ring type with insulated sleeve.

3.37 The basic control scheme shall be developed in the numerical relay using programmable (soft) logics.

3.38 Facilities shall be provided for mechanical tripping of the breaker and for manual charging of the stored energy mechanism for a complete duty cycle, in an emergency in closed door condition.

3.39 The segregation shall be designed to prevent arcs, smoke and/or vaporized metal from going directly or indirectly from one compartment to another so as to prevent the fault or its effects spreading to other compartments.

3.40 Compartmenting shall be such that maintenance can be carried out safely on one (1) circuit with other adjacent circuits still in service.

3.41 The switchgear construction shall be such that the operating personnel are not endangered by breaker operation and internal explosions, and the front of the panels shall be specially designed to withstand these. Pressure relief device shall be provided in each high voltage compartment of a panel, so that in case of a fault in a compartment, the gases produced are safely vented out, thereby minimizing the possibility of its spreading to other compartments and panels. The pressure relief device shall not however reduce the degree of protection of panels under normal working conditions. Gas duct from panel to be routed to outside of PEB.

3.42 The surge arrestors shall be provided for inverter transformer feeders, 33kVTransmission line feeders to limit the switching over voltages and for other feeders as per system study requirement. The surge arrestors shall be of metal oxide, gapped or gap less type generally in accordance with IEC 60099- 4 and suitable for indoor duty. These shall be mounted within the switchgear cubicle between line and earth, preferably in the cable compartment. Surge arrestor specifications and ratings shall be as per insulation coordination study. Insulation coordination study is in scope of Bidder.

3.43 Surge arrestor selected shall be suitable for un-earthed system and rating shall be in such a way that the value of steep fronted switching over voltage generated at the switchgear terminals shall be limited to the requirements of switchgear.

3.44 The Currents Transformers (CT) and Voltage Transformers (VT) shall be provided for protection and metering and shall be cast-resin encapsulated type with insulation class 'F' or better.

3.45 CTs shall be rated for switchgear fault level for 1 sec and conforming to accuracy class mentioned below: -

a) Class PS for differential relaying
b) Class 5P20 for other relaying
c) Class 0.2s for ABT metering system with ISF, burden and ratio (obtaining approvals is in the scope of bidder) as per regulatory requirements /concern competent authority requirements.
d) Class 0.2s for general Metering for 33kV Transmission lines with ISF<5
e) Class 0.5s or better for general metering for ICOG panel with ISF<5

3.46 Deleted

3.47 PS Class CT for Transformer differential protection (33kV side) shall be provided in HV Turret of Transformer.

3.48 Separate cores shall be provided for metering and protection applications. Core balance CT and associated relay combination shall be such as to ensure a pickup sensitivity of 10 A primary ground fault current for all the outgoing feeders.

3.49 Tariff metering panel, meter, CT and PT with sealing arrangement, all required accessories shall be provided as per statutory / RLDC / CEA requirement. 0.2s class ABT/Tariff Meter to be provided at the outgoing 33kV transmission line feeder to the MGVCL/GETCO Substation as applicable. Separate 0.2s class CT and separate 0.2 class PT and/or separate panel with sealing arrangement to be provided for this meter along with TTB as per statutory /RLDC / SLDC / CEA requirement. Tariff metering system shall be as per specification mention in respective section. MGVCL/ GETCO /RLDC / SLDC / CEA / other statutory bodies if required then Separate Tariff metering panel (CT/PT, TTB's, MCB's, 110V DC supply, Supply selection switch, UPS supply, ABT Meters and its accessories etc.) with required sealing arrangement front (Top Bottom), Rear (Top Bottom) shall be provided for each Out Going Transmission line to MGVCL/GETCO Substation. All communication ports (RS-485 and LAN Ports) of ABT Metering system shall be brought to Control cubicle of respective 33kV panel for future connections (as metering compartment of Tariff metering panel will be sealed by concerned authorities and we intend to have access of ABT meter communication ports.)

3.50 Multifunction Meters for general purpose of accuracy class 0.2s with separate 0.2s class CT and 0.2 class PT to be provided for the each outgoing 33kV transmission line feeder to MGVCL/GETCO Substation.

3.51 The List of parameters for all MFM shall be as per Secure Elite 445 or Rishabh RISH 3430. All parameters of the MFM shall be integrated to the SCADA system.

3.52 VTs for 33kV switchgear with suitable HRC fuses on primary and MCBs on secondary sides, under voltage relays, remote annunciation on supply failure shall be provided. Following 33kV VTs shall be provided:

a) Line VTs for each 33kV transmission line
b) Bus VTs for each 33kV sub-pooling switchgear
c) VTs for each 33kV ICOG panel (Towards sub-pooling switchgear side)

3.53 Accuracy class of the voltage transformers shall be as specified below.

a) Class 3P for protection
b) Class 0.2 for ABT metering system with burden (obtaining approvals is in the scope of bidder) as per regulatory requirements /concern competent authority requirements.
c) Class 0.2 for general Metering for 33kv Transmission line
d) Class 0.5 or better for general metering for ICOG panel

3.54 Deleted

3.55 Metering system of 3-phase, 4 wire, 3 elements, 0.5s Class (0.5s class MFM, 0.5 Class VT's and 0.5s class CT's) shall be provided at HV side of each Inverter Transformer at the ICOG panel.

3.56 Separate earthing trucks shall be provided for all ICOG and all sub-pooling switchgears breaker feeders for maintenance work. These trucks shall be suitable for earthing the switchgear busbars / cables as well as outgoing and incoming cables. The trucks shall have a interlock to prevent earthing of any live connection.

3.57 As an alternative to separate earthing trucks, the Bidder may also offer built-in earthing switches for the busbars / cables and outgoing & incoming connections for all breaker feeders at all sub-pooling switchgears and all ICOG panels. Earthing switches if opted shall be standard proven switchgear design. The inbuilt earthing switches shall be quick make type, independent of the action of the operator and shall be operable from the front of the switchgear panel. These switches shall have facility for padlocking in the earthed condition.

3.58 Suitable arrangement for power cable termination shall be provided as required. Cable entry shall be from the bottom. The bottom cable entry shall be fitted with removable gland plates of adequate size for fixing cable glands. A minimum clearance of about 600 mm shall be kept between the cable lug bottom ends and gland plates for stress cone formation for XLPE cables. Interphase clearance in the cable termination compartment shall be adequate to meet electrical and mechanical requirement besides facilitating easy connections and disconnection of cables. Dimensional drawing of cable connection compartment showing the location of lug, glands, CTs, gland plates etc. and the electrical clearances available shall be submitted for owner's approval during detail engineering

3.59 All wiring shall be carried out with wires of 1.1 KV grade, stranded copper conductors. The insulation shall be halogen free and flame retardant. Power circuits shall be wired with stranded copper conductors of adequate sizes to suit the rated current, the minimum size shall be 2.5 sq. mm. Unless otherwise specified, control alarm and indication circuits shall be wired with stranded, tinned copper conductors of sizes not smaller than 1.5 sq. mm. Space heater, CT and VT circuits shall be wired with stranded copper conductor of size not smaller than 2.5 sq. mm.

3.60 Compartment internal wiring truff fill factor shall not be more than 50%. LV compartment of the panel shall be spacious for any future requirement. (Minimum 20% additional space must be available)

3.61 Panel earthing arrangements to be provided and earth conductor location shall not obstruct access to cable terminations.

3.62 Hinged doors shall be earthed through flexible earthing braid.

3.63 Nameplate shall be provided for all switchgears.

3.64 Electrical Insulating mat (as per IS: 15652) shall be provided for all the panels (in front as well as back of the panel) as per statutory requirement to ensure safe operation.

3.65 The meters shall be suitable for operation from the secondary of CTs and VTs. They shall be provided with a separate test block (screw type, large size, three phase four wire) for the testing of the meters without disturbing the CT and PT secondary connections. Meters shall be equipped with communications interface with MODBUS protocol.

3.66 All protection relays shall be numerical type. Relays shall be in draw-out cases with built-in test facilities or plug in type with proper testing facilities. All protective relays shall be provided with test blocks (with CT, PT, Trip circuit, auxiliary supply, logical input, and output contact) for online testing (Secondary injection) without disturbing wiring. Adequate numbers of multi finger test plugs shall be provided

3.67 Numerical relays shall have the minimum following features

a) Type of relays shall be latest numerical high end version with highest display size and features available in proposed make and its product range

b) At least two group of settings

c) Min. no of LEDs - 10 (Minimum 2 LED’s for future use)

d) Front key pad for Parameter / Navigation.

e) In built lockout function with front key resetting.

f) EMC Compatible.

g) No adopter / Convertor is acceptable.

h) At least 10 disturbance recorder

i) At least 5 Fault recorder

j) Event recording at least 50

k) Unlimited logic gates

l) In-built timers

m) Freely programmable DI / DO. (Min 2 DI/DO for future use wired up to TB)

n) In built CB control function with interlocking.

o) Goose messaging for inter tripping command and interlocking in addition to hardware interlocking.

p) Non -Volatile memory with battery backup or suitable arrangement

q) Time synchronization

r) Self-diagnosis / watchdog / relay failure – two output contacts shall be configured.

3.68 All hardware and licensed software required for communication of relays, parameterization, download / analysis of fault data from relays and interfacing the relays with the SCADA system shall be supplied by the Bidder in complete with set of cables, accessories, etc.

3.69 All 33kV switchgear breaker feeders including ICOGs shall be provided with dedicated BCU or BCPU.

3.70 Following minimum protections shall be provided as specified below and any other required protections, functions, features, functionality required as per applicable regulation / norms / prudent industrial practices / system requirement shall be considered by the bidder without any extra cost to the owner.

a) Minimum Protections required for Inverter duty Transformers:

i. Transformer differential protection (87T) if applicable as per the CBIP manual
ii. IDMT & DMT overcurrent protection (50/51)
iii. IDMT & DMT earth fault protection (50N/51N)
iv. Under voltage protection (27)
v. Over Voltage Protection (59)
vi. Auxiliary relays for WTI (all windings), OTI, PRV1, PRV2, MOG, NIFPS, Buchholz etc.
vii. Under frequency (81U) and over frequency (81O)
viii. Instantaneous earth fault protection through CBCT (50 G)

b) Minimum Protections required for Incoming feeders of sub pooling stations (from Solar generation end):

i. IDMT & DMT overcurrent protection (50/51)
ii. IDMT & DMT earth fault protection (50N/51N)
iii. Under voltage protection (27)
iv. Over Voltage (59)
v. Under frequency (81U) and over frequency (81O)

c) Minimum protection required for Outgoing Transmission lines

i. IDMT & DMT overcurrent protection (50/51)
ii. IDMT & DMT earth fault protection (50N/51N)
iii. Instantaneous earth fault protection through CBCT (50 G).
iv. Under voltage protection (27)

v. Over Voltage (59)
vi. Under frequency (81U) and over frequency (81O)

d) Minimum protection required for Aux. Transformers (for 33KV Voltage class)

i. IDMT & DMT overcurrent protection (50/51)
ii. IDMT & DMT earth fault protection (50N/51N)
iii. Instantaneous earth fault protection through CBCT (50 G).
iv. Under voltage protection (27)
v. Over Voltage (59)

3.71 Relay cases shall have adequate number of terminals for making potential free connections to the relay coils and contacts including spare contacts.

3.72 Cable trench of HT panel board shall be designed after considering adequate margin of cable bending radius. Cable entry in the trench shall be at least above 1 meter to HFL (High Flood Level)

3.73 Annunciator (with AC and DC supply supervision) with SCADA integration to be provided for each feeder. (4 Nos of Spare window wired up to TB is to be provided in each annunciator).

3.74 Indication lamps shall be of the panel mounting, LED type. The lamps shall have escutcheon plates marked with its function, wherever necessary. LED indicating lamp shall be cluster type. Lamps shall have translucent lamp-covers as warranted by the application

3.75 Seismic Zone as per IS 1893 compliance for switchgear.

3.76 Hooter system is to be provided for each 33KV sub pooling switchgear board and ICOG panel.

3.77 Inter-cubicle looping of control and cubicle space heating supplies for all the panels of switchgear shall be carried out by the Supplier.

3.78 Aluminium or copper earthing bus shall be provided at the bottom and shall extend throughout the length of each switchgear. It shall be bolted to the framework of each panel and each breaker earthing contact bar.

3.79 Each switchgear cubicle shall be equipped with thermostatically controlled SS304 grade / Aluminium alloy space heaters to prevent moisture condensation within the enclosure and shall be complete with MCB for power supply. Heaters and MCB shall be suitable for continuous operation on 230V, 1 phase, 50 Hz AC supply.

3.80 All metallic hardware such as nuts, bolts, screws, washers etc. shall be of Hot dip galvanized as per IS standard.

3.81 230V, 1 phase, 50 Hz. AC plug point shall be provided in the interior of each cubicle with an on-off switch for connection of hand lamps.

3.82 Metering/wiring cubicle shall be provided with LED fitting for illumination.

3.83 The temperature of busbar and all other equipment, when carrying the rated current continuously shall be limited as per the stipulation of IEC 62271-1 2017, duly considering the specified ambient temperature.

3.84 Busbars and connection shall be fully insulated for working voltage with adequate phase/ground clearances. Insulating heat shrink sleeves (colour coated) for busbars and cast-resin shrouds / silicon rubber shrouds for joints shall be provided. Cross section of the main horizontal busbar shall be uniform throughout the switchgear and continuous in one transport unit. All buses and connection shall be supported and braced to withstand stresses due to maximum short circuit current and also to take care of any thermal expansion. Make of HT cable sleeves shall be Hong Shang or Raychem.

3.85 Name plate shall be of non-rusting metal or 3-ply limacoid with white engraved letterings, on black background or as per manufacturer's proven standards. Inscriptions and lettering shall be subjected to Owner's approval

3.86 Deleted

3.87 Painting shall be carried out by approved process. Painting procedure and thickness of paint shall be as per ISO 12944.. After preparation of the under surface the equipment shall be painted with epoxy-based paint by powder coating. Final shade shall be RAL-7035

4.0 Technical Parameters

Sl. No.	Description	Unit	Technical Requirements
1.	Type of switchgear	-	Metal Clad Switchgear, Extendable at both ends, Outdoor / Indoor
2.	Application		Outdoor / Indoor
3.	Rated Voltage	kV	33 ± 10%
4.	Frequency	Hz	50 ±5 %
5.	Max. System Voltage	kV	36
6.	Design Ambient Temperature	ºC	50 or as per CEA guidelines / working committee report

7.	Max. Temp. rise limited	ºC	90 for non-silver-plated joints 105 for silver plated joints
8.	Auxiliary Supply (AC)	V	230
9.	Auxiliary Supply (DC)	V	110
10.	Humidity	%	95
11.	System earthing	-	As per system requirement
12.	Insulation level		
	a) Power frequency withstand Capacity for 1 min.	kVrms	70
	b) Impulse Withstand Voltage	kVpeak	170
13.	Short Circuit Withstand capability	kA	As per system study and design requirements with an additional margin as per Central Electricity Authority (Technical Standards for Construction of Electrical Plants and Electric Lines) Regulations, 2022 (Chapter 4, Part B, Clause No 59)
14.	Bus bars		
	a) Material of bus bar	-	Aluminum EC-91 / Electrolytic grade Copper
	b) Cont. Current Rating of Busbar	A	As per system design study calculation
	c) Support insulators	-	Required
	d) Dynamic withstands current rating (min)	kAp	63
	e) Temperature rise of over design ambient of 50°C Bus bars f) Silver plated joints		 40°C 55°C
15.	Switchboard Construction		
	a) Material of construction	-	Sheet metal 2.5 mm thick CRCA/Aluzinc/Stainless Steel (minimum) suitable for outdoor /

			indoor application as per suitability to site condition.
	b) Thickness of Sheet steel		
	• Enclosure/ Frame/ Doors -CRCA	mm	2.5
	• Front Door	mm	2.5
	• Partition	mm	1.6
	• Gland Plate	mm	3.0/4.0
16.	Degree of Protection	-	IP42 for Indoor and for Outdoor IP55 with extended canopy
17.	Paint Shade	-	RAL-7035
18.	Earthing Bus Bar	-	Required, Size to be selected based on fault current
19.	Minimum safety clearances in air		
	a) Between phases	mm	320
	b) Between phase & earth	mm	270
20.	Accessories for the Panels		
	a) Locking facility	-	Required
	b) Lamp with switch	-	Required
	c) Power socket	-	Required
	d) Breaker Operation Counter	-	Required
	e) Power pack for Auxiliary DC supply for breakers	-	Required
	f) Anti-pumping Relay	-	Required
	g) AC/DC Fail Relay	-	Required
	h) Space heater	-	Required
	i) Indicating lamps	-	Required
	j) Nameplate	-	Required
	k) Danger Plate	-	Required
21.	Circuit Breaker		

	a) Type	-	VCB
	b) System	-	EDO, 3 Pole
	c) Rated Operating Duty	-	0 – 0.3S – CO – 3min – CO
	d) Rated Current	A	As per design requirement
	e) Short Circuit Breaking Current	kA	As per system study and design requirements with an additional margin as per Central Electricity Authority (Technical Standards for Construction of Electrical Plants and Electric Lines) Regulations, 2022 (Chapter 4, Part B, Clause No 59)
	f) Short Circuit Making Current	kAp	2.5 times of system fault current
	g) Opening time	-	3 cycles
	h) Closing time	-	4 cycles
	i) Spring Charging Motor	-	Required
	j) Auxiliary contacts	-	As per system requirement
22.	Current Transformer	-	
	a) No. of Cores	-	system requirement
	b) ISF		<5
	c) Accuracy Class	-	As per system requirement
	d) CT Ratio	-	As per requirement
	e) Burden	VA	As per system requirement
	f) Short time rating	kA	31.5 for 1 sec
	g) Type	-	Cast Resin
23.	Voltage Transformer	-	
	a) No. of Cores	-	As per system requirement
	b) Accuracy Class	-	As per System requirement
	c) Ratio	-	33000/√3:110/√3:110/√3
	d) Burden	VA	As per system requirement
	e) Type		Cast Resin

24.	Current Transformer for Tariff meter	-	
	No. of Cores	-	1
	ISF		<5
	Accuracy Class	-	0.2s
	CT Ratio	-	As per statutory requirement
	Burden	VA	As per statutory requirement
	Short time rating	kA	31.5 for 1 sec
	Type	-	Cast Resin
25.	Voltage Transformer for Tariff meter	-	
	a) No. of Cores	-	2
	b) Accuracy Class	-	0.2 for metering
	c) Ratio	-	33000/√3:110/√3:110/√3
	d) Burden	VA	As per statutory requirement
	Type		Cast Resin
26.	Space heater	W	Rating to be calculated as per design
27.	Seismic Acceleration		0.36g

5.0 Tests

5.1 The switchgear shall have valid Type Test Reports for the tests carried out within last ten years on equipment of similar rating/design shall be submitted for review (including Internal arc test as per IEC 622771-200, service class continuity test, LSC2B-PM as per IS/IEC 622771-200).

5.2 Dielectric tests including Lightning impulse withstand test, Power frequency withstand test, switching impulse test, partial discharge test, artificial pollution test, Power frequency withstand test on auxiliary and control circuits

5.3 IP protection test

5.4 Short time and peak withstand test

5.5 Temperature rise test

5.6 Radio interference voltage tests

5.7 Measurement of resistance of the main circuit

5.8 The supplier of these panel shall be the Original Equipment Manufacturer (OEM) or channel partners.

5.9 For circuit breaker, the list of type tests shall include the following minimum tests as per IS 13118:

a) Dielectric tests
b) Radio interference voltage test
c) Measurement of the resistance of the main circuit
d) Temperature-rise tests
e) Short time withstand current, and peak withstand current tests
f) Verification of the Protection
g) Tightness tests
h) Electromagnetic compatibility tests
i) Mechanical and environmental tests including Mechanical operation test
j) Short-circuit current making and breaking tests
k) Capacitive current switching tests
l) Magnetizing and inductive/capacitive current switching tests
m) Internal Arc Test as per IEC
n) Type test of, CT, PT, Relay etc. shall be as per IS/IEC standard.

5.10 The switchgear shall be tested as per relevant standards. However, the following minimum tests shall be carried out compulsorily under routine tests along with other tests.

a. IR and HV Test
b. Functional operation of VCB
c. Electrical interlock test
d. Secondary injection test for relay and meters
e. Communication with SCADA and compatibility check
f. Earthing continuity test

5.11 Tariff metering system including Tariff meter, CT/PT specifications, drawing approval, testing etc., including fees per requirement of WRLDC / RLDC/ SLDC/ STU / concern competent authority is in the scope of Bidder. For detailed specifications and scope also refer section Tariff Metering system.

6.0 Data to be furnished by vendor after award of contract

6.1 <u>Drawings / Documents for Approval:</u>

a) Switchgear cubicle: outline dimensions and GA, including plan, front elevation, rear elevation, side elevation and relevant cross-sectional views.
b) Switchgear layout plan including floor opening and fixing arrangement
c) Schematic control circuit diagram
d) Single line diagram & Schematic wiring diagrams
e) Metering and protection drawing

f) Short circuit withstand calculation for busbar (Thermal & dynamic)

g) Detail wiring diagram including terminal block numbers, ferrule numbers and cable connection.

h) Relay and instrument panel GA

i) Inter panel interconnection wiring diagram

j) Busbar sizing calculation

k) Relay setting and relay co-ordination,

l) Design calculations,

m) MQAP and QAP as per CEA regulations

n) Relay, CT, PT, Meter, related all items details drawing, catalogue

o) Erection & Commissioning procedure, O& M manual

p) Foundation Plan & loading details

q) Catalogues / drawings / leaflets for all items

r) Comprehensive memory mapping of ABT meters, Numerical relays and MFM's

s) Any other drawings / documents required by the Owner during detail engineering

6.2 <u>Drawings / Documents for Information:</u>

a) Type test reports

b) Manufacturer's catalogues

c) Erection manuals

d) Any other drawings / documents required by the Owner during detail engineering

B3 – AUXILIARY TRANSFORMER

1.0 Auxiliary Transformers

The design, material, construction, manufacture, performance, inspection and testing of Auxiliary Transformers shall comply with all latest versions of standards, statutes, regulations and safety codes in the locality where the equipment is proposed to be installed.

2.0 Codes & Standards

The design, manufacture and testing of auxiliary transformers shall be carried out as per the latest applicable standards including but not limited to the following:

Codes	Description
IS:2026	Power & Distribution Transformer
IS:11171 / IEC 60076	Dry Type Transformers
IS:12063	Degree of Protection Provided by Enclosures
IEC:60905	Loading Guide for dry type transformers
IEC60296	Fluids for Electrotechnical applications – Mineral insulating oil for electrical equipment
IS:2099	Specification for Bushings for Alternating voltages above 1000V
IS 3639	Specification for Fittings and accessories for Power Transformers

IS 10028	Code of practice for selection, installation, and maintenance of transformers
IS 1180	Outdoor/Indoor Type Oil Immersed Distribution Transformers upto and including 2 500 kVA, 33 kV
IS 3347	Dimension for porcelain transformer bushings
IS 4257	Porcelain Bushings for Transformers
IS 6600	Guide for Loading of Oil Immersed Transformers
IS-2705	Specification for Current Transformers
IEC 60076	Power Transformers (All parts)
Indian Electricity Act 2003 and Indian Electricity Rules, BEE notification, CEAregulations, guidelines, CBIP Manual on Transformers	

3.0 Design Criteria - Auxiliary Transformers

3.1 20% design margin shall be considered while sizing auxiliary transformers. Also, if required, the rating shall be increased to keep the voltage drop during starting of the largest motor within 15%.

3.2 The transformer shall conform to the latest editions of national and international standards indicated above. Also, the transformer shall comply with the requirements indicated in Technical Parameters.

3.3 The core shall be constructed from high grade non-ageing cold rolled grain-oriented silicon steel laminations of high grade or better quality. The insulation of core to clamp plates shall be able to withstand a power frequency voltage of 2 kV (rms) for one (1) minute.

3.4 Transformers and accessories shall be designed to withstand the expected fault levels.

3.5 The dry type transformers shall be housed in a metal protective housing, having a degree of protection of IP-23. In case it is placed outdoor, IP for enclosure shall be minimum IP-55. Enclosure shall be of a tested quality sheet steel of minimum thickness 2mm & shall also accommodate cable terminations. The housing door shall be interlocked such that it should be possible to open the door only when transformer is off. The enclosure shall be provided with lifting lugs and other hardware for floor mounting. Suitable bidirectional skids with pre-drilled holes shall be provided integral with the enclosure or bidirectional rollers shall be provided with suitable locking arrangement.

3.6 Winding conductor shall be electrolytic grade as per standard. Windings shall be of class F insulation or better. All windings are to be uniformly insulated.

3.7 The auxiliary transformer shall be suitable for cable connection on both HV and LV sides. Suitable cable terminating arrangements shall be provided for both sides. In case of single core cable termination, cable box gland plate shall be of nonmagnetic material.

3.8 MCB / MCCB shall be provided at Primary as well as secondary sides of small sized Auxiliary transformers. Also, MCB/ MCCB shall be provided at source (IDT or inverter) for dry type low voltage aux. transformers. However, HT panel with circuit breaker and all required protections and control system shall be provided for high voltage aux. transformers in line with standards, statutory requirement and tender specification.

3.9 If required, Transformer shall be provided with suitable ventilation system to ensure the temperature rise limits under most severe condition while in service however all tests and performance shall correspond to air natural cooling.

3.10 All materials used shall be of best quality and of the class, most suitable for working-under the conditions specified and shall withstand the variations of temperature and atmospheric conditions, overloads, over-excitation, short-circuits as per specified standards, without distortion or deterioration or the setting up of undue stresses in any part, and also without affecting the strength and suitability of the various parts for the work which they have to perform.

3.11 Auxiliary transformer of XX/0.415kV, suitable KVA rating shall be provided for meeting the Inverter block auxiliary loads / sub pooling station loads (Control room building). The

rating of the auxiliary transformer shall be based on the expected auxiliary loads of the Bidder's complete system.

3.12 This transformer shall derive auxiliary power from the inverter / Inverter Transformer LV cable box / LT Panel in case of string inverter and deliver to the 415V Main switchgear. Design shall be in such a way that Aux. supply of Inverter block shall be available in case of failure of incoming source supply (Auxiliary transformer to be fed from two inverters with suitable changeover switch).

3.13 The transformers shall conform to the latest editions of national and international standards indicated in above. Also, the transformer shall comply with the requirements indicated in Technical Parameters.

3.14 Fittings which are generally required for satisfactory operation of the transformers are deemed to be included, in the scope of supply of the Bidder.

3.15 The Cable glands shall be weatherproof Double compression type made of heavy duty brass machine finished and nickel chrome plated of suitable size. Thickness of plating shall not be less than 10 microns. Cable glands shall conform to BS:6121.

3.16 All Cable lugs for power cables shall be Heavy duty long barrel tinned copper ring type / bimetallic solderless crimping type of suitable size. Cable lugs for control cables shall be tinned copper ring type with insulated sleeve.

3.17 All control terminals shall be of Stud type (screw drive operated) and control wiring shall be terminated with tinned copper ring type lugs with insulated sleeve. Disconnecting stud type terminal shall be provided for CT circuits. 20% spare terminal shall be provided of each type. Printed single tube ferrules marked to correspond with panel wiring diagram shall be fitted at both ends of each wire. The wire identification marking shall be in accordance with IS:375. Red Ferrules should be provided on trip circuit wiring.

3.18 All wiring shall be carried out with wires of 1.1 KV grade, stranded copper conductors. The insulation shall be halogen free and flame retardant. Power circuits shall be wired with stranded copper conductors of adequate sizes to suit the rated current, the minimum size shall be 2.5 sq. mm. Unless otherwise specified, control alarm and indication circuits shall be wired with stranded, tinned copper conductors of sizes not smaller than 1.5 sq. mm. Space heater circuits, CT and VT circuits shall be wired with stranded copper conductor of size not smaller than 2.5 sq. mm.

3.19 All Auxiliary transformers neutral earthing shall be provided with dedicated earthing pits, earth flat etc.

3.20 All metallic hardware such as nuts, bolts, screws, washers etc. shall be of Hot dip galvanized as per IS standard.

3.21 Painting of all metallic enclosed electrical panels / JBs / MKs /DBs etc shall be of paint shade RAL -7035 and Shall be as per ISO 12944-5.

Unless noted otherwise, all steel structures exposed to environment would be painted to meet the requirements of corrosion category or would be galvanized to minimum 110microns

3.22 Design shall be as per Seismic Zone as per IS 1893

4.0 Technical Parameters

4.1 Dry Type Transformer

Sl. No.	Description	Unit	Technical Requirements
1.	Application	-	PV Block / Inverter station Auxiliary Loads
2.	Type	-	Indoor 2 winding, Dry Type Epoxy cast resin/resin encapsulated
3.	Power Rating	kVA	** TBD during DE
4.	Quantity	Nos.	As per requirement in multiples of XXkVA rating
5.	Voltage rating		
	a) Primary	V	XXV, 3 ph, 3 wire (suitable for inverter output voltage)
	b) Secondary	V	415V, 3 ph, 4 wire
6.	Impedance	%	As per relevant Standard
7.	Rated Frequency	Hz.	50
8.	Vector Group	-	As per system requirement
9.	Full load loss @ 75ºC	kW	As per relevant Standard
10.	System Earthing	-	Primary side as per system requirement and Solid Earthing on LV side
11.	System Fault level	kA	As per system requirement during detailed engineering
12.	Tapping:		
	a) Tap range	%	-5% to +5%
	b) Tapping step	%	2.5%

Sl. No.	Description	Unit	Technical Requirements	
13.	Type of voltage variation (CFVV/VFVV/CBVV)	-	CFVV	
14.	Over fluxing capability	-	110% continuous	
15.	Type of Cooling	-	Air natural	
16.	Winding insulation type	-	Uniform	
17.	Power frequency withstand voltage of winding a) HV winding b) LV winding	kV (rms)	* 3	
18.	Insulation class	-	F or better	
19.	Temp. rise above 50 °C (a) In winding by resistance	°C	70	
20.	Conductor material	-	Electrolytic Grade Copper	
21.	Paint shade	-	RAL 7035 for indoor	
22.	Ref. Standards	-	IS:2026, IS:1180 & IS:11171	
23.	Terminal arrangement	-	PRIMARY	SECONDARY
			Required	Required
24.	Mounting type		to be decided during detailed engineering as per Owner's requirement	
25.	Min. clearance in air (a) Phase-Phase (b) Phase-Earth	mm mm	25 20	25 20
26.	Creepage distance	mm/kV	31	31

4.2 Oil filled Transformer

Sl. No.	Description	Unit	Data
1.	Service		Outdoor, sub pooling station Auxiliary Loads
2.	Type		Oil Filled type, two winding
3.	No. of Phase		Three
4.	Rating	kVA	As per System requirement
5.	No. of windings		Two
6.	Conductor material		Electrolytic Grade Copper
7.	Nominal system voltage (HV / LV)	kV	xx/0.415 , 50 Hz
8.	Vector group		Dyn11
9.	Type of cooling		ONAN
10.	Impulse withstand level		
a)	HV side	kV	As per System requirement
11.	One minute Power frequency withstand voltage		
a)	HV side	kV	As per System requirement
b)	LV side	kV	3
12.	Connections		
a)	HV side		Delta
b)	LV side		Star
13.	Neutral Earthing		
a)	HV side		
b)	LV side		Solidly grounded
14.	Terminal arrangement		
a)	HV side		Cable Box
b)	LV side		Cable Box
a)	LV Neutral side		Ground conductor
15.	Bushings		
a)	Bushings Creepage distance		31 mm /kV
16.	Tap Changer		
a)	Type		OCTC
b)	Tap provided on		HV side
c)	Range of taps	%	+5% to –5% in steps of 2.5%
17.	Short circuit withstand duration	Sec	2
18.	LV neutral bushing CT		As per requirement
19.	Energy Efficiency Class		Level 3
20.	Losses		
	Copper Loss		As per IS
	Iron Loss		As per IS

Sl. No.	Description	Unit	Data
21.	Impedance		As required to limit fault level below 50kA
22.	Ref. Standards	-	IS:2026, IS:1180 & IS:11171
23.	Paint	-	RAL 7035 for indoor / outdoor and C4 / C5-M specifications

* Data to be furnished by Bidder

5.0 TESTS

The routine tests shall be carried out as per applicable standards on all the transformers.

The following tests shall be performed compulsory as part of routine tests along with other tests as per manufacturer recommendation and as per 2026 and or IEC-60076 and or CBIP Manual and or CEA regulations shall also be carried out:

a) Ratio, polarity, phase sequence and vector group.
b) Resistance of windings at all tap position
c) Magnetic balance test and measurement of magnetizing current
d) Insulation resistance.
e) Measurement of Load loss and impedance
f) Dimensional check.
g) Dielectric Tests.
h) Calculation of Efficiency & Regulation
i) Functional and continuity checking for marshalling box and auxiliary relays
j) Oil leakage test on completely assembled transformer along with radiators for oil filled transformers
k)

Following Type test reports shall be furnished along with the offer:

a) Temperature rise test for determining the maximum temperature rise after continuous full load run.
b) Dielectric tests (As per IEC 60076).
c) Vacuum and pressure tests on Transformer tank, conservator, cooler units, pipe and other fittings.
d) Degree of protection for Marshalling box
e) Testing of PRV / PRD
f) Noise-level measurement.
g) Any other tests required by Owner during detail engineering

6.0 Data to be furnished by vendor after award of contract

Drawing / Document for Approval and information:

a) Detailed technical data sheet
b) General outline drawings showing plan, front elevation, and side elevation, with all fittings and accessories, earthing terminals, foundation/floor fixing details, and weights of the following:
    a) Transformer
    b) Marshalling box
    c) Cable boxes & disconnecting links
    d) Terminals details
c) Rating and diagram plates, valve schedule etc. drawing
d) Any other required documents

B4 – LT AUXILIARY SWITCHGEAR

1.0 LT Switchboards

The design, material, construction, manufacture, inspection, testing and performance of 415V LT switchboards shall comply with all currently applicable statutes, regulations and safety codes in the locality where the equipment will be installed. The equipment shall also conform to the latest applicable standards mentioned in Codes & Standards.

2.0 Codes & Standards

Codes	Description
UL 746C	UV Resistant
IS-2147/ IEC 60529	Degree of protection provided by enclosures (IP Code)
IEC 61439	Standard for low voltage switchgear and control gear assembly
IEC 60352	Crimped connections – general requirement, test methods and practical guide
IEC 61326-1	Electrical equipment for measurement
UL 508	Standard for Industrial Control equipment
IEC 62208	Empty enclosure for low Voltage switchgear and control gear assemblies
IEC 60269-6	Low Voltage Power Fuses
IEC 62262	Level of Protection against Mechanical Impact (IK Rating)
IEC 60974	Low-voltage switchgear and control

3.0 Design Criteria and general requirements

3.1 Incomer feeder of 415V switchboard shall be provided with suitable MCCB along with CT & MFM of accuracy class 0.5s or better for measurement of plant auxiliary consumption. MFM shall have suitable communication port for integration with SCADA system. All outgoing Feeders shall be Provided with suitable MCB/MCCB/MPCB only.

3.2 MCCB for incomer shall be provided with auxiliary contacts to provide ON, OFF, TRIP feedbacks to SCADA & shunt trip. MCCB/MPCB/MCB, contactor and overload relay shall meet type 2 co-ordination as per applicable standard. All outgoing feeder shall be provided with suitable rated MCCB/MPCB/MCB, contactor and overload relay only.

3.3 The 415V LT switchboard shall be provided with thermostatically controlled SS304 / Aluminium space heater, cubicle lamp and utility power socket.

3.4 The 415V LT switchboard shall be suitable for floor mounting complete with gland plates, glands, body earthing terminals etc. single/double front and compartmentalised design. 415V LT switchboard shall be sheet steel enclosed and shall be dust, weather and vermin proof providing with degree of ingress protection IP: 42 as per IS/IEC 60947 for indoor application and IP:55 or better for outdoor application. All cut-outs shall be provided with EPDM / Neoprene gaskets. However, the control / relay compartments if provided shall have degree of protection not less than IP 5X.

3.5 The LT switchboards at sub pooling stations shall be equipped with two incomers (2X100%), and Bus coupler with auto change over facility (MCCB with Contactor/ MPCB/MCB plus Contactor), auto manual selection, required interlocks etc., Detail scheme shall be finalized during detail engineering as per Owner's requirement.

3.6 All switchboard frames and load bearing members shall be fabricated using suitable mild steel structural sections or pressed and shaped cold-rolled sheet steel of thickness 2.0mm. Frames shall be enclosed in cold-rolled sheet steel of thickness 1.6 mm. Doors and covers shall also be of cold rolled sheet steel of thickness 1.6 mm. Stiffeners shall be provided wherever necessary. The gland plate thickness shall be 2.0 mm for hot / cold rolled sheet steel and 3.0 mm for non-magnetic material.

Minimum clear distances in mm shall be as below mention table.

	Single Front	Double Front
Front	1000	1000
Rear	400	1000
Right	400	400
Left	400	400

3.7 All sheet steel work shall be degreased, pickled, phosphated and then applied with two coats of zinc chromate primer and two coats of finishing synthetic epoxy paint, both inside and outside the paint shall be of colour shade RAL 7035 as per ISO 12944..

3.8 Two earthing terminals with SS304 grade nut, bolt, spring and plan washers of suitable size shall be provided on both sides of the switchboard.

3.9 All doors, removable covers and plates shall be provided with neoprene gaskets. All accessible live connections shall be shrouded, and it shall be possible to change individual MCCBs/MCBs/MPCBs without danger of contact with live metal.

3.10 All live parts shall be provided with phase to phase and phase to earth clearances in air of at least 25 mm and 20 mm respectively. However, for busbars the clearances specified above should be maintained even when the busbars are sleeved or insulated. All connections from the busbars up to switch / MCB /MCCB shall be fully insulated and securely bolted to minimize the risk of phase to phase and phase to earth short circuits. All busbars and jumper connections shall be of high conductivity aluminium alloy / copper of adequate size and sleeved.

3.11 All switchboards shall be provided with three phase and neutral busbars. Entire busbar system shall be insulated with colour coated PVC sleeves. Busbar sleeves shall be compliant to UL224 (Extruded insulating tubing), CE/UL certified, having fire retardant properties and working temperature of 105°C.

3.12 The cross-section of the busbars shall be uniform throughout the length of switchboard section and shall be adequately supported and braced to withstand the stresses due to the specified short circuit currents. Neutral busbar short circuit strength shall be same as main busbars.

3.13 The Cable glands shall be weatherproof Double compression type made of heavy-duty brass machine finished and nickel chrome plated of suitable size. Thickness of plating shall not be less than 10 microns. Cable glands shall conform to BS:6121.

3.14 All Cable lugs for power cables shall be Heavy duty long barrel tinned copper ring type / bimetallic solderless crimping type of suitable size. Cable lugs for control cables shall be tinned copper ring type with insulated sleeve.

3.15 All control terminals shall be of Stud type (screw drive operated) and control wiring shall be terminated with tinned copper ring type lugs with insulated sleeve. Disconnecting stud type terminal shall be provided for CT circuits. 20% spare terminal shall be provided of each type. Printed single tube ferrules marked to correspond with panel wiring diagram shall be fitted at both ends of each wire. The wire identification marking shall be in accordance with IS:375. Red Ferrules should be provided on trip circuit wiring.

3.16 All wiring shall be carried out with wires of 1.1 KV grade, stranded copper conductors. The insulation shall be halogen free and flame retardant. Power circuits shall be wired with stranded copper conductors of adequate sizes to suit the rated current, the minimum size shall be 2.5 sq. mm. Unless otherwise specified, control alarm and indication circuits shall be wired with stranded, tinned copper conductors of sizes not smaller than 1.5 sq. mm. Space heater circuits, CT and VT circuits shall be wired with stranded copper conductor of size not smaller than 2.5 sq. mm.

3.17 All metallic hardware such as nuts, bolts, screws, washers etc. shall be of Hot dip galvanized as per IS standard.

3.18 All cable entries shall be located at bottom side of the panels / Junction boxes / MKs /DBs etc to prevent any possibility of water ingress into the box. All panels/Junction boxes/MKs /DBs etc shall be min. 450mm above finished floor level for cable connections

3.19 Outdoor panels/ JBs / MKs / DBs / cubicles etc. shall be completely weather-proof with a sloping extended canopy for protection against rain and providing a degree of protection of IP 55.

3.20 Busbars shall be of insulated. Busbars shall have adequate cross-section to carry the required continuous currents such that the operating temperature of the busbars does not exceed permissible temperature as per Indian standards / specification.

3.21 All busbars shall be adequately supported by non-hygroscopic, non-combustible, track resistant and high strength sheet molded compound or equivalent type polyester fiberglass molded insulator. Separate supports shall be provided for each phase and neutral busbar. If a common support is provided, anti-tracking barriers shall be provided between the supports. Insulator and barriers of inflammable material such as Hylam shall not be accepted. The busbar insulators shall be supported on the main structure

3.22 20% spares feeders shall be considered for each type & rating. Spare modules shall be completely wired up.

3.23 All busbar joints shall be provided with high tensile steel bolts, belleville / spring washers and nuts, so as to ensure good contacts at the joints. Non-silver plated busbar joints shall be thoroughly cleaned at the jointed locations and suitable contact grease shall be applied just before making a joint. The cable entry shall be from bottom side of the switchboard and maximum operating height of the switchboard shall be limited to 1800mm

3.24 All equipment and components shall be neatly arranged and shall be easily accessible for operation and maintenance. Replacement /Maintenance of individual equipment/component shall be possible without switching off or isolating the other equipment / components.

3.25 All Switchgears panels, Distribution Boards, JBs, Fuse boards, all feeders, local push-button stations etc. shall be provided with prominent, engraved identification plates All name plates shall be of non-rusting metal or 3-ply Lamicoid, with white engraved lettering on black background. Inscription & lettering sizes shall be subject to Owner's approval

3.26 Each Inverter station shall consist of one 415V, 3 phase 4 wire LT Switchboard or Power Distribution Board (PDB). Each PDB shall be with dry type transformers of sufficient rating as per system requirement. Input to PDB transformers shall be from secondary terminal box of Inverter Duty Transformer or AC Incomer of Inverter through MCBs / MCCBs. PDB shall be comprise of transformers Incoming & outgoing MCBs/MCCBs, 415V outgoing

MCBs/contactors, Overload relays/starter module and ventilation facility. PDB shall be of floor mounted, free standing, compartmentalised type with adequate space for cable entry at Inverter Station. For Indoor type PDB, degree of protection class shall be minimum IP42 and colour finish shade of PDB enclosure for interior shall be glossy white & for exterior it shall be, RAL 7035 of IS: 5 painting standard specifications for outdoor / indoor respectively. Design of PDB shall be such that in case of non-availability of incomer supply from that Inverter, Aux. supply to other inverter shall be available (Auxiliary transformer to be fed from two inverters with suitable changeover switch).

3.27 Cable termination arrangement for power cables shall be suitable for heavy duty, 1.1 kV grade, stranded aluminium conductor, PVC/ XLPE insulated, armoured / unarmoured and PVC sheathed cables. All necessary cable terminating accessories such as supporting clamps and brackets, hardware etc., shall be provided by the Bidder, to suit the final cable sizes.

3.28 Painting of all metallic enclosed electrical panels including, LT Panels, JB, DBs, MK, enclosures, etc. shall be of Shade RAL -7035 and Shall be as per ISO 12944-5.

Unless noted otherwise**,** all steel structures exposed to environment would be painted to meet the requirements of corrosion category or would be galvanized to minimum 110microns

3.29 Design shall be as per Seismic Zone as per IS 1893.

3.30 Moulded Case Circuit Breakers (MCCB) / Motor Protection Circuit Breakers (MPCB)

3.30.1 Moulded case circuit breakers (MCCBs) shall be provided when called for as specified. The MCCBs shall conform to the latest applicable standards.

3.30.2 MCCBs in AC circuits shall be of 3 pole type for 3 wire system and 4 pole type for all 3-Ph and neutral system. The ON, OFF and TRIP positions of the MCCB shall be clearly indicated and visible to the operator. Operating handle for operating MCCBs from door of board shall be provided.

3.30.3 MCCB shall be fixed type module, air break type, having trip free mechanism with quick make and quick break type contacts. MCCB of identical ratings shall be physically and electrically interchangeable. MCCB shall be provided with 1 NO and 1NC auxiliary contacts wired up to TB.

3.30.4 The instantaneous short circuit release shall be so chosen by the Supplier as to operate at a current in excess of the peak motor inrush current and a range of settings shall be provided for the Owner’s selection.

3.30.5 MCCB / MPCB terminals shall be shrouded and designed to receive cable lugs for cable sizes relevant to circuit ratings. Extended cable terminal arrangement for higher size cable may also be offered.

3.30.6 MCCB / MPCB shall have inbuilt front adjustable releases (overload & short circuit) and shall have adjustable earth fault protection unit also. The protection settings shall have suitable range to achieve the required time & current settings. LED indications shall also be provided for faults, MCCB status (on/off etc)

3.30.7 The MPCB's shall be in generally similar to that of MCCB's in all the features mentioned above.

3.30.8 MCCBs/MPCBs shall be provided with overload thermal release setting range of 50% to 100% of rated current and adjustable short circuit magnetic release of 5 to 10 times rated current.

3.30.9 The DC circuits shall be provided with DC MCCB / MCBs.

3.30.10 MCCBs/MPCBs shall have following accessories and features:

i) Shunt trip release
ii) Auxiliary contact set of 1 NO + 1 NC
iii) Fault signalling contact set of 1 NO + 1 NC
iv) Insulation shields to isolate the connection between each pole
v) Finger protection plate to prevent accidental contact
vi) The compartment door shall be interlocked with handle of MCCB/MPCB.
vii) OEM supplied Interphase Barriers, shrouds, spreader terminal etc.

3.31 Miniature Circuit Breaker (MCB):

Miniature circuit breaker (MCB) shall conform to IEC 898 and IS 8828. MCB shall be provided with thermo-magnetic type release for over current and short circuit protection. The MCB shall have breaking capacity not less than 10kA. MCB's are to be mounted on DIN channel only.

The operating handle shall have a clear trip indication.

3.32 Contactor, overload relay, switches, meter & instruments transformers, push button, indicating lamp etc. shall be in line with standard industrial practices and as per IS /IEC standard only and make and type shall be finalised as per system requirement during detail engineering.

4.0 Technical Parameters

Sl. No.	Description	Unit	Requirements
1.	Type	-	Floor mounted, Free standing, single/double front, compartmentalised.

Sl. No.	Description	Unit	Requirements
2.	Fully draw out / Semi-draw out / Fixed	-	Fixed
3.	Installation	-	Indoor / outdoor
4.	System Parameters	-	
	Main system	-	3ph, 4 wire
	Rated operational voltage	V	415V
	Impulse withstand voltage	V	As per IEC
	Dry frequency withstand voltage	V	As per IEC
	Earthing system	-	Solid earthing
5.	Sheet steel thickness	mm	2.0
6.	Paint shade	-	RAL 7035 as per ISO 12944
7.	Busbar continuous rating	A	As per system requirement
8.	Short time rating, (1-sec)	kA	As per system requirement
9.	Incomer & Outgoing terminals		As per system requirements
10.	Clearance in air a) Between poles b) Between pole and earth	 mm mm	 25 20
11.	Degree of protection provided by the enclosure	-	IP42 for indoor / IP 55 or Better for outdoor
12.	Earth busbar size	sq.mm	As per system requirement
13.	LED indication lamps provided for incoming feeder	-	Required
14.	Space heater, illumination & 5A, 5 pin sockets in ACDB	-	Required
15.	Illumination with LED lamp provided	-	Required
16.	5A, 5 pin sockets provided	-	Required
17.	Surge protection provided	-	Required
18.	Shunt trip for incomer MCCB	-	Required
19.	Multifunction meter with CTs (Accuracy class 0.5s or better)	-	Required
20.	**MCCB**		
	a) Voltage, frequency & no. of phases	-	415 V, 50 Hz & 3 PH
	b) Rated operating duty	-	As per IS

Sl. No.	Description	Unit	Requirements
	c) Rated ultimate breaking capacity (Icu) at 415 V, 0.25 PF	kA (rms)	As per system requirement
	d) Rated service breaking capacity (Ics) at 415 V, 0.25 PF	kA (rms)	As per system requirement
	e) Rated making current	kA (Peak)	As per system requirement
21.	Releases required		
	a) Over-load inverse time, short circuit and earth fault	Yes/No	Yes

5.0 Tests

5.1 Routine tests

All routine tests shall be carried out as per applicable standards but not limited to following:

a) IR test before and after HV test

b) HV test

c) Mechanical operations / interlocks test

d) Functional tests on auxiliaries, Alarms & indications

5.2 Type tests

Type test reports for the switchboard panel of similar rating for the following tests shall be submitted along with the Bid:

a) Temperature rise

b) Degree of Protection

c) Short Circuit

d) Salt spray test for a minimum duration of 500 hrs. (If applicable)

6.0 Data to be furnished by vendor after award of contract

6.1 Drawings / Documents for Approval:

a) Engineering Schedule indicating list of drawings, documents, data, test certificates, manuals, etc. to be submitted by the Bidder together with dates of submissions and category of approval i.e. for approval or for reference.

b) GA & Cross-sectional drawings.

c) Guaranteed Technical Particulars.

d) Single line diagram.

e) Bill of materials indicated with make, model, type, technical specification, etc. for all equipment / accessories.

f) Detailed cross-sectional drawings showing all relevant internal details of all equipment / accessories.

g) Drawing showing terminal connection.

h) Detailed quality assurance plan.

i) Final test procedures (at shop as well as at site) and Test Set-Up.

j) Design calculations (wherever necessary) to prove the adequacy of the equipment offered.

k) Any other drawings / documents considered necessary.

l) The manufacturer is to furnish a detailed QAP and MQAP as per standard / CEA regulations/guidance indicating the practice and procedure along with relevant supporting documents.

6.2 **Drawings / Documents for Information:**

a) Type test certificates valid for as per regulation for all equipment / accessories being supplied under this contract.

b) Instruction Manuals.

B5 – UPS AND UPS DISTRIBUTION BOARD

1.0 UPS & UPS Distribution Board

The design, material, construction, manufacture, performance, inspection, and testing of UPS shall comply with all latest versions of standards, statutes, regulations and safety codes in the locality where the equipment is proposed to be installed.

2.0 Codes & Standards

Codes	Description
IS 16242/ IEC 62040-3	Uninterruptible Power Systems (UPS)
IEC 60529	Degrees of protection provide by enclosures (IP Code)
IEC 60417	Graphical symbols for use on equipment
IEC 61439	Standard for low voltage switchgear and control gear assembly
IEC 60755	General requirements for residual current operated protective devices
IEC 61000-2-2	Electromagnetic compatibility (EMC)
IEC 61326-1	Electrical equipment for measurement
UL 508	Standard for Industrial Control equipment
IEC 60269-6	Low Voltage Power Fuses
IEEE 1184	Guide for Batteries for Uninterruptible Power Supply Systems

3.0 Design Criteria and Technical requirements

3.1 The UPS systems shall be designed to meet the auxiliary power requirements in respective Inverter stations, Sub-pooling stations/Control Room Building and PV Plant SCADA.

3.2 For each SCADA control room, UPS shall have 2x 100% configuration.

3.3 For each Inverter stations and each Sub pooling stations, UPS systems shall have 1 x 100% configuration.

3.4 Deleted.

3.5 During the sizing of UPS, following loads shall be considered (but not limited to).

a) UPS for Inverter Station

i. Data Logger
ii. Fire protection and alarm system
iii. CCTV
iv. Emergency lighting
v. PLC
vi. Inverter auxiliary supply (if applicable)
vii. WMS
viii. Inverter transformer
ix. ICOG
x. Module washing system (if applicable)
xi. Single Axis Tracker controller (Bidder to provide backup power from the UPS of inverter room as required)

b) UPS for Sub pooling station

i. Data Logger
ii. Fire protection and alarm system
iii. CCTV
iv. Emergency lighting
v. PLC
vi. Inverter auxiliary supply (if applicable)
vii. WMS (if applicable)
viii. Inverter transformer
ix. ICOG (if applicable) & Sub pooling panel loads
x. Modems for ABT metering systems
xi. Module washing system (if applicable)
xii. Single Axis Tracker controller (Bidder to provide backup power from the UPS of inverter room as required) (if applicable)

c) UPS for SCADA and monitoring station

i. Data Logger / SCADA

ii. Fire protection and alarm system
iii. CCTV
iv. Emergency lighting
v. PLC
vi. PPC
vii. WMS (if applicable)

d) Any other load as decided during detailed engineering

3.6 The charger shall be fed from 415V AC, 50 HZ, 3 phase, 3 wire system. Charger design shall ensure that there is no component failure due to fluctuations of input supply or loss of supply and restoration.

3.7 UPS for Inverter station / blocks shall have battery backup as per latest CEA technical standard respectively or 4 hours of battery backup whichever is higher .

3.8

3.9 Design temperature shall be 50 degree centigrade or as per CEA guidelines / working committee report.

3.10 UPS shall be sized considering 25% margin on full load requirement. Other criteria to be considered for UPS and battery sizing are

a) UPS load power factor shall be taken as 0.8 lagging.

b) UPS efficiency shall be taken as 80%.

c) UPS and charger design margin shall be taken 10% at 50 deg C.

3.11 IEEE-485 standard shall be followed for sizing calculation of Lead Acid Batteries and IEEE-1115 standard shall be followed for sizing calculation of Nickel- Cadmium batteries (if applicable).

3.12 For Battery sizing calculation, lowest electrolyte temperature shall be taken as 5 deg ºC more than the minimum ambient temperature or 15 deg ºC whichever is lower, with Temperature correction factors as per relevant standards.

3.13 Batteries aging factor shall be taken as 1.25 and design margin factor shall be taken as 1.10.

3.14 The UPS system shall include 230V AC distribution board with necessary MCBs / MCCBs. The UPS system shall be incorporated with complete circuit protection against all types of abnormal conditions which the system is likely to encounter while in service. All components, sub-assemblies & complete system, regulator, transformer, and the complete UPS, ACDB shall be subject to routine tests as per relevant standards. The UPS system offered shall be suitable for normal operation,

emergency operation with required protections for IGBT, automatic synchronisation etc. Necessary contacts required for remote alarm in SCADA shall be provided.

3.15 The UPS system shall be capable of operating without D.C battery in circuit under all conditions of load and the performance of various components of UPS like inverter, charger, static switch etc. shall be guaranteed without the battery in circuit.

3.16 Control circuitry of the rectifier shall be designed in such a way that the failure of any part of the control circuitry shall not result in unsafe mode of operation of UPS and associated equipment.

3.17 The conversion of DC to AC shall be carried out by IGBT based PWM DSP control.

3.18 The batteries provided for the UPS systems shall be of Lead-acid Tubular battery. For detail specification of Battery, refer the 110V Battery and Battery charger specification.

3.19 Manual bypass switch shall be provided for isolating the UPS during maintenance.

3.20 The static switch shall be provided to perform the function of transferring UPS loads automatically in case of failure of Inverter to standby AC source. The transfer time shall be ¼ cycle maximum in synchronous mode.

3.21 The Vendor shall clearly bring out the earthing philosophy to be adopted for the UPS electronics, protective earthing (PE) and neutral earthing. The requirement of separate clean earth independent of the plant electrical system earth shall be clearly brought out. All metallic non-current carrying parts of the Panel shall be bonded together and connected to the earth bus made of GI/Cu.

3.22 Indications & Annunciation

The UPS system shall be provided with necessary meters, mimic diagram, local indication / alarm conditions. High resolution digital display unit shall be provided for continuous monitoring of the UPS operation. The control system shall operate on Windows or equivalent platform. The following operating conditions shall be annunciated.

Alarm Indication:

a) System fault
b) Rectifier charger failure
c) Inverter failure/ faulty
d) Battery under voltage

e) End of Battery Discharge
f) UPS over temperature
g) Overload
h) Static transfer to stand-by
i) Transfer inhibited
j) Overload shutdown
k) Emergency shutdown
l) Battery circuit breaker / switch open
m) AC Main failure
n) AC stand-by source mains failure
o) AC stand-by frequency out of range
p) Manual bypass ON
q) Fan failure
r) Asynchronous condition
s) Control power failure
t) Any other alarm if required during detailed engineering

Status Indication on Mimic:

a) Mains on
b) Rectifier on
c) Battery on load
d) Inverter on
e) AC Stand-by source on
f) Inverter on –load
g) Manual by-pass on
h) Load on static bypass.

Display of measurements:

a) Inverter output phase-to-phase voltages
b) Inverter output currents
c) Inverter output frequency
d) Voltage across battery terminals
e) Rectifier input phase-to-phase voltages
f) Rectifier input currents
g) Active and apparent power
h) Power factor
i) DC voltage & Current
j) Any other display if required during detailed engineering

3.23 Remote Interface:

Bidder shall consider the UPS integration with remote SCADA for monitoring of all annunciations, alarm, and metering parameters. UPS shall have RS485 port with Modbus compatibility to communicate to remote system. The Modbus card shall be either an isolated port or terminal block. The terminal block shall allow conventional twisted pair cabling for daisy chaining.

Technical requirements of UPS DB:

3.23 The UPS Distribution board is to be provided to feed the loads. The UPS DB shall be provided with single input - Multi output feeders and the same shall be decided as per system requirement.

3.24 The AC Distribution board shall be made of CRCA material with full dust, water & vermin proof arrangement.

3.25 UPS Distribution board shall be provided with High Quality MCCB, RCCB, MCB, Aluminium busbar and cables of suitable ratings.

3.26 The UPS Distribution board shall have suitable arrangement for the following:

a) Incoming from ACDB shall be connected to bus bar.
b) All MCB o/p shall be connected at Common Al Busbar.
c) Arrangement for disconnection of each of the inputs.
d) Suitable space for workability and natural cooling.
e) Rating of all components of UPS Distribution board shall be suitable with adequate factor of safety.
f) Maintenance free earthing shall be done as per the relevant standards.
g) Proper ventilation to be provided and designed by considering 50-degree ambient temperature.
h) Busbar should be shrouded / sleeved to prevent accidental contact.
i) Suitable markings shall be provided on the bus bar for easy identification, and cable ferrules must be fitted at the cable termination points for identification. Cable ferrules should be sunlight / UV resistive.
j) Fire retardancy shall follow UL94 V0 standard.
k) All live parts which become accessible on opening any hinged door shall be shrouded.

4.0 Technical Parameters

Sl. No.	Description	Unit	Technical Requirements
1.0	**General requirements**		
1.1	Type	-	Static Type
1.2	Power Rating at Load PF 0.8 Lagging	-	To be decided based on Load
1.3	Application	-	SCADA, Inverter station and sub pooling station
1.4	Installation /Paint shade	-	Indoor / Shade RAL 7035 as per IS 12944
1.5	Input supply	V	415V, 1 Ø AC
1.6	Output Voltage	V	240V, 1 Ø AC
1.7	Frequency	Hz	50
1.8	Current rating	-	By Bidder
1.9	AC voltage accuracy (steady state) over entire load, load PF & DC voltage range	-	1%
2.0	**Technical requirements**		
2.1	Range of adjustment of AC output	-	95 to 105%
2.2	Rectifier	-	IGBT Based PWM Technology
2.3	Ripple content in DC without Battery	-	<1%
2.4	Ripple content in DC with Battery	-	<1%
2.5	Inverter	-	IGBT Based PWM Technology
2.6	AC harmonic content	-	5% total, 3% Max for any individual
2.7	Design Ref. Ambient	ºC	50 or CEA guidelines / working committee report
2.8	Storage Temperature	ºC	-15 to 60
2.9	Overload capacity	-	120% for 10 min 150% for 1 min
2.10	Battery type	-	1X100%, Lead Acid Tubular
2.11	Battery Backup time	Hrs	As per latest CEA technical standard or 4 hours of battery backup whichever is higher

Sl. No.	Description	Unit	Technical Requirements
2.12	Static Transfer Switch		Required
2.13	Servo Controlled Voltage stabilizer		Required
2.14	Type of UPSDB		Wall mounting
2.15	Seismic Acceleration		0.36g
2.16	Ingress Protection		IP 42 for indoor / IP 55 or better for outdoor

5.0 TESTS

5.1 Routine tests on the complete UPS system shall be carried out as per relevant standards for each major sub-system in the UPS, viz., Rectifier, Inverters, batteries, stand-by supply etc.

5.2 Type and routine tests certificates for all components used in the UPS system shall be furnished. Tests for components shall be as per relevant standards.

5.3 BIDDER shall furnish the quality assurance plan for the equipment offered. The quality assurance plan shall include bought out components and assemblies used in the UPS system.

5.4 System tests shall be performed on the completely assembled UPS system. System tests shall include frequency regulations, Voltage regulation, current limiting feature and harmonic content tests in addition to the tests to prove the functional requirements such as synchronisation with range of adjustments, transfer of static switches for conditions of loss of square wave, overload and under voltage conditions.

5.5 Endurance test on static switches shall be performed for not less than 10 transfer / retransfer cycles at full load.

5.6 Heat run test shall be carried out on each branch of UPS including bypass (if provided) and on overall UPS system at rated load under relevant ambient conditions for a period of 8 hours. This test shall be conducted as a routine test on all UPS being supplied.

6.0 Data to be furnished by vendor after award of contract

6.1 **Drawings / Documents for Approval:**

a) Detailed schematic diagram of the UPS system showing all components

b) Bill of Material indicating rating & type designation of components.

c) General Arrangement drawing showing overall dimensions, foundation fixing details, location of various devices, mimic diagram, list of protections, annunciation and meters, cable openings, etc.

d) UPS and Battery Sizing Calculation
e) Battery room Layout
f) Battery Drawings/documents as specified in battery Specification
g) Single Line Diagram
h) Data sheet
i) Factory acceptance test
j) Manufacturing quality plan
k) Any other drawing required during detailed engineering

6.2 **Drawings / Documents for information:**

a) Type test reports on components chosen.
b) Quality assurance plan.
c) Instruction manuals.

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B6 – 110V BATTERY AND BATTERY CHARGER

1.0 110V Battery and Battery Charger

110V Battery Charger with 110V **Lead-acid Tubular (OPzS) battery** complete with battery racks, inter-cell and inter-tier connectors and all other accessories shall be provided as per system requirement in all 33kV sub-pooling stations. The design and engineering shall as per latest Indian standards or IEC standards.

For each sub pooling substation 100% redundant DC system shall be provided. However for inverter stations DC system to be provided as per project requirement.

Each set shall consist of the following:

a) set of 110V Battery

b) 110V Float cum Boost Charger

c) DC Distribution Board (Compartmentalized, integral DCDB with charger is not acceptable)

d) DC Cables for connecting battery to charger and DCDB

e) Battery rack with fixing arrangements in line with specification requirement

f) Inter cell, Interbank and Terminal connectors in line with specification requirement

2.0 Codes & Standards

Codes	Description
IEC: 60896-2	General requirement and method of tests for Valve regulated battery
IS: 1069	Water for Storage Battery
IS: 266	Sulphuric Acid
IS: 6071	Synthetic separator for Lead Acid Batteries
IEEE: 485	Recommended practice for sizing Lead acid batteries for stationary applications
UL: 924	Containers & Vent Plugs

Codes	Description
UL: 1778	Battery Enclosures
IS: 1146	Rubber and plastic containers for lead acid storage battery
IEC 61439	Switchgear and control-gear for voltages upto and including 1000V A.C. and 1200V D.C
IEC 60529	Degree of protection provided by enclosures (IP Code)
IS:7098 (Part -I)	Cross linked polyethylene insulated PVC sheathed cables for working voltages up to and including 1100V

3.0 Design Criteria

3.1 Lead-acid Tubular (OPzS) battery

3.1.1 Batteries shall be SAN container Lead-acid tubular (OPzS) type. (Type II, High discharge performance cell as per IS 1651)

3.1.2 Battery shall be sized considering ten (10) hour load cycle. Battery sizing and cell selection shall be based on IEEE. While estimating battery capacities the following shall be considered:

a) Maximum ambient temperatures & minimum site ambient temperatures

b) 10% design margin

c) An ageing factor of 1.25

d) 10% to 15% Future Load

3.1.3 The standard temperature used for stating cell capacity is 27deg C at a 10-hour discharge rate. The nominal voltage per cell shall be 2.0V. End voltage of cell shall be not less than 1.85V.

3.1.4 Battery racks / stands shall be constructed from best quality FRP. The racks shall be rigid, mechanically strong, free standing type and free from warp and twist. The completed racks shall be suitable for being bolted end to end to form continuous row. Insulators shall be provided below the legs of the stands.

3.1.5 Batteries shall preferably be located in the single tier arrangement. However, batteries having a complete cell weight of lower than 50 Kg could be located in the double tier arrangement.

3.1.6 The electrolyte shall be prepared from battery grade sulphuric acid and distilled water.

3.1.7 Battery containers shall be made of transparent styrene acrylo nitrile (SAN) polymer. Containers shall be robust, heat resistance, fire retardant, leak proof, non-absorbent, acid/alkaline resistant, non-bulging type and free from flaws such as wrinkles, cracks, blisters, pin holes etc.

3.1.8 Batteries shall have thick plates designed for maximum durability during all service conditions including high rate of discharge and rapid fluctuations of load. The tubular plate construction shall consist of high pressure cast lead alloy spines.

3.1.9 Transparent SAN containers shall have marked electrolyte level indicator on its body.

3.1.10 The separators shall maintain the electrical insulation between the plates and shall allow the electrolyte to flow freely. Separators should be suitable for continuous immersion in the electrolyte without distortion.

3.1.11 The cells shall be supported on FRP insulator fixed on to the FRP rack with adequate clearance between adjacent cells.

3.1.12 The positive and negative terminals shall be clearly marked.

3.1.13 Vent plug shall be provided which shall be anti-splash type. It shall allow the gases to escape freely but prevent the acid spray from the battery.

3.1.14 Sufficient sediment space shall be provided beneath the plates to accommodate any plate deposit, which accumulates at the bottom of the cell over a reasonable life of battery without short circuiting the plates.

3.1.15 The following items shall be provided for the battery.

a) Rack insulators

b) Cell insulators

c) Long/Short connectors

d) Inter row connectors (Insulated solid plated copper busbars)

e) Interbank connectors (Insulated solid plated copper busbars)

f) Vent plug

g) Float guide

h) Proper Battery take-off arrangements and shall be finalized during detail engineering as per owner requirement.

i) Level indicator

j) Fasteners (SS-304)

k) Cell number plates (On cells as well as on stand / rack)

3.1.16 Lead coated copper connectors shall be used for connectors. Bolts, nuts and washers shall be effectively lead coated to prevent corrosion. All the terminals and cells, interconnections shall be fully insulated or have insulation shrouds/covers. Connectors shall be supplied by OEM of battery cell only.

3.1.17 The cell terminals posts shall be provided with connector bolts and nuts, effectively coated with lead to prevent corrosion.

3.1.18 End take off connections from positive and negative poles of batteries shall be made by single core cables having stranding class 4 copper conductors and shall be XLPE insulated. Necessary supports and lugs (Heavy duty long barrel copper lugs) for termination of these cables on batteries shall also be supplied. All connectors and lugs shall be capable of continuously carrying specified discharge current of the respective batteries and through fault short circuit current which the battery can produce and withstand for the period declared.

3.1.19 Lead-coated bent copper plate, tubular copper lugs, teakwood clamp, bolts, nuts, washers, etc. shall be furnished for connection of outgoing copper conductor cables.

3.1.20 FRP Racks / Stands shall be free standing type, mounted on porcelain insulators. Numbering tags for each cell shall be attached on to the racks as well as on the cells. The bottom tier of the stand shall not be less than 150 mm above the floor. Wherever racks are transported in dismantled conditions, suitable match markings shall be provided to facilitate easy assembly.

3.1.21 Battery racks and other supporting/interconnecting accessories shall be as per layout arrangement to be approved by Owner during contract engineering stage.

3.1.22 Battery bank installation shall have minimum clear distance of 1.0 meter between inter row and from all side (Walls, other battery bank etc.) and installed in room with partition. Proper ventilation, eye washer, Acid proof tiles etc. shall be provided in battery room as per statutory requirements.

3.1.23 Following accessories shall be provided for each substation.

a) Electronic Syringe type Hydrometer with temperature measurement and with built in memory suitable to measure up to four set of battery banks each of 110 cells.

b) Digital Multimeter with measuring probes.

c) Acid resistant funnel.

d) Acid resistant jug.

e) Rubber apron and gloves.

f) Insulated Spanners- 2 sets.

g) Wall mounted teak wood rack/ Acid resistance rubber insulated FRP rack for above items

h) Lifting device for cell

3.1.24 The rating indicated is minimum requirement. Vendor shall carry out sizing calculation and provide required rating. After finalization of rating by calculations (including design margins), additional 10% to 15% capacity shall be added for the purchaser's / GIPCLs' future requirement

3.2 DC Distribution board

3.2.1 DC Distribution board shall be preferably Floor mounted, compartmentalised type construction or inbuilt in charger itself.

3.2.2 Positive and negative bus bars in the DC switchgears shall be completely segregated from each other by sheet steel partitions.

3.2.3 The maximum voltage variation allowed at the load end shall be +10% to -15% at all operating conditions for both DC systems.

3.2.4 Short circuit withstand rating of the DCDB shall be as per system study.

3.2.5 DCDB shall be sheet steel enclosed and shall be dust, weather and vermin proof. Sheet Steel used shall be cold rolled and at least 2.0mm thick and properly braced to prevent wobbling. The components shall be housed in a well-ventilated sheet metal cubicle complete with input and output terminals. 20% spare feeders of each type and ratings complete in all respect shall be provided for Future use.

3.2.6 Suitable synthetic rubber gaskets shall be provided to make boards completely dust and vermin-proof with a degree of protection of IP42 (minimum) for indoor installation.

3.2.7 DBs shall have bottom entry for cables. Cable entry facilities shall be provided with removable gland plates (pre-drilled) of suitable thickness. All incoming and outgoing cables shall be terminated on suitable terminal blocks

3.2.8 All wiring shall be carried out with wires of 1.1 KV grade, stranded copper conductors. The insulation shall be halogen free and flame retardant. Power circuits shall be wired with stranded copper conductors of adequate sizes to suit the rated current, the minimum size shall be 2.5 sq. mm.

3.2.9 Unless otherwise specified, control alarm and indication circuits shall be wired with stranded, tinned copper conductors of sizes not smaller than 1.5 sq. mm. Space heater circuits etc shall be wired with stranded copper conductor of size not smaller than 2.5 sq. mm.

3.2.10 All control terminals shall be of Stud type (screw drive operated) and control wiring shall be terminated with tinned copper ring type lugs with insulated sleeve. Printed single tube ferrules marked to correspond with panel wiring diagram shall be fitted at both ends of each wire. The wire identification marking shall be in accordance with IS:375. Red Ferrules should be provided on trip circuit wiring.

3.2.11 Module details of DC Distribution board:

3.2.12 The incomer modules shall be MCCB controlled. Each incomer shall be provided with:

a) Ammeter & voltmeter

b) Under voltage relay with timer

c) Indicating lamps for ON, OFF, UNDER VOLTAGE conditions

d) Outgoing feeders shall be with double pole MCBs

3.2.13 DCDBs for sub pooling stations shall be provided with tie feeder on both side. One of the tie feeder shall have voltmeter on bus side as well as line side and shall be provided with ammeter. All instruments shall be integrated with SCADA system.

3.3 DC System Cables (for 110V DC battery system)

3.3.1 1100V grade, single core cables with stranded Copper conductor, XLPE insulated, with PVC inner sheath, armoured and outer sheath made of FRLSH PVC compound, generally conforming to IS 7098 (for XLPE) shall be used from batteries/ battery chargers to DCDB, main DC supply to various system cabinets / panels, Switchgears etc. and for critical auxiliaries.

3.3.2 Voltage drop in cables between battery to DCDB and battery charger to DCDB shall be limited to 2%. Voltage drop in cables between DCDB and loads shall be limited to 3%.

3.3.3 Design Calculation for arriving at cable size shall be submitted for Owner's approval.

3.3.4 The Cable glands shall be weather proof Double compression type made of heavy duty brass machine finished and nickel chrome plated of suitable size. Thickness of plating shall not be less than 10 micron. Cable glands shall conform to BS:6121.

3.3.5 All Cable lugs for power cables shall be Heavy duty Long barrel tinned copper ring type / bimetallic solderless crimping type of suitable size. Cable lugs for control cables shall be tinned copper ring type with insulated sleeve.

3.4 Battery Charger

3.4.1 The float and boost battery charger shall be SMPS (Switch Mode Power Supply) type SMPS modules shall be hot swappable. It shall have N+1 redundancy.

3.4.2 The float cum boost charger shall be designed for supplying:

a) The D.C continuous load.

b) The float charging current of the battery.

c) Largest D.C motor running current, if any

d) 25% margin over the above loads

e) Supplying the boost charging current of the battery.

3.4.3 The SMPS Modules shall be designed for single phase or 3 phase, 50 Hz input supply.

3.4.4 The D.C. output voltage during float charging shall be stabilized within ± 1% of the set DC bus voltage for AC input voltage variation of ±10%, frequency variation of ± 5% and DC load variation from 0 - 100%. The voltage regulation shall be achieved by a constant voltage regulator with high frequency SMPS with intelligent control.

3.4.5 The float charger will be normally ON, supplying the D.C. load and at the same time trickle charging the battery. FCBC shall be suitable for float charging as well as boost charging the battery. Each battery charger shall be capable of float charging the battery supplying the station normal DC load. Design shall be such that in case the load exceeds the charger capacity, the excess load current shall be supplied by the battery

3.4.6 The ripple content shall be within 1% of D.C. output nominal voltage with battery disconnected. Also, in any mode of operation, the maximum harmonics (THD) in the charger input shall not exceed 5% and input power factor shall be better than 0.85.

3.4.7 The setting of the output D.C. bus voltage shall be adjustable between ±10% of nominal rated voltage.

3.4.8 All battery chargers shall be provided with facilities such as automatic voltage regulator (AVR) for both automatic and manual control of output voltage and current. A selector switch shall be provided for selecting the mode of output voltage / current control, whether automatic or manual. Means shall be provided to avoid current / voltage surges of harmful magnitude / nature which may arise during changeover from auto to manual mode or vice-versa under normal operating condition

3.4.9 Charger cubicles shall be sheet steel enclosed and shall be dust, weather and vermin proof. Sheet Steel used shall be cold rolled and at least 2.0mm thick and properly braced to prevent wobbling. The components shall be housed in a well-ventilated sheet metal cubicle complete with input and output terminals.

3.4.10 Electronic equipment shall be of modular design consisting of plug in modules in standard metallic racks with metallic card guides. Card to card wiring shall be through motherboard. The modules shall be hot-swappable to reduce MTTR (Mean Time to Repair).

3.4.11 Indications, controls and output voltage setting adjustments shall be on front panel.

3.4.12 Louvers shall be provided for ventilation backed up by fine wire mesh so that the degree of protection shall be equal to or better than IP-42 or better

3.4.13 All wiring shall be carried out with wires of 1.1 KV grade, stranded copper conductors. The insulation shall be halogen free and flame retardant. Power circuits shall be wired with stranded copper conductors of adequate sizes to suit the rated current, the minimum size shall be 4 sq. mm. Unless otherwise specified, control alarm and indication circuits shall be wired with stranded, tinned copper conductors of sizes not smaller than 1.5 sq. mm. Space heater circuits, etc circuits shall be wired with stranded copper conductor of size not smaller than 2.5 sq. mm.

3.4.14 All control terminals shall be of Stud type (screw drive operated) and control wiring shall be terminated with tinned copper ring type lugs with insulated sleeve. 20% spare terminal shall be provided of each type. Printed single tube ferrules marked to correspond with panel wiring diagram shall be fitted at both ends of each wire. The wire identification marking shall be in accordance with IS:375. Red Ferrules should be provided on trip circuit wiring

3.4.15 Ground terminals with isolating links shall be provided. The DC System shall be ungrounded and float with respect to the ground potential when healthy.

3.4.16 MCCB shall be Triple pole type for incoming supply to Battery charger, Double Pole type for outgoing supply from Battery charger. It shall be quick make, quick break, independent manual type with trip free feature. All MCCB shall have the following

a) Short circuit release
b) ON/OFF and Trip position indicators.
c) On / Off and Trip position potential free contacts to be integrated to SCADA
d) Test trip push button
e) Voltage rating shall be suitable for 500 volts AC/DC

3.4.17 Following features shall be provided in the charger:

a) One (1) Auto / Manual selector switch for selecting the mode of operation of the controller.

b) One (1) set of MCCB for AC input with suitable ratings and with trip indication for each of the charger units.

c) One (1) set of MCCB complete with fuse fittings for the DC output and with trip indication.

d) One (1) DC under voltage of the battery shall be integrated to the SCADA.

e) One (1) cubicle thermostatically controlled space heater suitable for 240 V AC 50 Hz, single phase shall be provided.

f) One (1) 240 V AC lamp for cubicle internal lighting shall be provided.

g) Two (2) - ON/OFF switches with MCB for space heater and internal lighting shall be provided.

3.4.18 Following annunciation shall be provided as minimum and shall be integrated to the SCADA

a) Mains AC failure

b) Charger over load

c) DC output breaker tripped

d) AC input breaker tripped

e) Battery fully discharged

f) Battery on boost

g) DC system earth fault

h) DC under voltage

i) DC Over voltage

j) Charger current limited protection operated

k) AVR Defective

l) SMPS module failure

m) Battery breaker tripped

n) Battery on boost

3.4.19 Following analogy / digital meters shall be provided for charger to read the following measurement parameters:

a) AC input voltage and current

b) Charger input current.

c) DC Output current of Float/Boost Charger

d) DC Output voltage of Float/Boost Charger

e) Load voltage and current

f) Battery voltage

g) Battery current

h) Charge/discharge currents of the battery

3.4.20 For remote metering of the following parameters shall be provided for each Charger. 4-20 mA Transducers with dual output type to monitor the following:

a) DC Voltage and Current of float charger & Float cum Boost Charger

b) DC Voltage and Current of Battery and Potential free contacts to be integrated to SCADA to monitor:

c) Battery voltage low, high and normal

3.4.21 All Indoor equipment, panels and cabinets (Battery Chargers) shall be pre-treated as per IS 6005 before being factory-painted with epoxy based paint shade of paint shall be RAL 7035. Corrosivity grade as per ISO 12944 shall be considered for indoor equipment. Painting shall be carried out by approved process. Sufficient quantity of touch-up paint shall be furnished for application at site.

3.4.22 Design shall be as per Seismic Zone as per IS 1893.

4.0 Technical Parameters

Sl. No.	Item Description	Unit	Technical Requirement
	Battery		
A.	**General**		
1.	Application	-	For Protection/Control system and emergency Lighting
2.	Type of battery	-	Lead-acid Tubular (OPzS) battery
3.	Nominal Voltage	V	2
4.	Battery Capacity	AH	To be calculated by Bidder based on Duty Cycle
5.	Number of battery banks required	No.	As design
6.	Number of cells (approximate)	No.	54
7.	Temperature		
	(a) Min. temp.	^{0}C	10
	(b) Design ambient temperature	^{0}C	50
B.	**Rating**		
1.	Design margin	%	10
2.	Ageing factor	-	1.25
3.	DC System Voltage at DC bus of the Switchboard		
	(a) Normal	V	110
	(b) Maximum	V	121
	(c) Minimum	V	93.5
4.	End Cell Voltage (Volts / Cell)	(V/Cell)	1.8
C.	**Discharge Duty**		
1.	Ampere Hour Capacity of Battery at min. temperature, 10 hour rate to give final end cell voltage	C_{10}	To be calculated by Bidder based on Duty Cycle
D.	**Layout and Construction**		

Sl. No.	Item Description	Unit	Technical Requirement
1.	Tentative size of cables to connect battery to external circuit		
	(a) Type	-	XLPE
	(b) Size	mm^2	To be submitted by Bidder
	(c) Conductor material		Copper
2.	Whether FRP stands to be designed for Seismic force	Yes/ No	Yes
E.	**Miscellaneous**		
1.	Tapped Cell arrangement for float cum boost charging arrangement.	Required / Not Required	Required
2.	Dropper Diode arrangement for float cum boost charging arrangement.	Required / Not Required	Required
	Battery Charger		
A.	**General**		
1.	Quantity required	Set	One
2.	Type (Float charger or Float-cum Boost charger)	-	Float-cum-Boost charger
3.	Charger Technology	-	SMPS
4.	DC System Voltage (Nominal)	V	110
5.	DC System Earthing	-	Unearthed
6.	Ambient Design Temperature	Deg. C	50
B.	**Battery Details**		
1.	Battery capacity & no. of cells	AH	AH to be calculated by Bidder
2.	Battery type	-	Lead-acid Tubular (OPzS) battery
3.	Battery discharge facility	-	Required
C.	**AC SYSTEM DATA**		

Sl. No.	Item Description	Unit	Technical Requirement
1.	Supply		
	(a) Voltage	V	415 / 230
	(b) Phase		3 / 1
	(c) Frequency	Hz	50
2.	(a) Variation in supply Voltage	%	±10%
	(b) Variation in supply frequency	%	± 5%
3.	Type of earthing	-	Solidly Earthed
D.	**Performance**		
1.	DC voltage setting adjustment for float charger	%	±10% of nominal voltage
2.	Voltage stabilisation for constant voltage regulator	%	±1% of set D.C voltage, with AC input variation as specified
3.	Maximum permissible variation in DC voltage (no load to full load)	%	±1%
4.	D.C. voltage setting adjustment for boost charging	%	70% to 100% of max. boost charging voltage
5.	D.C. current adjustment for boost charging	%	30% to 100% of max. boost charging current
6.	Current stabilisation for constant current regulator for boost charger	%	±2%
7.	Minimum permissible power factor at rated continuous load	-	0.85
8.	Permissible ripple content at rated continuous load	%	1% (maximum)
9.	Maximum permissible harmonics with or without battery	%	5%
E.	**Miscellaneous**		

Sl. No.	Item Description	Unit	Technical Requirement
1.	Cable entry	-	Bottom
2.	Cable Sizes		
	(a) Battery	sq.mm	To be calculated by Bidder
	(b) DC output	sq.mm	To be calculated by Bidder
	(c) AC input	sq.mm	To be calculated by Bidder
3.	Degree of protection of charger cubicle	-	IP 42 or better
4.	Overall efficiency of charger	-	>80%
5.	Communication Support	-	RS 485 (to be integrated with SCADA)
6.	Communication Protocol	-	MODBUS

5.0 Tests

Acceptance tests shall be conducted at site on completion of installation and commissioning and immediately prior to putting the battery and charger in service.

5.1 **The tests for Lead-acid Tubular (OPzS) battery shall comprise of:**

a) Visual inspection
b) Dimensional check
c) Capacity test
d) Test for voltage during discharge
e) Storage test
f) Internal resistance of battery
g) Vendor shall carry out the capacity test on battery for the following conditions:
   i. For the load cycle specified.
   ii. For 10 Hr discharge.

5.2 **The tests for SMPS shall comprise of:**

a) Ripple, power factor and input harmonics measurement by oscilloscope at different loads of battery charger
b) Demonstration of guaranteed efficiency and power factor.
c) HI Electronic controller, at 2 kV AC for one min on battery charger
d) Checking of DC charger system monitoring and associated communication system
e) Checking of auxiliary devices, protective devices & control equipment

5.3 Type test report on an identical type and capacity of the battery and battery charger shall be submitted for Owner's review. If type tests reports as per applicable standard is not available then these Type tests shall be conducted on a minimum of one sample cell, typical and identical with the cells forming the complete battery offered (free of cost to owner). However, the tested cell shall not be included in the battery offered.

a) Verification of constructional requirements.

b) Verification of marking

c) Verification of dimensions.

d) Test for capacity

e) Test for suitability of float operation

f) Endurance test.

g) Charge retention test

h) Short circuit current and Internal resistance measurement test

i) Heat run test

6.0 Data to be furnished by vendor after award of contract

6.1 **Drawings / Documents for Approval:**

a) Layout drawing showing the battery room dimensions, No. of rows, overall dimensions of each row, cable termination location with dimension, cross sectional view etc.

b) No. of air changes recommended,

c) Detailed calculations for sizing of the battery DCDB and Battery charger considering various factors and the specified duty cycle.

d) Copies of Test Reports as specified in distribution schedule.

e) Schematic drawings showing main components and basic schemes.

f) General arrangements showing dimensions and space requirements.

g) DCDB and charger OGA, Schematic and wiring diagram , drawings and documents with all component details make, type shall be provided.

h) MQAP / QAP as per CEA Regulation

i) Stand / rack & & fixing arrangement, insulator drawing

j) O&M manual

6.2 **Drawings / Documents for information:**

6.2.1 Battery characteristics:

(a) Curve showing cell volts Vs. time of different discharge rates.

(b) Curve showing cell volts Vs. time at different charging currents.

(c) AH capacity Vs. years of service.

(d) Capacity retention characteristic

(e) Percentage capacity Vs Temperature

(f) Charge current(A), Cell voltage(V) and charge quantity(%) Vs time.

6.2.2 Copies of instruction manuals as per distribution schedule to cover installation, commissioning, operation and maintenance

B7 – LT POWER AND CONTROL CABLE

1.0 LT Power and Control Cable

LT Power & control cables shall be of minimum 1100 volts grade XLPE & PVC insulated flame retardant, low smoke, FRLS / FRLSH As per CEA regulation type conforming to IS 7098 part-1 & IS 1554 part-1. 1.9/3.3kV grade LT cable shall be used for interconnection between inverter-to-inverter transformers.

2.0 Codes & Standards

Codes	Description
IS :1554 - I	PVC insulated (heavy duty) electric cables for working voltages upto and including 1100V.
IS: 3961	Recommended current ratings for cables
IS: 3975	Low carbon galvanized steel wires formed wires and tapes for armouring of cables.
IS: 5831	PVC insulation and sheath of electrical cables.
IS:7098 (Part -I)	Cross linked polyethylene insulated PVC sheathed cables for working voltages up to and including 1100V.
IS : 3961	Recommended current ratings for cables
IS 8130	Conductors for insulated electrical cables and flexible cords.
IS: 10418	Specification for drums for electric cables.
IS: 10810	Methods of tests for cables.
ASTM-D -2843	Standard test method for density of smoke from the burning or decomposition of plastics.
IEC-754 (Part-I)	Tests on gases evolved during combustion of electric cables.
ASTM-D-2863	Standard method for measuring the minimum oxygen concentration to support candle like combustion of plastics.
IEEE-383	Standard for type test of Class IE Electric Cables

3.0 General Requirements of LT Power Cables

3.1 1.1 KV grade XLPE power cables shall have compacted aluminium/ copper conductor, XLPE insulated, PVC inner-sheathed (as applicable), armoured FRLS/as per CEA regulation PVC outer-sheathed conforming to IS:7098. (Part-I). Cables which are directly buried shall be armoured. However, in case of unarmored cable, adequate mechanical protection shall be ensured by the bidder.

3.2 The cables shall be suitable for laying on racks, in ducts, trenches, conduits and underground (buried) installation with chances of flooding by water.

3.3 If cables are to be laid underground, laying shall be as per latest relevant IS code. Cables to be buried in ground will be provided with special protection either through PE/LS sheath/Jacket considering soil with saline water.

3.4 All cables shall be flame retardant (FRLS)/as per CEA regulation type designed to withstand all mechanical, electrical and thermal stresses developed under steady state and transient operating conditions as specified elsewhere in this specification.

3.5 Copper/aluminium conductor used in power cables shall have tensile strength as per relevant standards. Conductors shall be stranded.

3.6 The cables specifications / design shall be suitably selected as per laying final philosophy/ methodology decided during detail engineering by the Bidder considering the site environmental conditions etc. Bidder shall submit the final specification with methodology for Owner's Approval

3.7 XLPE insulation shall be suitable for a continuous conductor temperature of 90 deg. C and short circuit conductor temperature of 250 deg C. for duration of one second

3.8 For 3 Phase, 4 Wire power system, Neutral conductor size shall be of same size as the phase conductors' size. Half neutral shall not be acceptable.

3.9 LT cable maximum voltage drop shall be limited to 3% of rated voltage. 1.9/3.3kV grade LT cable shall be used for interconnection between inverter to inverter transformer.

3.10 For single core armoured cables, armouring shall be of copper/aluminium wires/ formed wires. For multicore armoured cables, armouring shall be of galvanised steel as follows:

Calculated nominal dia. of cable under armour	**Size and Type of armour**
Upto 13 mm	1.4mm dia GS wire

Above 13 & upto 25mm	0.8 mm thick GS formed wire / 1.6 mm dia GS wire
Above 25 & upto 40 mm	0.8mm thick GS formed wire / 2.0mm dia GS wire
Above 40 & upto 55mm	1.4 mm thick GS formed wire /2.5mm dia GS wire
Above 55 & upto 70 mm	1.4mm thick GS formed wire / 3.15mm dia GS wire
Above 70mm	1.4 mm thick GS formed wire / 4.0 mm dia GS wire

3.11 The aluminium used for armouring shall be of H4 grade as per IS: 8130. Copper / aluminium conductor shall be of electrolytic grade.

3.12 The gap between armour wires / formed wires shall not exceed one armour wire / formed wire space and there shall be no cross over / over-riding of armour wire / formed wire. The minimum area of coverage of armouring shall be 90%. The breaking load of armour joint shall not be less than 95% of that of armour wire / formed wire. Zinc rich paint shall be applied on armour joint surface of GS wire / formed wire.

3.13 Outer sheath shall be of PVC as per IS: 5831 & black in colour for power cables. In addition to meeting all the requirements of Indian standards referred to, outer sheath of all the cables shall have the following FRLS/as per regulation properties.

i) Oxygen index of min. 29 (as per IS 10810 Part-58)
ii) Acid gas emission of max. 20% (as per IEC-754-I)
iii) Smoke density rating shall not be more than 60 % (as per ASTMD-2843)
iv) Temperature index of minimum 250°C when tested as per IS 10810 Part-64Acid gas emission of max. 20% (as per IEC-754-I)
v) Average light transmission of 40% minimum when tested as per IS 10810 Part-63
vi) Flammability requirements as per IS 10810 Parts-53 and 62
vii) Flame retardant requirements as per IS 10810 Part-61
viii) Halogen content requirements as per IEC 60754Smoke density rating shall not be more than 60 % (as per ASTMD-2843)

3.14 In addition to manufacturer's identification on cables as per IS, following marking shall also be provided over outer sheath. Cable size and voltage grade - To be embossed Word 'FRLS/actual specification' at every three meter - To be embossed Screen Fault current _ _ _KA for _ _ _ Sec. (Value of current & time shall be indicated) (If applicable) Sequential marking of length of the cable in meters at every one meter -To be embossed / printed The embossing shall be progressive, automatic, in line and marking shall be legible and indelible.

3.15 All cables shall meet the fire resistance requirement as per IEEE - 383 with cable installations made in accordance with 'Flammability Test' and as per Category-B of IEC 332 Part -3.

3.16 Allowable tolerances on the overall diameter of the cables shall be +\-2 mm maximum, over the declared value in the technical data sheets. Repaired cables shall not be accepted.

3.17 All the cables (Power and control) shall be protected against rodent and termite attack. Necessary chemicals shall be added into the PVC compound of the outer sheath. The sheath shall be resistant to saline water, UV radiation, fungus, etc

3.18 All LT cables shall be of minimum 1100 V grade, single/multi-core, stranded aluminium conductor, extruded XLPE insulated (hot water cured), with extruded PVC inner sheath (Type ST-2), armoured and overall sheath with extruded Flame-Retardant Low Smoke (FRLS)/as per CEA regulation PVC compound (Type ST-2), however cable for Inverter to Inverter transformer shall be of minimum 1.9/3.3KV grade. These cables shall conform to IS-7098-Part-I

3.19 All necessary cable terminating accessories such as supporting clamps and brackets, hardware etc., shall be provided by the Bidder, to suit the final cable sizes and shall be GI as per standard. All Cable lugs for power cables shall be Heavy duty long barrel tinned copper ring type / bimetallic solderless crimping type of suitable size conforming to IS:8309. Cable lugs for control cables shall be tinned copper ring type with insulated / sleeved.

3.20 Double compression type Cable glands made of heavy-duty brass machine finished and nickel chrome plated shall be provided for cable glanding. Thickness of plating shall not be less than 10 microns. Cable glands shall conform to BS:6121

3.21 For Power cable joint shall only be permitted if single cable length as per OEM does not meet the requirement.

3.22 **Cable selection & sizing:**

Cables shall be sized based on the following considerations:

a) Rated current of the equipment. Full load current carrying capacity under installation conditions considering Site ambient temperature & site installation (Grouping) conditions based on Manufacturer’s recommendation. Permissible voltage drop limits under steady state/transient state as applicable. Voltage drop shall be limited to 3% of rated voltage.

b) Short circuit withstand capability of 1 second.

This will depend on the feeder type. For a MCB/MCCB protected circuit, cable should be sized to withstand the let-out energy of the fuse. For breaker-controlled feeder,

cable shall be capable of withstanding the system fault current level for total breaker tripping time inclusive of relay pickup time.

3.23 **Derating Factors:**

De rating factors for various conditions of installations including the following shall be considered while selecting the cable sizes:

a) Variation in ambient temperature for cables laid in air
b) Grouping of cables
c) Variation in ground temperature for buried cables
d) Soil resistivity for buried cables.
e) Any other derating factor required to be considered as per site condition.

3.24 Cable lengths shall be considered in such a way that straight through cable joints are avoided. Cables shall be armoured type if laid directly buried. Cable shall be capable of laying in underground soil with saline water in case of laying methodology selected is under ground.

4.0 General Requirements of Control Cables

4.1 1.1 KV Grade Control Cables shall have stranded copper conductor and shall be multicore PVC insulated, PVC inner sheathed, armoured, FRLS/as per CEA regulation PVC outer sheathed conforming to IS: 1554. (Part-I).

4.2 The cables shall be suitable for laying on racks, in ducts, trenches, conduits and underground (buried) installation with chances of flooding by water.

4.3 All cables shall be flame retardant, low smoke (FRLS)/as per CEA regulation type designed to withstand all mechanical, electrical and thermal stresses developed under steady state and transient operating conditions as specified elsewhere in this specification.

4.4 Outer sheath shall be of PVC as per IS: 5831 & grey in colour for control cables. In addition to meeting all the requirements of Indian standards referred to, outer sheath of all the cables shall have the following FRLS/as per regulation properties.

a) Oxygen index of min. 29 (as per IS 10810 Part-58).

b) Temperature index of minimum 250°C when tested as per IS 10810 Part-64

c) Acid gas emission of max. 20% (as per IEC-754-I).

d) Smoke density rating shall not be more than 60 % (as per ASTMD-2843).

e) Average light transmission of 40% minimum when tested as per IS 10810 Part-63

f) Flammability requirements as per IS 10810 Parts-53 and 62

g) Flame retardant requirements as per IS 10810 Part-61Smoke density rating shall not be more than 60 % (as per ASTMD-2843).

4.5 Cores of the cables shall be identified by colouring of insulation. Following colour scheme shall be adopted:

a) 1 core - Red, Black, Yellow or Blue
b) 2 core - Red & Black
c) 3 core - Red, Yellow & Blue
d) 4 core - Red, Yellow, Blue and Black

4.6 For control cables having more than 5 cores, core identification shall be done by numbering the insulation of cores sequentially, starting by number 1 in the inner layer (e.g. say for 10 core cable, core numbering shall be from 1 to 10).

4.7 Double compression type Cable glands made of heavy duty brass machine finished and nickel chrome plated shall be provided for cable glanding. All lugs shall be Ring type tinned copper with insulated/sleeved only.

4.8 No Joints shall be permitted in any of the control cables.

4.9 While preparing cable schedules for control / protection purpose following shall be ensured:

a) Separate cables shall be used for AC and DC circuits

b) For different cores of CT and VT, separate cables shall be used

c) Two separate cables shall be used from DC Source-I & Source-II to each control /relay panel, each 33 KV board, SCADA, server, etc. for main & redundant control supply and Auxiliary supply

4.10 **Cable selection & sizing:**

Control cables shall be sized based on the following considerations:

a) The minimum conductor cross-section shall be 1.5 sq.mm.

b) The minimum number of spare cores in control cables shall be as follows:

No. of cores in cable	Min. No. of spare cores
2C, 3C	NIL
4C,5C, 7C	2

10C & above	4

c) Current transformer leads shall be checked for lead burden, VA capacity and knee point voltage. In case 2.5 mm2 Copper Conductor is not adequate, conductor of 4 mm2 cross section or higher shall be used. Voltage transformer leads shall be checked for voltage drop which shall be limited to within 1% for all cases other than tariff metering. For tariff metering the voltage drop shall be limited to 0.2%. In case the voltage drop with 2.5 sq.mm copper conductor exceeds this value, higher conductor sizes shall be used

4.11 Cable identification system

a) In addition to manufacturer's identification on cables as per IS, following marking shall also be embossed/printed on the outer sheath at an interval of three 3) meter throughout the length of cables.

i. Owner: GIPCL

ii. BIS mark

iii. Manufacturer's name and or trade mark.

iv. Year of manufacture

v. Cable code

vi. Type of cable and voltage class.

vii. Nominal cross section area of conductor and no. of cores.

viii. Progressive sequential length making.

b) Cables shall be marked as having FRLS/actual specification outer sheath at every three (3) meters.

c) The embossing/printing shall be progressive, automatic, in line and marking shall be legible and indelible.

4.12 Cables Laying and Fitting Accessories

a) For power and control cables, Ladder type GI cable tray with top cover and all fittings and accessories like coupler plates, bolts, nuts, washers, brackets, elbows, bends,

reducers, tees, crosses, strap, hook etc shall be provided. Proper GI support system shall be provided for cable tray.

b) Cables inside the control room and in the transformer yard shall be laid in Galvanized Cable Trays mounted on GI steel supports, in constructed trenches with RCC raft and brick sidewalls and provided with removable RCC covers.

c) Power and control cables shall be laid on separate tiers in line with approved guidelines/ drawings. The laying of different voltage grade cables shall be on different tiers according to the voltage grade of the cables.

d) Cable tray shall be fabricated out of mild steel sheets with min thickness of 2 mm and for coupler plates it shall be 3 mm thick. Material of Cable tray and all its fittings and accessories shall be Hot dip Galvanized as per IS standard.

e) Suitable size clamps with all fixing GI accessories shall be provided for clamping of multicore cables at every 5 meters interval. Die cast Aluminum or Fibre glass or Nylon Trefoil clamps with all fixing GI accessories shall be provided for single core cables. Trefoil clamps shall be provided at distance of every 2 meters and on either side of bends. Control cables shall be bunched, clamped and tied with self-locking type nylon cable ties with de interlocking facility to keep them in position.

f) Cable drums shall be unloaded, handled, stored and laid as per OEM guideline or as per IS standard. Suitable jacks or on cable wheels shall be used to unreeling the cables. All possible care shall be taken during unreeling and laying to avoid damage due to twist, kink or sharp bends. Ground rollers shall be used at every 2 meter interval for cable laying to avoid cable touching ground.

g) Suitable clearances shall be maintained between HT power-LT Power-Control cable laying in line with IS standard. Required length of cable for LT straight through joints shall be kept at each end location for future use.

h) The cable passing through openings in the cable trenches/ road /wall /floor/cable tunnel/ cable culvert shall be laid in the GI pipe /HDPE/ Hume Pipe of approved make. All opening/ entry of cables shall be provided with fire stop sealing with modular multidiameter sealing system (ROXTEC or equivalent).

i) All cable/wires shall be provided with Punched Aluminium tags only on both sides of a wall or floor crossing, on each duct/conduit entry / exit, and at every 10 meters in cable tray/trench runs. The marking on tags shall be done with good quality letter and number ferrules of proper sizes so that the cables can be identified easily. Suitable cable tray marking shall be provided. Cross ferruling shall be provided for each control cable cores.

5.0 Technical Parameters

5.1 The 1.1KV grade XLPE Power Cables shall comply with the particulars indicated below:

Sl. No.	Description	Unit	Requirements
1.0	General Requirements		
1.1	Voltage Grade	kV	Minimum 1.1
1.2	Core	-	Single, Multi
1.3	Conductor Material	-	Copper – Cable size upto 6sq.mm Aluminium - Cable size above 6sq.mm
1.4	Insulation	-	XLPE
1.5	Inner Sheath	-	Extruded PVC Compound (ST-2 for PVC Insulation)
1.6	Armouring	-	Galvanized steel round wire/ galvanized steel strip
1.7	Outer Sheath	-	Extruded FRLS/As per CEA Regulation PVC Compound (ST-2 for PVC Insulation)
1.8	Maximum Conductor temperature	-	
	a) Rated	ºC	90
	b) During Short Circuit	ºC	250
2.0	System details	-	
2.1	Nominal power system voltage	V	415
2.2	Maximum system voltage for continuous operation	kV	1.1
2.3	System neutral earthing	-	As per system requirements
2.4	Design Ambient Temperature	ºC	50 or as per CEA guidelines / working committee report

5.2 The 1.1KV grade PVC Control Cables shall comply with the particulars indicated below:

Sl. No.	Description	Unit	Requirements
1.0	General Requirements		
1.1	Voltage Grade	kV	Minimum 1.1
1.2	Core	-	Multi
1.3	Conductor Material	-	Copper

1.4	Insulation	-	Extruded PVC
1.5	Inner Sheath	-	Extruded PVC Compound (ST-1 for PVC Insulation)
1.6	Armouring	-	Galvanized steel round wire/ galvanized steel strip
1.7	Outer Sheath	-	Extruded FRLS/As per CEA regulation PVC Compound (ST-1 for PVC Insulation)
2.0	System details	-	
2.1	Nominal power system voltage	V	415
2.2	Maximum system voltage for continuous operation	kV	1.1
2.3	System neutral earthing	-	As per system requirements
2.4	Design Ambient Temperature	ºC	50 or as per CEA guidelines / working committee report

5.3 The 1.9 /3.3 KV grade XLPE Power Cables shall comply with the particulars indicated below:

Sl. No.	**Description**	**Unit**	**Requirements**
1.0	General Requirements		
1.1	Voltage Grade	kV	1.9 / 3.3
1.2	Core	-	As per system requirements
1.3	Conductor Material	-	Copper / Aluminium - Cable size as per system requirement
1.4	Insulation	-	XLPE
1.5	Inner Sheath	-	Extruded PVC Compound (ST-2 for PVC Insulation)
1.6	Armouring	-	Galvanized steel round wire/ galvanized steel strip
1.7	Outer Sheath	-	Extruded FRLS/As per CEA Regulation PVC Compound (ST-2 for PVC Insulation)
1.8	Maximum Conductor temperature	-	
	c) Rated	ºC	90
	d) During Short Circuit	ºC	250
2.0	System details	-	

2.1	Nominal power system voltage	V	As per system requirements
2.2	Maximum system voltage for continuous operation	kV	1.9/3.3
2.3	System neutral earthing	-	As per system requirements
2.4	Design Ambient Temperature	ºC	50 or as per CEA guidelines / working committee report

6.0 Tests

6.1 Cables shall be subjected to routine and acceptance tests as per IS-7098 (Part-1). Acceptance tests and FRLS/as per CEA regulation tests as specified shall be conducted on cables and same shall be witnessed by the Purchaser. The FRLS/as per regulation tests shall be carried out on one cable of every batch of compound used. Test certificates for routine, acceptance and special tests shall be furnished by the Bidder for review and approval. Charges for these shall be deemed to be included in the equipment price.

6.2 All equipment to be supplied shall be of type tested quality. Certified copies of reports of type tests conforming to IS-7098 (Part-1) carried out on similar type and rating of cables (offered under this contract) shall be furnished to the Purchaser for review and approval. Type tests shall also include anti rodent and anti-termite test. The tests should have been either conducted at on independent laboratory or should have been witnessed by a client. In case the bidder is not able to submit report of the type test(s) conducted, or in case the type test report(s) are not found to be meeting the Specification requirements, the bidder shall conduct all such tests under this contract, free of cost to the Owner and submit the reports for approval

6.3 Acceptance tests as per IS standard and approved QAP shall be carried out on each type and size of the cables on the cable drums selected at random as per following sampling plan:

Sl. No.	**No. of drums in the lot**	**No. of drums to be taken as sample**
1.	Upto 50	2
2.	51 to 100	5
3.	101 to 300	13
4.	301 to 500	20

6.4 Following Special Tests shall be conducted at factory in presence of Owner / Owners representative

a) Oxygen index test as per IS 10810 Part-58
b) Temperature index test as per IS 10810 Part-64
c) Acid gas generation test as per IS 10810 Part-59
d) Smoke generation test as per IS 10810 Part-63
e) Flammability tests as per IS 10810 Parts-53 and 62
f) Flame retardant test as per IS 10810 Part-61

7.0 Data to be furnished by vendor after award of contract

7.1 **Drawings / Documents for Approval:**

a) Design basis report
b) Cable sizing calculation
c) Completely filled-in Data Sheets and Schedules.
d) Technical particulars of cable cross sectional drawing, MQAP, FQAP, QA Plan (as per CEA regulation) and technical catalogues.
e) Estimated weight of cables and cable drums.
f) Experience list where cables of similar rating and sizes have been installed and are in satisfactory operation.
g) Type test certificates/reports for the equipment covered in the specification.
h) Any other drawings/documents considered necessary

7.2 **Drawings / Documents for information:**

a) Continuous current rating of the cable
b) General technical data
c) Construction details including type of material used and thickness of each material for each type of cable in a tabular form.
d) Instruction Manuals
e) Type/Routine test certificates for all types of cables included in the order and special tests on FRLS/ cables in line with applicable standard.
f) All detailed catalogues and literature of Cables supplied

B8 - 33KV POWER CABLES

1.0 33kV Power Cables

Power cables shall be provided from HT side of Inverter Duty Transformers to 33kV Pooling substation/Control room building. The design and engineering shall as per latest Indian standards or IEC standards.

2.0 Codes & Standards

Codes	Description
IS 7098	Cross linked polyethylene insulated PVC sheathed cable for (Part - II) working voltage from 3.3KV up to & including 33 KV
IS 3961/ IEC 60287	Recommended current ratings for cables
IS 3975	Low Carbon Galvanized steel wires formed wires and tapes for armouring of cables.
IS 5831	PVC insulation and sheath of electrical cables.
IS 8130	Conductors for insulated electrical cables and flexible cords.
ASTM-D -2843	Standard test method for density of smoke from the burning or decomposition of plastics.
ASTM-D-2863	Standard method for measuring the minimum oxygen concentration to support candle like combustion of plastics.
IS 10810	Methods of tests for cables.
IEC-754 (Part-I)	Tests on gases evolved during combustion of electric cables.
IEEE-383	Standard for type test of Class IE Electric Cables
IEC-332 Part-3	Tests on electric cables under fire conditions. Tests on bunched wires or cables (Category-B).
IS: 10418	Specification for drums for electric cables.

3.0 General and Installation Requirements

3.1 The cable shall be 19/33kV Grade, high conductivity stranded compacted circular aluminium conductor, Three cores, XLPE insulated, Inner PVC ST2 sheathed, metallic screened suitable for carrying the system earth fault current, conductor and insulation screened galvanized steel strip armoured with overall separate extruded PVC ST2 outer sheath, FLRS/ FRLSH /as per CEA regulation, conforming generally to I1S:7098 (part-II)-1985 and lasted amendment thereof suitable for 33kV 3 phase 50 Hz earthed system. Alternatively, HDPE Outer sheath (ST-7) with UV Resistant property as per IEC 60502-1 standards shall also be acceptable.

3.2 The insulation of each core and outer and inner sheath, shall comply with the IS: 5831. The manufacturing process shall ensure that insulation shall be free from voids. The insulation shall withstand mechanical and thermal stresses under steady state and transient operating conditions.

3.3 Method of curing for XLPE insulation shall be gas/steam curing. Conductor screen and insulation screen shall both be of extruded semi-conducting compound and shall be applied with XLPE insulation in one operation through triple extrusion.

3.4 To confine electrical field to the insulation, insulation screening consisting of two parts, namely metallic (non- magnetic) and non-metallic (semi conducting) shall be provided. The non-metallic semi-conducting shield shall be put over the insulation of each core. The insulation shield shall be extruded in the same operation as the conductor shield and the Insulation by triple extrusion process. The insulation shield shall be bonded and Strippable, on adequate heat-treatment. Metallic shield shall be provided over non-metallic portion as per provision of clause 12.4 of IS: 7098 (Part- 3)/ 1985 and amendment thereof.

3.5 The cables specifications / design shall be suitably selected as per laying final philosophy/ methodology decided during detail engineering by the Bidder considering the site environmental conditions etc. Bidder shall submit the final specification with methodology for Owner's Approval

3.6 The sheath shall be suitable to withstand the operating conditions and the desired temperature rating of the cable. It shall be of adequate thickness, consistent quality and free from all defects.

3.7 All the armouring shall be hot dip galvanized steel strip. The dimensions of steel strip shall be as per table 4 of IS:7098 (Part-II)/1985 and its latest amendment and strip shall conform to latest provisions of IS: 3975 -1988 and amendment thereof.

3.8 Extruded PVC outer sheath of type ST-2 as per IS: 5831/1984 and its latest amendment shall be applied over armouring with suitable additive to prevent attack by rodent and termite and Its thickness shall be in accordance with clause -17.32 of IS:7098 (Part-III)/1985 and latest amendment thereof. All the cables shall be protected against rodent

and termite attack. Necessary chemicals shall be added into the outer sheath compound of the outer sheath. The sheath shall be resistant to saline water, UV radiation, fungus, etc. Alternatively, HDPE Outer sheath (ST-7) with UV Resistant property as per IEC 60502-2 standards shall also be acceptable

3.9 The construction of cable shall have suitable PVC fillers laid up with insulated cores to provide substantially circular cross section before the inner sheath is applied. The fillers shall be suitable for operating temperature of the cable and compatible with the insulating material.

3.10 Outer sheath shall be of PVC as per IS: 5831 & black in colour for power cables. In addition to meeting all the requirements of Indian standards referred to, outer sheath of all the cables shall have the following FRLS/as per applicable regulation properties.

a) Oxygen index of min. 29 (as per IS 10810 Part-58).
b) Acid gas emission of max. 20% (as per IEC-754-I).
c) Smoke density rating shall not be more than 60 % (as per ASTMD-2843).
d) Temperature index of minimum 250 degC when tested as per IS 10810 Part-64
e) Average light transmission of 40% minimum when tested as per IS 10810 Part-63 (average smoke density is maximum 60%)
f) Flame test requirements as per IS 10810 Parts-53 and 62
g) Flame retardant test requirements as per IS 10810 Part-61

3.11 In addition to manufacturer's identification on cables as per IS, following marking shall also be provided over outer sheath. Cable size and voltage grade - To be embossed Word 'FRLS/ actual specification ' at every three meter - To be embossed Screen Fault current _ _KA for _ _ _ Sec. (Value of current & time shall be indicated (If applicable). Sequential marking of length of the cable in metres at every one metre -To be embossed / printed The embossing shall be progressive, automatic, in line and marking shall be legible and indelible.

3.12 All cables shall meet the fire resistance requirement as per IEEE - 383 with cable installations made in accordance with 'Flammability Test' and as per Category-B of IEC 332 Part -3

3.13 Allowable tolerances on the overall diameter of the cables shall be +\-2 mm maximum, over the declared value in the technical data sheets. Repaired cables shall not be accepted.

3.14 All materials used in the manufacture of cable shall be new, unused and of finest quality. All materials shall comply with the applicable provisions of the tests of the specification, IS, Indian Electricity Rules, Indian Elect. Act and any other applicable statutory provisions, rules and regulations.

3.15 The PVC material used in the manufacture of cable shall be of reputed make. No recycling of the PVC is permitted. The purchaser reserves the right to ask for documentary proof of the purchase of various materials to be used for the manufacture of cable and to check that manufacturer is complying with quality control.

3.16 Short circuit ratings of various sizes cable calculated for duration of one second at maximum temperature of 250º C shall be provided by vendor in GTP.

3.17 Cores of the cables of upto 3 cores shall be identified by colouring of insulation or by providing coloured tapes helically over the cores with Red, Yellow & Blue colours.

3.18 The cables shall be suitable for being installed directly in the ground, in the pipes or in the cable trays/trenches. The cables shall therefore be suitable for satisfactory operation under the tropical climatic conditions listed in the relevant clause.

3.19 Only terminal cable joints shall be accepted. No cable joint to join two cable ends shall be accepted, except if single cable length as per OEM not meet the requirement

3.20 Cable installations shall be as per latest IS 1255. Packing and marking shall be as per clause No. 18 of IS 7098 (part I)/1988 amended up to date.

3.21 **Cable identification system**

a) In addition to manufacturer's identification on cables as per IS, following marking shall also be embossed/printed on the outer sheath at an interval of three 3) meter throughout the length of cables.

i. Owner: GIPCL

ii. BIS mark

iii. Manufacturer's name and or trade mark.

iv. Year of manufacture

v. Cable code

vi. Type of cable and voltage class.

vii. Nominal cross section area of conductor and no. of cores.

viii. Progressive sequential length making at every meter.

b) Cables shall be marked as having FRLS/actual specification outer sheath at every three (3) meters.

c) The embossing/printing shall be progressive, automatic, in line and marking shall be legible and indelible.

d) Three core 19/33 kV earthed grade, cables shall constitute the following:

i. Circular stranded and compacted aluminium conductor

ii. Extruded semi conducting compound as conductor screen
iii. Extruded XLPE insulation
iv. Extruded semi conducting compound as insulation screen
v. Copper tape as metallic screen for each core
vi. Semi conducting water swellable tape with minimum 20% overlap
vii. Extruded PVC inner sheath
viii. Galvanized steel formed wire
ix. Extruded FRLS and or as per CEA regulation PVC outer sheath or HDPE outer sheath
x. Core identification shall be color coded (R,Y,B)
xi. Min Bending Radius: 20D (min.)

3.22 Cables Laying and Fitting Accessories

a) Cables inside the Sub pooling station / Switchgear area shall be laid in Galvanized Cable Trays mounted on GI steel supports, in constructed trenches with RCC raft and brick sidewalls and provided with removable RCC covers. Ladder type GI cable tray with top cover and all fittings and accessories like coupler plates, bolts, nuts, washers, brackets, elbows, bends, reducers, tees, crosses, strap, hook etc shall be provided. Proper GI support system shall be provided for cable tray.

b) Power cable shall be laid on separate tiers in line with approved guidelines/ drawings. The laying of different voltage grade cables shall be on different tiers according to the voltage grade of the cables.

c) All End termination kits, jointing kits with all required accessories and hardware required for 33kV cable terminations at both ends (including Transmission line) is in scope of Bidder. Cable end termination kit & jointing kit (if unavoidable) shall be of approved make & shall be installed by OEM certified jointer.

d) Each Transmission Line shall be of XLPE armoured cables design for site requirement with **20% additional** design margin (additional design margin shall be applied to the final calculations).

e) Cable tray shall be fabricated out of mild steel sheets with min thickness of 2 mm and for coupler plates it shall be 3 mm thick. Material of Cable tray and all its fittings and accessories shall be Hot dip Galvanized as per IS standard.

f) Suitable size clamps with all fixing GI accessories shall be provided for clamping of multicore cables at every 5 meters interval. Die cast Aluminum or Fibre glass or Nylon Trefoil clamps with all fixing GI accessories shall be provided for single core cables. Trefoil clamps shall be provided at distance of every 2 meters and on either side of bends.

Control cables shall be bunched, clamped and tied with self-locking type nylon cable ties with de interlocking facility to keep them in position.

g) Cable drums shall be unloaded, handled, stored and laid as per OEM guidelines or as per relevant IS standards. Suitable jacks or on cable wheels shall be used to unreeling the cables. All possible care shall be taken during unreeling and laying to avoid damage due to twist, kink or sharp bends. Ground rollers shall be used at every 2 meter interval for cable laying to avoid cable touching ground.

h) Suitable clearances shall be maintained between HT power-LT Power-Control cable laying in line with IS standard. Required length of cable for HT straight through joints shall be kept at each end location for future use.

i) The cable passing through openings in the cable trenches/ road /wall /floor/cable tunnel/ cable culvert shall be laid in the GI pipe /HDPE/ Hume Pipe of approved make. All opening/ entry of cables shall be provided with fire stop sealing.

j) All cable/wires shall be provided with Punched Aluminium tags only on both sides of a wall or floor crossing, on each duct/conduit entry / exit, and at every 10 meters in cable tray/trench runs. The marking on tags shall be done with good quality letter and number ferrules of proper sizes so that the cables can be identified easily. Suitable cable tray marking shall be provided. Cross ferruling shall be provided for each control cable cores.

4.0 Design Criteria

The HT 33kV power cables shall be sized based on current carrying capacity, short circuit rating and permissible power loss as per specified under relevant performance guarantee clauses. Cable shall be capable of laying in underground soil with saline water.

4.1 Current carrying capacity:

The cable shall be able to carry the full load current of the circuit continuously under the specified ambient temperature and other conditions of installation. For this purpose, suitable de-rating factors shall be considered due to:

a) Thermal resistivity of soil.
b) Ambient ground / Air temperature.
c) De-rating factor for grouping & method of laying of cables over the current ratings at normal conditions given in standards. The minimum design ambient temperature for this plant shall be considered as 50°C or as per CEA guidelines / working committee report whichever is higher.
d) Any other derating factor that may be required shall be considered during detail engineering.

4.2 **Short circuit rating:**

HT power cables, if protected by circuit breaker, shall be able to withstand the fault current of the circuit for the desired fault clearing time as per protection time grading requirement and as per statutory requirement.

4.3 **Permissible power loss:**

The power loss in HT cables shall be limited such that overall plant AC ohmic loss shall be within permissible limit as specified under relevant performance guarantee clauses.

5.0 Technical Parameters

Sl. No.	Description	Unit	Requirements
1.0	General requirements		
1.1	Voltage Grade	kV	33 kV
1.2	Core	-	Multi
1.3	Conductor Material	-	Aluminium as per applicable standards and codes
1.4	Conductor screen	-	Extruded semi conducting compound
1.5	Insulation	-	Extruded XLPE
1.6	Insulation screen	-	Extruded semi conducting compound with metallic tape screen over it
1.7	Inner Sheath	-	PVC Compound (ST-2)
1.8	Armouring	-	Galvanized steel strip / galvanized steel round wires
1.9	Outer Sheath	-	FRLS/FRLSH PVC compound (ST-2) as per CEA regulation. Alternatively, HDPE Outer sheath (ST-7) with UV Resistant property as per IEC 60502-2 standards shall also be acceptable.
1.10	Cross Sectional area of conductor		Shall be as per design calculation and no negative tolerances is permitted
2.0	System Details		
2.1	Nominal Power System Voltage	kV	33
2.2	Maximum System Voltage	kV	36
2.3	System Neutral Earthing	-	As per system requirement
2.4	Design Ambient Temperature	ºC	50 or as per CEA guidelines / working committee report whichever is higher

Sl. No.	Description	Unit	Requirements
2.5	FRLS/FRLSH as per CEA regulation PVC outer sheath required	Yes / No	Yes
2.6	Short circuit fault current capability for 1 sec	kA	As per System Design
2.7	Metallic screen ground fault current capability for 1 sec	kA	Bidder to select as per the ground fault current of the system
3.0	Specific Requirements and Quantity		
3.1	No of cores	-	As per system requirements
3.2	Quantity required.	km	As per project requirement
3.3	Cable Size	-	As per project requirement
3.4	Drum length requirement	-	As per project requirement

6.0 Tests

Cables offered shall be type tested and proven type. Routine tests as per IEC/IS standard shall be carried out on 100% drums. Acceptance tests & Special Test shall be carried out on no. of drums selected on random basis in the lot as per IS 7098 Part-I (Appendix-A) & Part-II (Annexure-D), of each type and size of cable of each lot. Bidder / Cable manufacturer shall provide the Type Test & Special Test reports as per Cl. No. 12.2 of IEC-62067.

1	Routine tests as per IEC /IS standard		
	a) Electrical resistance of conductors	-	As per IEC 60228/ IS 7098-2
	b) Partial Discharge test	-	As per IEC 60885-3/ IS 7098-2
	c) Voltage test	-	As per IEC 60502-2/ IS 7098-2
	d) Overall Diameter test	-	As per IEC 60502-2 / IS 7098- 2
2	Sample tests	-	As per IEC 60502-2 / IS 7098- 2
3	Type tests, Electrical		
	a) Bending test	-	As per IEC 60502-2 / IS 7098-2 / IS 10810
	b) Partial Discharge test	-	
	c) Tan δ measurement for cables	-	
	d) Heat cycle test	-	As per IEC 60502-2 / IS 7098-2 / IS 10810
	e) Impulse test followed by a voltage test	-	
	f) Voltage test for 4 h	-	
	g) Impulse test	-	As per IEC 60502-2 / IS 7098- 2 / IS 10810

	h) Insulation resistance measurement at maximum conductor temperature	-	As per IEC 60502-2/ IS 7098- 2 / IS 10810
4	Type tests, Non-Electrical		
	a) Measurement of thickness of insulation	-	As per IEC 60811-1-1 / IS 7098- 2 / IS 10810
	b) Measurement of thickness of non-metallic sheaths	-	As per IEC 60811-1-1 / IS 7098- 2 / IS 10810
	c) Tests for determining the mechanical properties of insulation before and after ageing	-	As per IEC 60811-1-2 / IS 7098- 2 / IS 10810
	d) Tests for determining the mechanical properties of non-metallic sheaths before and after ageing	-	As per IEC 60811-1-1 / IS 7098- 2 / IS 10810
	e) Additional ageing test on pieces of completed cables	-	As per IEC 60811-1-2/ IS 7098- 2 / IS 10810
	f) Loss of mass test on PVC sheaths of type ST2	-	As per IEC 60811-3-2 / IS 7098- 2/ IS 10810
	g) Pressure test at high temperature on insulations and non-metallic sheaths	-	As per IEC 60811-3-1 / IS 7098- 2 / IS 10810
	h) Test on PVC insulation and sheaths at low temperatures	-	As per IEC 60811-1-4/ IS 7098- 2 / IS 10810
	i) Test for resistance of PVC insulation and sheaths to cracking (heat shock test)	-	As per IEC 60811-3-1 / IS 7098- 2
	j) Water absorption test on insulation	-	As per IEC 60811-1-3 / IS 7098- 2
	k) Shrinkage test for XLPE insulation	-	As per IEC 60811-1-3 / IS 7098- 2
	l) Thermal stability test for PVC insulation	-	As per IEC 60811-3-2 / IS 7098- 2
	m) Flame spread test on single cables	-	IEC 60332-1-2 / IS 7098- 2
	n) Shrinkage test for PE over sheaths	-	As per IEC 60811-1-3 / IS 7098- 2
5	Special Tests		
	a) Oxygen index test	-	IS 10810 Part-58
	b) Temperature index test	-	IS 10810 Part-64
	c) Acid gas generation test	-	IS 10810 Part-59
	d) Smoke generation test	-	IS 10810 Part-63

	e) Flammability tests	-	IS 10810 Parts-53 and 62
	f) Flame retardant test	-	IS 10810 Part-61
6	Acceptance, Routine and Type Test for HDPE outer sheath (ST-7) cable	-	IEC 60811/ IS 7098-2

7.0 Data to be furnished by vendor after award of contract

7.1 **Drawings / Documents for Approval:**

a) Completely filled-in Data Sheets and Schedules.
b) Technical particulars of cable cross sectional drawing, QA Plan and technical catalogues.
c) Estimated weight of cables and cable drums.
d) Experience list where cables of similar rating and sizes have been installed and are in satisfactory operation.
e) Type test certificates/reports for the equipment covered in the specification.
f) Any other drawings/documents considered necessary
g) MQAP & Field quality plan as per CEA regulations
h) Cable sizing calculation

7.2 **Drawings / Documents for information:**

a) Continuous current rating of the cable
b) General technical data
c) Construction details including type of material used and thickness of each material for each type of cable in a tabular form.
d) Instruction Manuals
e) Type/Routine test certificates for all types of cables included in the order and special tests on cables in line with applicable standard.
f) All detailed catalogues and literature of Cables supplied.
g) Any other drawings/documents considered necessary

B9 – SCADA SYSTEM

1.0 SCADA

1.1 a) This Section specifies the minimum requirements for design, engineering, installation, and testing of the PV Plant Scada System. Bidder to note that for each Solar Project (per location) one dedicated SCADA system is required, which shall be placed in Inverter Station Blocks and Main Control Rooms) building.

b) The SCADA includes all the software, hardware, wiring, servers, infrastructures, Gateway, Networking Equipment, HMI, Laser Printer etc., required to provide the monitoring, control and management capabilities described in this section. The provided system shall include a Graphical User Interface (GUI) for display and representation of data. The Scada must be permanently connected to the internet and the software platform shall have the ability to be accessed remotely and locally with an HMI machine. The Scada hardware infrastructures shall be in the Control Room along with all required supporting equipment. Communication equipment installed shall be interoperable, to allow seamless integration between different vendors.

c) The SCADA system shall be designed with Redundant and HOT stand by.

d) All switchgears, IEDs, Meters, ABT meters, all other electrical equipment like, Battery charger, UPS, NIFPS etc. shall be fully integrated to SCADA system in comprehensive manner for monitoring and control with time synchronization.

e) Reliability of SCADA shall be as per CEA Technical Standards for Communication System in Power System Operations 2020 and amendments.

1.2 a) The system must be designed, engineered, and installed by an experienced integrator/provider with proven track record of successful installations. All component manufacturers must be ISO 9001 certified. All software must be modular and be programmed using open-source programming languages.

b) All software License shall be perpetual/ SCADA life.

c) In case of anti-virus software, the license shall include regular updates until the end of warranty and five (05) year's annual maintenance contract (AMC) period.

d) Any defect in the software, which may arise during defect liability period and AMC period of the system shall be fixed at no cost to the Owner. During warranty period for any fault in entire SCADA package, the fault shall be rectified within 24 hours from time of intimation given to bidder/O.E.M and system should function with all functionalities as at time of commissioning.

e) All software with license and key shall be handed over to GIPCL.

1.3 Control and monitoring of photovoltaic systems and Inverters is essential for reliable functioning and maximum yield of PV solar electric system

1.4 A common, centralized, Supervisory Control and Data Acquisition System (SCADA) is envisaged for providing control and monitoring functions related to PV solar plant, Electrical system shall be envisaged

1.5 The PLC based Scada System shall monitor, control and process alarms of all required components and be able to integrate and display information of such components in a single software platform. The Scada must accumulate functions of control, monitoring, data processing and analytics and supervision and alarm management.

1.6 The Scada should be designed and engineered with the following guidelines:

i. The system should have high availability, stability, and reliability as per CEA Technical Standards for Communication System in Power System Operations 2020 and amendments during its operations and usage.

ii. The solution should allow scalability to include the possibility of expansion of the system without rearrangement of the existing system architecture, allowing an increment just by adding equipment.

iii. Architecture should be simple and should be modular to account for system maintenance, addition and correction of features or components to the system

1.7 I&C system shall permit centralized operation of the plant from the Main Control Room in the control building. The Human Machine Interface (HMI) of the SCADA shall be housed in the Main control room in the control building

1.8 The Plant SCADA (Supervisory Control and Data Acquisition) software applications consists of acquisition and gathering of all information generated by the solar plant equipment such as fiscal meters, inverters, recombiner box, network analyzer, weather stations, data loggers and trackers.

1.9 The SCADA is composed for software and hardware, and it is designed for local and remote monitoring, historical trending, and operation of the plant. Receive in real-time plant information for all plant monitoring.

1.10 All services including specialized services necessary for proper erection, testing and commissioning of all items of the package covered under this proposal shall be arranged by the Bidder. The SCADA shall be of latest OPC version 2.05a or higher compliant and implement an OPC- DA 2.05a server as per the specification of OPC Foundation

1.11 SCADA system shall support Modbus (TCP/IP, RS-485), RTU, ASCII, IEC 61850, IEC 60870-5-101 & 104, FTPs, Licensed Web based secured remote monitoring (for 4 simultaneous users), standard protocols (Included but not limited to) to communicate with different sub system/Devices.

Web based secured remote monitoring shall work on popular web browser without need of additional software. It shall be authorized by user ID and password. User Id and password for remote view can only be changed by SCADA administrator. Internet connection for transferring data to web shall be taken by Bidder in name of GIPCL site for O&M period.

1.12 Web access through a VPN client server firewall (minimum bandwidth recommended: 1Mb/s for Upload and 1Mb/s for download) for secure transmission over IP networks

1.13 SCADA shall provide for the following control / monitoring as per CEA Technical standards and amendments

a) PV plant Monitoring– Zone monitoring at Inverter Level in case of Central inverter
b) In case of String inverter - monitoring at recombiner box level
c) Control and monitoring of Plant electrical equipment, Feeders and their energy meters (Tariff based / Performance based) etc.
d) Provision for remote Enterprise system interface for MIS
e) PPC (power plant Controller) Single PPC shall be provided at Solar Project (per location/site)..
f) Tracker System
g) Module Cleaning System dry and wet (if applicable)
h) UPS and battery chargers
i) NIFPS
j) Fire Protection System
k) Weather Station

1.14 SCADA shall have the following hardwired / Soft links to facilitate the below:

a) Weather station data (Soft link)

b) Soiling Station
c) Inverter parameters, alarms, and ON/OFF Command (Soft link)
d) Transformer monitoring (hardwired)
e) HT Switchgear all equipment including annunciator
f) NIFPS Integration with SCADA
g) UPS and Battery Charger data (Soft Link)
h) Display and storage of derived/ calculated/ integrated values
i) Tele protection, Data and Speech communication with SLDC/GETCO Substation as per CEA technical standards and regulation and amendments

1.15 5% spare IO shall be considered for engineering contingencies and 10% overall spare shall be considered for each type of module for future expansion.

1.16 Critical plant and Outgoing Feeder related parameters shall be made available online and shall also be historized, for offline analysis to track plant performance and ensure asset availability.

SCADA shall provide 1, 15, 30 minutes interval daily, monthly, and annual average of all the measurements. PPC reports shall have minimum 1 sec time resolution or as per CEA requirements. All reports shall be made available in CSV, MS Excel file type. It also generates, store and retrieve user configurable periodic report.

1.17 Provision for Licensed Web based secured remote monitoring shall be provided at least for 4 simultaneous users.

1.18 All systems shall be “State of the Art”, (Latest Technology) with a proven track record, suitable for the entire range of site ambient conditions as specified in Specification.

1.19 Entire equipment pertains to the I&C system including SCADA system shall not get obsolete within 15 years of taking over of the complete plant. The bidder shall provide spares and service support letter on O.E.M letter head for the offered systems for at least 15 years from COD.

1.20 Bidder shall ensure appealing aesthetics and ergonomic designs while selecting control room consoles, HMI equipment and furniture and obtain Owner’s prior approval for the same.

1.21 Deleted

1.22 The control system shall provide safe operation under all plant disturbances and on component failure so that under no condition the safety of plant, personnel or equipment is affected. Control system shall be designed to prevent abnormal swings due to loss of Control System power supply, failure of any Control System component, open circuit/short circuit. On any of these failures the controlled equipment/parameter shall either remain in last position before failure or shall come to fully open/close or on/off state as required for the safety of plant/personnel/equipment and as finalized during detailed engineering.

1.23 System shall be designed such that there will be no upset when power is restored. This operation shall be demonstrated by vendor during Factory Accepted Test (FAT) in the presence of GIPCL Representative.

1.24 Power plant controller (PPC) shall be provided with two processors (main processing unit and memories), one for normal operation and one as hot standby.

1.25 In case of failure of working PPC processor, there shall be an appropriate alarm and simultaneously the hot standby PPC processor shall take over the plant control function automatically. The transfer from main processor to standby processor shall be totally bump less and shall not cause any plant disturbance whatsoever.

1.26 It shall be possible to keep any of the PPC processors as master and other as standby. The standby processor shall be updated in line with the changes made in working processor. The solar plant SCADA and PPC networks shall be suitably designed, so that PPC shall directly and independently able to control the individual solar inverter. Detailed control logic in the PPC shall be finalized during detailed engineering stage.

1.27 **The cyber security program shall address the following (to be complied for 500 MW):**

a) Compliance with provisions of the Information Technology Act, 2000 (21 of 2000) and National Cyber Security Policy, 2013 as amended from time to time.

b) Implementation of the National Critical Information Infrastructure Protection Centre (NCIIPC) Guidelines.

c) Implementation of guidelines and advisories issued by Computer Emergency Response Team (CERT India) and applicable Sectoral Computer Emergency Response Team (CERT).

d) Compliance to the Central Electricity Authority (Cyber Security in Power Sector) Guidelines 2021 and amendments

e) The bidder shall conduct cyber security audit of their entire SCADA Infrastructure after commissioning of SCADA through CERT-In empanelled Auditors so as to identify gaps and appropriate corrective actions shall be taken by bidder.

f) In audit Vulnerability Assessment of SCADA infrastructure shall be carried out. If SCADA is found vulnerable to any exploits or upon any patch updates or major configuration changes, then further Penetration Testing may be carried out offline or in a suitably configured laboratory testbed to determine other vulnerabilities that may have not been identified so far.

g) Bidder shall submit the audited report and comply with the requirement if found any in audit report.

2.0 CODES AND STANDARD

2.1 The following Indian Standard Codes, unless otherwise specified herein, shall be applicable. In all cases, the latest revision of the codes shall be referred to:

Codes	**Description**
IEEE	The Institute of Electrical and Electronic Engineers
ANSI	American National Standards Institute
IEC	International Electrochemical Commission
EN	European standards
ITU	International Telecommunication Union
ISO	International Standards Organization.
ISA	Instrumentation, Systems and Automation society

3.0 DESIGN CRITERIA

3.1 DATA ACQUSITION, STORAGE AND ANALYSIS

3.1.1 The SCADA shall acquire process and analyses data. All required components shall have communication protocols compatible with the SCADA and all communication lines and infrastructures shall be included in the monitoring system. After acquisition of data the software platform shall be capable of providing the following analytics and reporting:

a) Yield and Performance Ratio (PR) calculation.

b) Display of reports, events, and alarms.

c) Creation and scheduling of reports of PV plant KPIs trends for different time scales, such as hourly, daily, monthly, and yearly.

d) Display of overall plant layout, individual equipment status and areas with colour codes for each area of the PV Power Plant in the GUI.

e) Max irradiation, annual irradiation and generation today, month and year with date.

f) Block number and 15 min generation in that block / as per the regulation requirements.

g) Any other requirement as required by GIPCL.

h) All data acquired during the lifespan of the plant must be logged, archived and available in the platform.

3.1.2 The acquired data shall be stored in local servers and periodically send to Historian. Acquisition system parameters:

a) Monitoring stations, SCADA Hardware, Accessories and Communication Link

b) Weather station

c) Inverter

d) Alarms and warnings of PV equipment

e) Main PV Plant Switch

f) Monitoring of electrical parameters of Energy Meter, MFM, PQ Meter, Numerical relay, Fire alarm panel, GPS, Transformers, Trackers

g) Data logger equipment

h) Reading of network analyzers

i) Supervisor of systems and protections (team that monitors the status of the protection low voltage and medium voltage).

j) HT Switchgear equipment

k) UPS and Battery Charger (if required) parameters

l) Any other equipment parameters required

3.1.3 The connection between different field communication devices (Inverters, network analyzers, weather station, etc.) and the server will be made through the local network installation, using switches to group equipment. The field communication devices will be located on the control box at each power station. Through the fiber optic (Single mode) the data collected from the power stations, meter and weather stations will be carried to Main switch panel into the Main Control box located at control room.

3.1.4 The Scada shall have control functions to issue commands and settings to the control enabled equipment. Control functions of the PV power plant shall include at least:

a) Remote and local curtailment of power, through issuance of commands to the PV inverters as per requirements of local grid codes and regulations

b) Control functions shall allow a reaction time for ramp up and ramp down of PV output power at a rate in compliance with local grid codes and regulations

c) Reaction time for controls and curtailment of PV inverters shall the shortest possible and must comply with local grid codes

d) All limits and thresholds shall be easily adjustable remotely and via local operator login at the HMI

e) Remote control (on/off) of PV inverters, main switchgear including setting of all parameters

f) Other required control functions not listed in this document required by local grid codes and regulations.

3.1.5 Following Meteorological Station data shall be included in SCADA

For each of the installed meteorological stations:

a) Ambient temperature, in ºC

b) Back of module cell temperature, in ºC

c) Global Horizontal Irradiance from pyranometer, in W/m2

d) Global irradiance in collector plane from a pyranometer, in W/m2

e) Diffused irradiance from pyranometer, in W/m2

f) Wind speed, in m/s.

g) Wind direction, in degrees
h) Cloud in %
i) Rain falls in mm
j) Humidity
k) Weather station communication status

3.1.6 Following INVERTER minimum data shall be included in SCADA

a) Inverter alarms including diagnostic alarm
b) DC voltage, in V DC
c) DC current from each input, in A
d) Power supply voltage, in V
e) Power supply load, in kW
f) AC output apparent power, in kVA
g) AC output active power, kW
h) AC reactive power, kVAr
i) Power Factor
j) Phase angle, in degrees
k) For each output AC phase
l) Voltage, in V
m) Current, in A
n) Active power, in kW
o) Reactive power, in kVAr
p) Apparent power, in kVA
q) Temperature inside the inverter
r) AC switch position (open or closed)
s) AC trip status
t) All other standard PV inverter parameters
u) Communication status
v) ON/OFF command to Inverter
w) Any other parameters as required by GIPCL

3.1.7 Following Energy Meters minimum data shall be included in SCADA

a) Active (kWh) and reactive (kVArh) exported energy at the output of the inverter.
b) Active (kWh) and reactive (kVArh) imported energy at the output of the inverter.

c) Frequency (in Hertz) at the output of the inverter.

d) Harmonics

e) True RMS of current (in Amperes), voltage (in Volts) and power (in kW): average, actual, maximum, and minimum, for each of the phases of the output of the PV inverter.

f) Voltage shall be measured at the middle of each pair of cables in the inverter output bus.

g) Current shall be measured by high accuracy current transformers and the point of measuring should be in the output cables of the inverter.

h) Communication status

i) Any other parameters as required by GIPCL

3.1.8 Following MV Switchgear minimum data shall be included in SCADA

a) MV AC switching cell status (open or closed) for all the cells: transformer, transmission system.

b) Transformer MV fuse trip status (blown or ok).

c) Trip status of transformer MV switch for pressure and/or temperature.

d) Communication status

e) Any other parameters as required by GIPCL

3.1.9 Following Plant Delivery Station minimum data shall be included in SCADA

a) Switching station temperature.

b) Status of each switch for each loop line, transformer and exit line (open or closed).

c) Transformer trip status from pressure and/or pressure.

d) Status of protection from the current transformer cell and its protection fuses (blown or ok).

e) Status of each protection relay.

f) Differential pressure and its status.

g) Status of cooling fans.

h) Communication status of all devices in the room.

i) Any other parameters as required by GIPCL.

3.1.10 Following Fire Protection Devices minimum data shall be included in SCADA

a) Alarm status of MV switching cell room.

b) Alarm status of Plant Delivery Station.

c) Alarm status of buildings.

d) Any other parameters as required by GIPCL

3.2 HARDWARE & SOFTWARE REQUIREMENTS

3.2.1 PV Plant SCADA, Monitoring and spare room building shall have the following feature:

a) Facility for implementation of all logic functions for control, protection and annunciation of the equipment and systems.

b) SCADA shall be provided with two processors (main processing unit and memories), one for normal operation and one as hot standby. In case of failure of working processor, there shall be an appropriate alarm and simultaneously the hot standby processor shall take over the complete plant operation automatically.

c) The transfer from main processor to standby processor shall be totally bump less and shall not cause any plant disturbance whatsoever.

d) In the event of both processors failing, the system shall revert to fail safe mode.

e) It shall be possible to keep any of the processors as master and other as standby. The standby processor shall be updated in line with the changes made in working processor.

f) The memory shall be field expandable.

g) The memory capacity shall be sufficient for the complete system operation and have a capability for at least 20% expansion in future.

h) Programmed operating sequences and criteria shall be stored in non-volatile semiconductor memories like EPROM.

i) All dynamic memories shall be provided with buffer battery backup for at least 360 hours. The batteries shall be lithium or Ni-Cd type.

j) A forcing facility shall be provided for changing the states of inputs and outputs, timers, and flags to facilitate fault finding and other testing requirements. It shall be possible to display the signal flow during operation of the program.

k) Bidder must provide suitable hardware DMZ network firewall to restrict unauthorized access to HMI/ SCADA system.

3.2.2 State of the art microprocessor-based SCADA system for Plant control and monitoring including PV solar plant, BOP systems, Electrical system. In addition, SCADA shall facilitate optimized inverter control. The performance, memory and hard disk of the workstation shall be

sufficient to fulfil the requirements specified in this document and supports its activities throughout the lifetime of the plant. Also, one number mini-PLC controller shall be mounted in each Inverter Room.

3.2.3 Human Machine Interface (HMI).

3.2.4 Two numbers Operator workstation, One Engineering workstation, one redundant historian server, one OPC Server, one laptop with EWS and OWS programming and two gateway systems (one is main and Redundant) with 24 inch" LED monitor minimum for Engineer work station and 50 inch for operator work station. Both the systems to be connected to redundant servers (24x7). The Systems to be functionally interchangeable. I.e., The function of both Engineering station and operator station shall be possible from both the systems. Operator shall be able to access all control/information related data under all operating conditions including a single processor and computer failure/hardware failure. Bidder shall provide dedicated Laptop configured to work as Operator cum Engineering Workstation.

3.2.5 All the required software to be provided including supply of Graphic interface card for implementation of control logic, operator station displays / logs, storage & retrieval and other functional requirement shall be provided. The programs shall include high level languages as far as possible. The Bidder shall provide sufficient documentation and program listing so that it is possible for the GIPCL to carry out modification later.

3.2.6 The SCADA shall include two (2) redundant Control Unit Servers working in hot-standby mode. The performance, memory and hard disk of Control Unit servers shall be sufficient to fulfil the requirements specified in this document Hard disk for archiving shall be a RAID05 system providing resilience against a single hard disk failure. The servers shall have the high reliability, easy maintenance and shall be of 19" industry standard rack-layout design with slide-out rails, collapsible, high resolution. As a minimum, the servers shall meet at least the following:

a) Redundant monitored power supply, hot pluggable
b) Monitored cooling fans
c) Redundant hot pluggable, hot swappable hard disk array
d) Power supply: redundant from UPS

3.2.7 One number A4 colour Laser printer equipped for colour laser printing, scanning, copying and faxing facility.

3.2.8 Redundant Server based Network Panels including Network switches, Remote wireless connection related interface devices etc.

3.2.9 The Bidder shall provide standard hardware and software configurations to the extent possible if it meets or exceeds the requirements of this Specification. International standards shall be applied for hardware and software interfaces to allow system expansion in terms of equipment and software functions (if required).

3.2.10 Licensed software copy required for the proposed system shall be provided. The latest proven antivirus software shall be installed in the SCADA

3.2.11 All logins to the system shall be password protected. Data transmission via public internet shall be encrypted.

3.2.12 Application software, MIS software & HMI software to meet the specified functional requirements of SCADA.

3.2.13 Sequence of Events recording and annunciation system – integral to SCADA system.

3.2.14 Historization and archiving relevant data for analysis.

3.2.15 Interposing relays, isolators as required.

3.2.16 Control desk, Control panel, system / marshalling cabinets, as required.

3.2.17 All Instrumentation & Control cables, serial link cables, single mode / Multi mode armored fiber optic cables, SCADA system cables etc., between any two-system supplied by Bidder.

3.2.18 2x100% Redundant 230VAC UPS for SCADA, mini-PLC in PVCS. UPS shall be provided as per CEA requirement or 4 hours battery backup whichever is higher.

3.2.19 Required Power Distribution Boards as required for distributing the UPS / other power supplies to all consumers of the total system.

3.2.20 MIS Server for Enterprise network interface.

3.2.21 Dedicated Earthing system (separate electronic and frame earth).

3.2.22 Emergency local push buttons.

3.2.23 Control panel to be in Control room, with operating, monitoring hardware and Annunciation system as per system requirement.

3.2.24 GPS Master clock-They shall be connected, and time synchronized via the Global Positioning System (GPS). All measured data, events, alarms, logs etc. shall be time stamped with a 1msec resolution. A master clock (e.g., via GPS) shall be provided and shall be used for time synchronization of all auxiliary systems and equipment of the PV power plant such as Meteorological Measurement Station, etc.

3.2.25 The Scada shall be based on standard proven firmware and software, which shall already be implemented in other systems. The software engineering tool shall be provided to configure, set up and modify the data acquisition, data processing and database system components. The software application shall include facilities to perform programmable logic functions.

3.2.26 The system shall have monitoring and self-diagnostics features for both, hardware, and software. Licensed software copy required for the proposed system shall be provided. The latest proven antivirus software shall be installed in the SCADA. All logins to the system shall be password protected. Data transmission via public internet shall be encrypted. Application software, MIS software & HMI software to meet the specified functional requirements of SCADA. Sequence of Events recording and annunciation system – integral to SCADA system. Historization and archiving relevant data for analysis.

The Bidder shall provide software license for all software being used SCADA system. The software license shall be provided for the project (e.g., Organization or Site License) and shall not be hardware/machine specific. That is, if any hardware/machine is upgraded or changed, the same license shall hold good, and it shall not be necessary for GIPCL to seek a new license/renew license due to up gradation/change of hardware/machine in SCADA system at Site. All licenses shall be valid for the continuous service life of the plant. All SCADA software with license shall be handed over to GIPCL. All hardware and software shall be licensed to GIPCL.

3.2.27 **PARAMETRIC REQUIREMENTS**

The control system shall be designed such that under worst case loading conditions the response time shall not be worse than the following: -

a) On/Off Command: - The response time for screen update after the execution of the control command from the time the command is issued shall be one second (excluding the drive actuation time).

b) Adjustment Command: - 0.5 to 1 second.

c) On screen Updating and All Control related displays: - 1 second.

d) Bar Chart displays, Plant Mimic displays, Group review displays, X-T Plot Displays and Plant Summary Displays: - 1 to 2 seconds.

All the Analog data shall be scanned at the resolution of 1(one) second and refreshed on screen however, recording of data shall be as finalized during detail engineering.

3.3 PLANT PERFORMANCE CALCULATION & TRACKING IN SCADA SYSTEM

3.3.1 SCADA shall have provision to calculate and display the following:

a) Performance Ratio.

b) Energy yield

c) Day, month, annual generation curves etc.

d) Displays shall also include current and histories trends for generation curve, yield curve, module temperature variations, wind velocity, radiation variation etc.,

e) Individual Inverter performance shall be tracked and displayed.

3.4 ARCHIVING SERVER SYSTEM

3.4.1 Multiple, dedicated RAID disk systems shall be provided in all servers, to maximize system throughput and minimize data exchange delays.

3.4.2 Disk drives that make up the RAID array shall be hot pluggable and be capable of being replaced online. The system shall be capable of automatic recovery from a single disk drive failure.

3.4.3 Each disk array's total capacity shall be expandable in configuration and adding more drives, with no requirement to physically shutdown of the disk array and restart the system.

3.4.4 Minimum capacity of the data disk array that is useable data storage shall be 1TB and shall be of sufficient qty to store data for duration of three (3) years.

3.4.5 For regular backup of the RAID data storage array a Network Attached Storage unit (NAS) shall be provided. The unit shall have a sufficient capacity to allow:

a) Complete backup of the whole server and workstation operating system files and application programs – this backup to be done by the system administrator on monthly basis. Only one historical backup and one actual backup shall be maintained on the storage unit.

b) The unit shall be capable to ensure backup capacity of those files for a continuous period of 6 months. An alarm shall be raised when the NAS capacity decreases to less than 20%.

3.4.6 Equipment for automatic backup of operator workstation and Central Unit Servers shall be provided. Removable media (e.g., hard disk, DVD or similar) shall be provided to enable storage of backups

3.5 INVERTER TRIP ANALYSIS

Inverter trip mechanism and settings shall be tuned site specific to match with the evacuation system requirements. Inverter trips and causes of trips shall be logged with a sequence of events recording feature of SCADA with millisecond resolution.

3.6 HISTORIZATION AND ARCHIVING

a) Data temporarily stored in inverters memory shall be periodically acquired in PLC hard disk. Data logging shall be envisaged for various environmental and PV plant system related parameters and shall facilitate detailed overview about the whole system. User configurable trend and Report formats shall be available.

b) Alarm, Event, Periodic plant data, selected logs/reports History shall be available for archiving.

c) The Historian shall collect, store and process system data from SCADA data base. The data shall be saved online on hard disk and automatically transferred to nonerasable long term storage media once in every 30 Days periodically for long term storage. Provision shall be made to notify the operator when hard disk is certain percentage full.

d) The system shall provide user-friendly operator functions to retrieve the data from historical storage. It shall be possible to retrieve the selected data on operator cum engineering workstation in form of trend/report by specifying date, time & period. Further, suitable index files/directories shall also be provided to facilitate the same.

e) In addition to above, the system shall also have facility to store & retrieve important plant data for a very long duration on portable external long term storage media. Bidder shall provide two numbers of portable external hard drive of 2TB each.

f) For long term plant performance analysis, the following plant data as a minimum with time stamping and interval as indicated in below table but not limited to shall be stored daily on historian.

g) Important plant data for a very long duration (plant life) Storage on Historian

Sl.	Parameter	Time Interval *
1	**Weather Monitoring Stations data:** Global Horizontal Irradiance, Global Inclined Irradiance and Diffuse Horizontal Irradiance, Ambient Temp, PV Module Temperature, Wind Speed, Wind Direction, Rain Fall and Relative Humidity.	1 (One) Minute
2	Calculated Daily Global Horizontal Insolation, Global Inclined Insolation and Diffuse Horizontal Insolation.	24 (Twenty-Four) Hours
3	**Inverters:** DC Voltage, DC Power, DC Current, SMB/SMU Current (Inverter end), AC Active & Reactive Power, Power factor, AC Current & Voltage, Energy, Inverter room temp, Inverter Cabinet temp and Modules Temp	1 (One) Minute
4	**MFM, Energy meter and Numerical Relay data: -** Active & Reactive Power, Energy (day), Current and Voltage	1 (One) Minute
5	**Export feeder/s Energy Meter Data: -** Active & Reactive Power, Energy import and export, Current and Voltage and Grid Frequency	1 (One) Minute
6	Daily energy export from each Inverter	24 (Twenty-Four) Hours
7	Total sum of daily energy export from all Inverter	24 (Twenty-Four) Hours

* The time interval shall be in compliance with relevant CEA regulation / RLDC/ SLDC/GETCO requirement etc.

3.7 OVERALL SCADA PERFORMANCE REQUIREMENTS

a) All equipment shall be of high quality and reliability. The overall system availability of the shall be 99% or better.

b) Loss of monitoring data shall be avoided by means of redundant hard disk drives or RAIDs and an appropriate automatically operating backup technology for removable media.

c) The SCADA Manufacturer shall provide service support for minimum 15 years.

d) Diagnose performance issues (soiling, incorrect alignment) detection and alarms Optimize solar farm operations and maintenance (panel cleaning schedule)

e) Track Module performance, weather monitoring system data, irradiance

f) Evaluate long-term system reliability and performance, inverter failure rate etc.

g) Track System Losses to provide basis for upgrades

h) Online “Overall Photovoltaic System Performance Monitoring” as per IEC 61724

i) Alarm detection and management and alerts to minimize the equipment downtime.

j) Integrated Reporting system to meet compliance requirements

k) Online Weather-corrected PR calculations for mapping consistent results throughout the year, as a metric for performance guarantees & for use in predicting actual annual system yield

l) Remote connection to Module, Inverter OEM Centers for remote diagnostics and immediate corrective actions (Optional)

m) Online calculation and reporting of carbon credits under CDM.

3.8 SCADA GRAPHICAL USER INTERFACE (GUI) REQUIREMENTS

a) HMI configured around latest state-of-the art servers/Workstations with open architecture supporting OPC /TCP/IP protocols, etc.

b) Display of status of major equipment in Single Line/Mimic Diagram. Mimic Diagram colour shall comply to IS 11954: Guide for colour coding of electrical mimic diagrams.

3.8.1 Screen shots shall cover topography of the layout with dynamic colour change based on generation Daily plant PR, plant down time and the cumulative inverter down time shall be displayed on the main screen.

3.8.2 Clear indication of screen for Summary, IR, Block, SLD DC, SLD AC, SLD Communication Architecture, Customized and defined Report, Data Flow to SLDC, String / SMB, Tracker, Alarm, Trend to choose and drop any parameter for comparison graphically.

3.8.3 Operation of plant along with central restriction for load to be injected.

3.8.4 From the main screen plant layout, one should be able to enter any specific block by pressing on that block in the plant layout Overview Screen

3.8.5 In the inverter summary page, the fault description shall be indicated.

3.8.6 All weather station data, meter data, relay data (numerical relay, protection relay etc.,) shall be displayed block wise.

3.8.7 Fault locations (E.g., Earth, LV/HT panels) shall be displayed.

3.8.8 On the Outgoing Feeder screen, the AC SLD should be displayed. All circuit breakers, positions should be displayed and controllable remotely (with layered security access) from this page. Another pop-up should allow navigation to details of the switchgear panels which should display (red/green) the mimic diagram, and all alarms and positions of switches. Transformers winding temperature & oil temperature should be displayed and logged. Grid failure indication and battery charger failure indication should have displayed here and the main screen as well. The mimic shall be configured on the HMI, and it shall be possible to control, monitor and operate the plant from the same.

3.8.9 All transformers winding temperatures & oil temperatures in each block should be displayed and logged.

3.8.10 SCADA access should be layered as per criticality and each layer should be password protected.

3.8.11 Remote access of the system should be layered, and password protected.

3.8.12 On the main screen, actual power of each inverter shall be monitored with the other inverters and if the difference is more than a set value (e.g., 10 kW), an indication / alarm should appear on the front screen for that inverter tag

3.8.13 The graphical display should allow plotting plant AC power, plant DC power, GHI, GTI, average irradiation of all pyranometers, and individual irradiation of all pyranometers, Module surface temperature & ambient temperature values.

3.8.14 There should be separate generation of all Event logs, Fault logs, inverter logs (including individual inverter down time), alarm logs, transformer winding and oil temperature logs.

3.8.15 All the above specified data shall be available in SCADA for the last 30 days.

3.8.16 Alarm signals shall be accompanied by hooter /Buzzer.

3.8.17 The SCADA shall have a view displaying a connection single line diagram with different voltage levels. The current state of all equipment/plant sectors shall be displayed using a colour code.

3.8.18 The equipment access structure should be organized in a logic hierarchy. When selecting equipment in the platform, a new view shall be shown with detailed information and the appropriate graphs or tables (power, currents, availability, etc.) about the device.

3.8.19 The main view shall be a plant map with different areas corresponding to each inverter.

3.8.20 Each different section of the plant named, and its status shall be distinguished by colour gradient from green to red, with full red being an error/alarm. When selecting a section, it shall trigger a detailed view of all information relating to that section.

3.8.21 The main view shall include a section of the screen dedicated to display information of total production and of also of each plant sector.

3.8.22 In other data directly from the plant we will have a record of historical data, alarms and events. These historical are represented by tables or diagrams.

3.8.23 The above data shall be available via the Web portal.

3.8.24 The operator workstation shall have minimum but not limited to the following interlinked display graphics:

a) PV Power Plant Overview with user adjusted real time data display.

b) PV Plant Single Line Diagrams representation with overview and details for different voltage levels for all main electrical equipment including presentation of real time data and status (open/closed switches).

c) System parameter setting and command issuance management with command log and settings change log; The system shall have built-in safety features that will allow/disallow certain functions and entry fields within a function to be under password control to protect against inadvertent and unauthorized use of these functions. Assignment of allowable functions and entry fields shall be based on user profile. The system security shall contain various user levels with specific rights as finalized by the

GIPCL during detailed engineering. However, no. of user levels, no. of users in a level and rights for each level shall be changeable by the programmer (Administrator).

d) Alarm and event management system including alarm and event list.

e) SCADA architecture along with communication network status.

f) Diagnostic screen including overall system architecture and status.

g) User configurable and adjustable views.

h) Programming of the SCADA and Historian shall be user friendly with graphical user interface and shall not require knowledge of any specialized language. For example, Flow-chart or block logic representing the instruction graphically or Ladder Logic, etc.

i) The programming of SCADA (like development and modification of data base, mimics, logs / reports, Historian functionalities etc.) shall also be possible through user-friendly menus etc.

j) All programming functionalities shall be password protected to avoid unauthorized modification.

3.9 SCADA ACCURACY AND COMMANDS / FEEDBACKS

3.9.1 The overall system accuracy from signal input terminals to output presentation on display and printers for the least accurate input range and maximum scan rate shall not be worse than + / - 0.1% of full scale of the engineering process range + / - 1/2 LSB for 4 - 20 m A input.

3.9.2 Monitoring of UPS, DC system, Weather station shall be included

3.9.3 Control and monitoring of all plant electrical equipment from Plant control room mounted consoles shall include – all HT/LT breakers, etc.,

3.9.4 Monitoring shall include surge protection device monitoring, Inverter, Transformers, Relays (numerical and microprocessor-based protection relays), ABT Meters, MFM Etc..

3.9.5 Virus scanners, Malware scanners, firewalls etc., shall be envisaged to protect SCADA system

3.9.6 Control of Electrical Equipment (Hardwired)

3.9.7 **Commands:**

a) Two Remote Commands from SCADA system to HT SWGR- Start /Stop.

b) Individual interposing relays for the above two commands shall be provided and mounted in respective SWGR. SCADA digital output (24 V DC) shall drive these relays.

3.9.8 **Feedbacks:**

a) SCADA shall include minimum 6 numbers of feedbacks (potential free contacts) for the following:

b) Breaker - ON

c) Breaker - OFF

d) Lockout relay activated

e) Trip circuit healthy

f) Breaker available

g) Breaker in Local/Remote

3.9.9 ABT Meters and multifunction meter interface to comprehensive data to SCADA

3.9.10 Protection relay interface to provide individual protection activated, deactivated signals with time stamping

3.9.11 Operator Interface Graphics shall include

a) Control displays

b) Online Performance calculations (Management information system)

c) Configurable trends, X-Y plots

d) SER (sequence of events recording) with time tags

e) Configurable logs /Reports etc.,

f) AC/DC SLD

g) Electrical Mimics

h) SMJB status

i) Inverter displays

j) Description of system architecture offered for this project (plant network, control network etc.)

k) Alarm (alarm segregation, history collection) & Event management (including sequence event recording) and alerts to minimize equipment downtime

l) Graphic implementation philosophies (Colour code, display builder settings, symbol philosophy pop up behavior, Font behavior, logs, phase plate display of controller & other electrical systems etc.)

m) Logic implementation philosophies

n) Hardware & Software diagnostics

o) System redundancies in Power supply, communication, controller etc.

p) Trend display & configuration

q) Mimic display for plant and different systems

r) Disturbance recording

s) Remote access facility

t) Grid synchronization details

3.10 SOLAR PV PLANT PERFORMANCE TEST

3.10.1 Integrated site performance test of PV plant, using SCADA shall be envisaged. The test would include verifying AC/DC losses and calculation of Performance Ratio.

3.10.2 Solar Modules are free Supply to the Bidder. Hence the following shall be specifically confirmed.

a) Overall Plant performance shall be carried out as per relevant sections specified in this tender.

3.10.3 The PV Plant performance test will be completed if the following is satisfied:

a) The transmission of all signals as required by the Grid Code is established.

b) The facility operates in accordance with the set point values for:

i. Active power

ii. Reactive power (maximum leading reactive power and maximum lagging reactive power) (those set values will be agreed by the parties and approved by the Testing Expert)

3.11 EARTHING

Separate safety earth for enclosure and electronic earth for electronic modules with dedicated earth pits

3.12 CABINETS

3.12.1 Central Unit Servers and associated accessories shall be accommodated in dedicated equipment cabinets.

3.12.2 For indoor application, the cabinets shall be constructed as follows

a) Standard sized steel cabinets with external painting colour as per Client's approval.
b) Certified for minimum IP31 protection class.
c) Power distribution box with main filter and main switch (separate 2-pole breakers for each device).
d) Front-patches for LAN cabling.
e) Cable organizers, cable trays, suspensions, and termination components with strain relief for all internal and external cabling.
f) Overvoltage protection for all devices (if applicable).
g) Housing space for future equipment.
h) Ventilation fan to ensure proper equipment working temperature.
i) Bottom cable access.
j) Document pocket.
k) Grounding bus bar for grounding connections.
l) Doors with glass front and locking system.
m) Inner light and power socket for maintenance.
n) Provision of easy access for maintenance and repair, all devices with rear plugs shall be under a drawer type rack.

3.13 ALARM AND EVENT MANAGEMENT

3.13.1 All alarms including system alarms and important events shall be listed up on the display. The lists shall be in chronological sequence showing:

a) Time stamped, the precise date and time with the specified resolution in actual sequential of events shall be shown.
b) Clear identification of device alarm with clear text/denomination of alarms and/or events and status message (open, close, off, high, low). For the case of analogue values, the values shall be shown along with the thresholds.
c) Sorting of alarms per subgroup shall be possible.

3.13.2 Flashing functions of alarm messages shall be according to standards related to conventional alarm. The flashing frequency for coming and going alarms shall be adjustable. Alarms shall be checked to be cleared.

3.13.3 Automatic and configurable generation of typical reports with user selected variables shall be supported. It shall be possible to print the generated reports and export to common file formats. The format of the logs and reports shall be subject to the approval of the Client.

3.14 COMMUNICATION NETWORK INFRASTRUCTURES

DATA COMMUNICATION SYSTEM

The Data Communication System shall include a redundant Main System Bus with hot back-up. Other applicable bus systems like cubicle bus, local bus, I/O bus etc shall be redundant except for backplane buses which can be non-redundant.

Redundant fault tolerant armoured optical fibre ring shall be between PLC/SCADA of Inverter Station Blocks and SCADA of Main Control Building. Bidder shall submit SCADA architecture drawing. Each optical fibre shall have minimum 4 nos. of spare fibre. All optical fibre shall be spliced in LIU with all required accessories.

3.14.1 The following are minimum features:

a) Redundant communication controllers shall be provided to handle the communication between I/O Modules (including remote I/O) and PLCs and between PLCs and operator workstation.

b) The design shall be such as to minimize interruption of signals. It shall ensure that a single failure anywhere in the media shall cause no more than a single message to be disrupted and that message shall automatically be retransmitted. Any failure or physical removal of any station/module connected to the system bus shall not result in loss of any communication function to and from any other station/module.

c) If the system bus requires a master bus controller philosophy, it shall employ redundant master bus controller with automatic switchover facility.

d) Built-in diagnostics shall be provided for easy fault detection. Communication error detection and correction facility (ECC) shall be provided at all levels of communication. Failure of one bus and changeover to the standby system bus shall be automatic and completely bump less and the same shall be suitably alarmed/logged.

e) The design and installation of the system bus shall take care of the environmental conditions as applicable.

f) Data transmitting speed shall be sufficient to meet the responses of the system in terms of displays, control etc. plus 25% spare capacity shall be available for future expansion

g) Cat 6 UTP or fiber optic cables shall be employed.

h) The Bidder shall furnish details regarding the communication system like communication protocol, bus utilization calculations etc.

i) Bidder shall setup Gigabit Ethernet based Plant Local Area Network (LAN) to connect to different communication nodes at Inverter /Switchgear location etc. with redundant backbone using ring or better topology.

j) . Each Modbus cable shall be provided with Surge protection device at SCADA Panel End. Specification of OFC and Modbus cable has been given elsewhere in this specification.

3.14.2 The network infrastructures of the SCADA, includes all hardware, wiring, connections, and equipment required to comply with the specifications defined herein. These components and hardware include, but not limited to cables, accessories, converters, repeaters, amplifiers, switches and routers, servers, UPS, equipment including accessories, their housing as required, as well as the management systems necessary to operate the data communication network.

3.14.3 The network design must include redundancy and account for reliability and availability as a design factor. All Ethernet infrastructures shall have a minimum data rate of 100 Mbit/s.

3.14.4 Uninterrupted power supply for the SCADA shall be provided by a UPS. All servers and data archiving servers shall have redundant power supply modules.

3.14.5 The Bidder shall perform all cabling and installation works for outdoor and indoor equipment as well as the interface interconnection and termination at existing devices.

3.15 INDUSTRIAL ETHERNET SWITCHES (MANAGED TYPE)

Industrial Ethernet Switches foreseen for installation shall provide the following:

a) Compliance: IEEE 802.3 ISO/IEC 8802/3
b) Technology: Store and forward
c) Filtering Services/prioritization: IEEE 802.1 D/p
d) Port type: Min 100 Mbps Media as necessary
e) Diagnostics: Indication of power status, link status, data, full duplex, link failure (fiber disconnected)
f) Management: SNMP, HTTP
g) Design: Fan less
h) Mechanical design: Stability against shock and vibration
i) Min. operating temp. range: 0°C - 55°C
j) Rel. humidity: 0% - 100%

k) Diagnostics: LEDs for indication of power status, link status, data, full duplex, link failure (fiber disconnected)

l) EMC: EN 55022, EN 50082-2

m) VLAN support: IEEE 802.1Q, MAC Address / Port Based

n) MTBF: >20 years

3.16 **LAYOUT OF "PV Plant SCADA, monitoring and spare room" building**

3.16.1 An air-conditioned PV Plant SCADA control room in Main Control room building and ventilated SCADA room in Inverter station block, shall be provided for SCADA.

3.16.2 All furniture for control room mounted equipment shall be supplied and shall be subject to Owner approval.

3.16.3 Plant control desks, system and marshalling cabinets shall be complete with all instruments and control equipment duly mounted and pre-wired.

3.16.4 The Bidder to submit the proposed drawing of control room building and inverter station block room for Owner's review.

4.0 TECHNICAL DATA SHEET

SL. NO.	DESCRIPTION	REQUIREMENT
1.0	SCADA	SCADA system shall support Modbus (TCP/IP RS-485, RTU, ASCII, IEC61850, IEC60870-5101 & 104) standard protocols (Included but not limited to) to communicate with different sub system/Devices
1.1	SCADA Interface	Latest OPC version 2.05a or higher compliant and implement an OPC- UA or DA 2.05a server as per the specification of OPC Foundation
1.2	System offered	Make / Architecture / Configuration Drawing to be enclosed

SL. NO.	DESCRIPTION	REQUIREMENT
1.3	Year of launching of the system in the market	Bidder to specify
1.4	**Technical Features of SCADA system**	
1.4.1	Operating System	Latest /As per monitoring design
1.4.2	UPS (2X100% Redundant or HOT STAND BY) 230 V AC, 1Ø, 50 Hz	UPS (Power supply 12-24V is required to be derived by bidder)
1.4.3	Power Consumption	As per monitoring design, bidder to indicate
1.4.4	Modules – type and Manufacturers	a) Time / clock interface dev. b) EIU (Electrical Interface Unit) for data acquisition c) DS (Data server) d) CU (Control units) e) I/O Modules f) Graphic Interface modules g) Communication Modules h) Workstation i) I. Archive Server
1.4.5	Environmental conditions description	To be Compliant with project requirement
1.4.6	Minimum operation temperature	+5°C
1.4.7	Maximum operation temperature	+50°C

SL. NO.	DESCRIPTION	REQUIREMENT
1.4.8	Maximum Humidity	100% relative indoor
1.4.9	Cycle time Data In to command out	10ms
1.4.10	PV power curtailment rate	Minimum: 10%/sec
1.4.11	Programming Capacity	As per monitoring design
1.4.12	Data handling Capacity	As per monitoring design
1.4.13	SCADA Precautions	RAID 5 Access per password
1.4.14	Response time	a) Scanning rate of maximum 1 second for measurement analog signals system parameters b) Loop execution time- 200 ms (max) for all loops including for CLCS input scan. c) Loop execution time: 100 ms (max) for all loops including for OLCS input scan. d) Scanning rate of: Programmable 50 -100 ms (max.) digital signals e) Update time of 1 second or better. display OLCS / CLCS f) Time for display in 1 -2 seconds. screen on operator's request g) Keyboard command to field equipment to be executed in less than 1 second. h) The communication network in any case shall not be loaded more than 50% under worst case data loading i) Under worst system loading conditions, the controller loading to be limited to 50% within the specified scan / loop response time and

SL. NO.	DESCRIPTION	REQUIREMENT
		screen update times after considering all specified spare I/O channels, modules, and slots.
1.4.15	Auto switchover time to backup/redundant component at a) Processor level b) Communication level c) Power supply level d) I/O module level	a) Transfer from main to hot standby shall be Instantaneous and bump-less. (Bidder to indicate the switchover time) b) During switchover, by default, outputs shall be held stay put
1.4.16	Display Call up time in HMI	1 -2 sec
1.4.17	Dynamic update time of parameters in the HMI monitor	1sec
1.4.18	Spare Memory capacity required in the control processor (after considering spare I/O channels, modules, slots)	Minimum 40 %
1.4.19	Output status on controller failure	Configurable in Engineering station
1.4.20	Output status on power supply failure	Configurable for switching to fail safe mode
1.4.21	Status indication for each channel in card	LED indication required

SL. NO.	DESCRIPTION	REQUIREMENT
1.4.22	Power supply healthiness status in all modules	LED indication required
1.4.23	Optical Isolation for DI / DO	Required
1.4.24	Galvanic isolation for AI / AO	Required
1.4.25	Spare capacity in RAM	Minimum 40 % including spare I/O
	Processor Redundancy	Dual redundant hot stand-by
	Software	Required software including application software, MIS software, HMI software
1.4.26	Battery backup for RAM	Rechargeable Ni. Cd /Flash RAM
1.4.27	Duration of battery backup for dynamic memory	72 Hrs.
1.4.28	Server	a) Industrial grade server b) Based on latest state of art Servers c) Technology suitable for Power Plant Requirement d) Redundant Power supply e) Redundant Communication controllers f) Power Fail Auto Restart (PFAR) g) Rack / blade / Tower type Redundant and HOT STAND BY server with dual power supply port h) Operating system- /latest i) Antivirus & MS office software- Latest j) No of HDMI & VGA ports: 1 (Minimum) k) RAM- 8 GB RAM or better

SL. NO.	DESCRIPTION	REQUIREMENT
		l) Hard disc-Min. 1 TB hard, RAID 5 configuration m) Processor: 64-bit server grade Xenon or equivalent, Octa core minimum n) Processor speed- 3.1 GHZ, 64 bits o) Monitor-24" inch and 50" inch LED MONITOR p) No: of USB port: 2(minimum) q) No: of Ethernet port: 4(minimum) r) DVD R/W feature s) Storage Capacity=1 year
1.4.29	Communication Port	a) Modbus RTU b) TCP/IP c) Ethernet 60780-5-104 d) RS 232 e) RS 485 f) OPC RDI g) Others: to be named
1.4.30	I/O modules	Online insertion/replacement of modules to be supported
1.4.31	Signal type analog (Type and quantity to be named)	4 – 20 mA 0 – 10 V Others to be named Galvanically separated Resolution: 12 bits Number of inputs /outputs per card
1.4.32	Signal type digital / binary	Voltage rate: Contacting loads: Number of inputs /outputs per card

SL. NO.	DESCRIPTION	REQUIREMENT
1.4.33	Cable connection	Terminated screwed Wire wrap Plug In Others:
1.4.34	Maximum number of channels in I/O modules -	Analog I/O modules - 16 Channels RTD, Thermocouple - 16 Channels Digital I/O modules - 32 Channels
1.4.35	Power supply to the field transmitters /	Analog input module shall drive the connected field transmitter on 2 wire loops
1.4.36	Interrogation voltage for Digital signals	24 V DC
1.4.37	USB ports on Operator station	4 no’s (minimum)
1.4.38	Displays on HMI monitor	Process mimic displays, trend displays, system status, alarm displays, logs / reports etc.
1.4.39	Minimum no of plant mimics	75
1.4.40	Time activated logs	Periodic logs, shift report, daily report, status change log, Control system fault log etc.,
1.4.41	SER / Annunciation System	Integral SER with one m sec resolution for 256 points, Integral Annunciation with HMI display.
1.4.42	Password protection	Included
1.4.43	Programming language	English

SL. NO.	DESCRIPTION	REQUIREMENT
1.4.44	Printers	One (1) number A4 network printer colour laser jet printer,
1.4.45	Interface with Other systems	Through redundant, proven Industrial communication links
1.4.46	Spare Channels in I/O Modules	10 % (wired up) spare channels over the entire population of each type of module.
1.4.47	Spare slots in the I/O rack	20% additional slots in each rack
1.4.48	Fuse for I/O channels	Individual for analog signals Group of max 8 for digital channels
1.4.49	Diagnostics	As per monitoring design/Extensive self-diagnostic features to monitor completely the software and hardware faults in the system. Hardware diagnostic up to card/component level shall be provided.
1.4.50	Test facilities	included
1.4.51	Interposing Relays.	24 V DC with freewheeling diode across the coil – Relay contact rating shall be 5A at 240 V AC
1.4.52	Cabinets to be in control room	Self-Standing type with maximum height of 2200mm
1.4.53	Height /Width/Depth	Bidder to specify
1.4.54	Weight	Bidder to specify
1.4.55	No. Of cabinets	Bidder to specify

SL. NO.	DESCRIPTION	REQUIREMENT
1.4.56	Construction	Steel ,19" rack mounting
1.4.57	Mechanical features of PLC cabinet	a) Minimum 2mm thick CRCA b) 3mm removable gland plate c) 2.5 mm thickness for double doors d) door switch operated light e) Fans f) IP31 in A/C rooms and IP65 enclosure outdoor g) Smoke detector in PLC cabinet h) All accessories as required
1.4.58	Panel Earthing	Separate Safety earth for enclosure and electronic earth for electronic modules with dedicated earth pits.
1.4.59	Quality Assurance	As per OEM quality plan to be approved by the Purchaser / Consultant
1.4.60	Remote interface to OEM facility etc.,	Wireless communication if required
1.4.61	Factory Inspection Requirements	Integrated test at factory for SCADA, PLC, HMI, Printer
1.4.62	Approved makes of PLC	SCADA system, including PLC shall be of the same make based on Owner's approved make.
1.4.63	Software	a) All necessary software required for implementation of control logic, operator station displays / logs, storage & retrieval and other specified functional requirement shall be provided. b) All system related software including Real Time Operating System, File management

SL. NO.	DESCRIPTION	REQUIREMENT
		software, screen editor, database management software, online diagnostics/debug software, peripheral drivers, software, serial link software, remote interface software and latest versions of standard PC-based software and latest WINDOWS based packages etc. c) Soft l link software, Remote interface software, etc., which shall comply with the requirements on the other side. d) ABT software, MIS software, as applicable
1.4.64	Industrial standard Serial Links	As specified
1.4.65	Number of Controllers	Bidder to specify
1.4.66	SCADA Electrical function requirements: • Control • Interlocking function • Emergency operation • Graphic mimic display • Synchronism & Energizing check • Analog measurements • Event Recording function • Disturbance Recording • All Switchgear Feeder protection functions	
1.4.67	Network Management system: • Configuration Management • Fault Management • Performance Monitoring	

SL. NO.	DESCRIPTION	REQUIREMENT
1.4.68	Redundant Armoured 8 core minimum Fibre optic cables shall be supplied for the Redundant FO ring. CAT-6 Ethernet cable to be provided wherever applicable for local wiring within the building only.	
1.4.69	Ethernet switch/Network switches: • Redundant, Manageable type • Redundant power supply • Min 2 no's of spare port • Min refresh rate of 1 sec • Shall accept both IEC 61850 as well as Modbus TCP/IP, RTU network	
2.0	**GPS Master Clock system**	
2.1	Make & Model no. Latest make and model supports SNTP	
2.2	The system shall be linked to Global Positioning satellite and shall include GPS antenna, GPS receiver, comparator units, signal processing & multiplexing unit etc. Accuracy +/- 1µSec or better.	
2.3	System shall be with redundant configuration: i. GPS Receiver: Microprocessor based ii. Tracking method: Code / Carrier tracking iii. Output data format: NEMA 0183 iv. Communication speed: > 9600 BPS v. Output rate: every second vi. Signal Processing Unit: Microprocessor based Digital type vii. Overvoltage Protection	
3.0	**Operator / Engineering Stations**	
3.1	Monitors	Full HD LED

SL. NO.	DESCRIPTION	REQUIREMENT
		Min. 24inch for engineering and 50 inch for operator station No: of USB port: 2 No of HDMI and VGA ports: minimum 1 port each Refresh rate- min 75 Hz Graphic Memory: 16 MB
3.2	Keyboard	Qwerty type (ASCII)
3.3	Mouse	Optical type
3.4	Slots and devices	DVD 16X or higher USB SDHC Others to be named
3.5	Interfaces	Ethernet: 4nos built in ethernet network port Graphic interfaces Printer Modems Serial Bus: 2 nos. Expansion Slot: 2 nos. Others to be named
3.6	CPU	Processor: 64-bit server grade Xenon or equivalent, Octa core minimum Type: 62 Bit, RISC based, consisting of measurement system, interlock and protection system, sequence control, closed loop control, etc. Clock freq: Bidder to specify Make and type: Bidder to specify

SL. NO.	DESCRIPTION	REQUIREMENT
3.7	Workspace (RAM)	Minimum 16 GB RAM (upgradable up to 24 GB minimum) capacity shall meet all the process functional requirements, response requirements, I/O requirement including the spare philosophy specified. (Spare capacity in RAM Minimum 40 % including spare I/O). Make and type: Bidder to specify
3.8	HDD	HDD capacity: 1 TB minimum RAID HDD make and type: Bidder to specify
	Software	M.S Windows (latest), MS Office Editor (Excel, Word, Power Point), Adobe Acrobat, Anti-virus, Network Security, etc.
4.0	**FOCSs and ODFs:**	
4.1	Cable:	
4.2	Type of cable	Armored type Single mode Multimode
4.3	No of fibers	According to monitoring design
4.4	Cable abbreviated designations	According to monitoring design
4.5	Switches/Patch panels	According to monitoring design
4.6	Manufacturer	Bidder to specify
4.7	Type	19”

SL. NO.	DESCRIPTION	REQUIREMENT
4.8	Bandwidth	100MHz
4.9	No. of ports	According to monitoring design
4.10	ODF ports connector type	ST, SC, FC/PC

5.0 TIME SYNCHRONISATION EQUIPMENT

5.1 The bidder can shall provide GPS, for this required hardware/software/cables etc. shall be in scope of bidder.

5.2 Bidder can supply his own Time Synchronization equipment and shall be in the Control Room.

5.3 It shall receive Coordinated Universal Time (UTC) transmitted through Geo Positioning Satellite (GPS) for time synchronization of all components of the SCADA.

5.4 It shall be complete in all respects including antenna, all cables, processing equipment, etc.

5.5 All auxiliary systems and special cables required for synchronization of the equipment shall be supplied and commissioned by the Bidder.

5.6 It shall work from DC supplies only and the Bidder to clarify if any built-in battery backup is provided, in which case, same shall be of long-life lithium batteries.

5.7 It shall be immune to hostile electrical environment. Suitable protections are to be provided against lightning surges and over-voltages in power supply systems and antenna feeders.

5.8 The system shall be fully tested to the relevant international standards such as IEC: 801 and IEC: 255.

5.9 All components of the SCADA, Workstations, and all numeric protection relays, ABT meters, MFMs etc. as per requirement under this scope of technical specification or offered by bidder shall be synchronized with an accuracy of 1ms.

5.10 The GPS shall be synchronized with the SCADA system to be supplied under this contract. Necessary software and Hardware (including laying of communication cable)

required for time synchronization with SCADA and all other devises shall be in scope of Bidder.

6.0 The system should be able to track more than 1 satellite at a time to ensure no interruptions of synchronization signals.

The system shall have provisions for combination of any of the following output signals:

6.1 NTP (network time protocol) 100Mbits Ethernet port IRIG-B00x (TTL, pulse width modulated signal) x Pulse per half-hour/ Pulse per minute/ Pulse per second outputs via potential free contacts. Any other output port as may be required for the offered system. Alarm status contact indicating healthy status of system.

6.2 These output ports shall be compatible with the requirement of the equipment to be synchronized as per scope of the specification. The master clock in control room shall also be synchronized with the time synchronization system. The actual port requirements (no./type) in line with the system offered shall be finalized during detailed engineering.

6.3 The equipment should have a periodic time correction facility of one-sec. periodicity. The equipment shall also have real time display in hour, minute, second (24-hour mode) and have a separate time display, having display size of approx. 144mm height.

6.4 Technical Specification for Network Firewall

These are minimum features additional feature shall be finalized during detailed engineering

Technical Requirements for Network Firewall		
Sr .NO	**Feature**	**Required Parameter**
A	**General**	
1	Common criteria certification	The offered product series or its operating system series must have achieved EAL (Evaluation Assurance Level) certification of EAL4 or higher in the common criteria for Information Technology Security Evaluation (ISO/IEC 15408) for computer security certification.
2	Architecture	The firewall shall be a purpose build hardware application based next generation firewall (NGFW) solution having application awareness & intrusion prevention function.
3	End of sale	OEM end of sale declaration shall not have been released for the offered model at the time of bid submission
B	**Hardware Specification & Performance Parameter**	
1	Firewall Interfaces	Minimum four or as required no's of gigabit 10/100 base T Ethernet ports to be provided
		Provision of addition of at least Two Nos of gigabit fibre SFP ports shall be available

		Each port must be configurable flexibly in any security zone as per the requirement without any fixed zone assignments
		All the above specified interfaces shall be firewall interfaces. Internal Switch interfaces shall not be considered.
		The firewall shall not have any wireless interfaces
2	Security Zones	At least four security zones must be supported
C	**Firewall Inspection**	
1	Application Support for Inspection	Should support Standard Protocols
		Internet based applications like Telnet, FTP, SMTP, http, DNS, ICMP etc. Should be supported for filtering
		Internet web 2.0 application and widgets
2	NAT & PAT	Dynamic NAT as well as one-to-one NAT
		Port/IP Address Forwarding
		PAT
3	Resistance to Evasion	The firewall shall be able to detect and block evasion techniques including SYN flood, address spoofing and TCP split handshake etc.
D	**Application awareness**	
1	Application intelligence and control	Firewall should support detection of application regardless of port, protocol etc
		Firewall must identify and control applications sharing the same session
		The firewall should allow creation of securities policies to identify, allow, block, or limit an application regardless of port, protocol etc
E	**Intrusion Prevention System (Integrated with firewall)**	
1	General	The IPS must provide intrusion prevention functionality out of the box
		The IPS should be capable of accurately detecting intrusion attempts and discern between the various types and risk levels, including unauthorized access attempts, pre-attack probes, suspicious activity, vulnerability exploitation etc
		The IPS should provide protection from Advanced Botnets, inbound and outbound
		The IPS should use stateful detection and prevention techniques and provide zero-day protection against worms, Trojans, Spyware, Keyloggers and other malware from penetrating the network
2	Detection Methods	The offered solution should use the following methods for detection of malicious traffic.
		Signature based detection
		Statistical Anomaly based detection
3	Threat Intelligence and signature updates	The IPS OEM should have a 24X7 security service update and should support real time signature update of the system as soon as updates are released

4	Exception List	The IPS should support the creation of Access Control List to bypass the inspection of any specific flow
5	DoS/DdoS protections	The offered solution should be capable of preventing Denial of service and distributed denial of service attacks
6	Threat Control Features	The offered solution should provide the following security features
		Detection and blocking malicious web traffic on any port
		Capability of detecting attacks within protocols independent of port used
		IPS sensor should allow the admin to create IPS policies on the basis of IP address and range
7	Signature Tuning	The offered solution should allow enabling/disabling of each individual signature. Each signature should allow granular tuning to suit user requirement

6.5 System Spare Capacity:

6.5.1 Over and above the equipment and accessories required to meet the fully implemented system as per specification requirements, Control System shall have spare capacity and necessary hardware/equipment/accessories to meet the following requirement for future expansion at site:

a) 10% spare channels in input/output modules fully wired up to cabinets TB.

b) Wired in “usable” space for 10% module in each of the system cabinets for mounting electronic module wired up to the corresponding spare terminals in the system cabinets.

c) Empty slot between individual modules/group of modules, kept for ease in maintenance or for heat dissipation requirement as per standard practice of the Bidder shall not be considered as wiring “usable” space for I/O modules.

d) Terminal assemblies (if any offered) corresponding to the IO module shall be provided for above mentioned 20% blank space.

e) Each processor/controller shall have 20% spare functional capacity to implement additional functional blocks, over and above implemented logic/loops.

f) Further, each processor/ controller shall have spare capacity to handle minimum 20% additional input/output for each type including above specified spare requirements, over and above implemented capacity.

g) Each of the corresponding communication controllers shall also have same spare capacity as that of processor/controller.

h) The data communication system shall have the capacity to handle the addition mentioned above.

i) 10% spare relay of each type and rating mounted and wired in the cabinets TB.

j) All contact of relay shall be terminated in the terminal block of the cabinet.

k) The spare capacity as specified above shall be uniformly distributed throughout the cubicles.

l) The system design shall ensure that above mention addition shall not require any additional controller/processor/peripheral drives in the system delivered at site.

6.5.2 Further, these additions shall not deteriorate the system response time/duty cycle, etc. From those stipulated under this specification.

6.6 SCADA PANEL/CABINET/CONTROL DESK/FURNITURE

6.6.1 The SCADA cabinets shall be IP-22 or better protection class.

6.6.2 The Bidder shall ensure that the packaging density of equipment in these cabinets is not excessive and abnormal temperature rise, above the cabinet temperature during normal operation or air-conditioning failure, is prevented by careful design.

6.6.3 The Bidder shall ensure that the temperature rise is limited to 10 deg. C above ambient and is well within the safe limits for system components even under the worst condition and specification requirements for remote I/O cabinets.

6.6.4 Ventilation blowers shall be furnished as required by the equipment design and shall be soundproof to the maximum feasible extent. If blowers are required for satisfactory system operation, dual blowers with blower failure alarm shall be provided in each cabinet with proper. Suitable louvers with wire mesh shall be provided on the cabinet.

6.6.5 The cabinets shall be designed for front access to system modules and rear access to wiring and shall be designed for bottom entry of the cables for control room.

6.6.6 The cabinets shall be totally enclosed, free standing type and shall be constructed with minimum 2 mm thick steel plate frame and 1.6 mm thick CRCA steel sheet or as per supplier's standard practice for similar applications, preferred height of the cabinet shall not higher than 2200 mm. The cabinets shall be equipped with full height front and rear doors.

6.6.7 The floor mounting arrangement for other cabinets shall be as required by the Owner and shall be furnished by the Bidder during detailed engineering. Wall mounted cabinet is acceptable for Inverter room/sub-pooling switchgear.

6.6.8 Cabinet doors shall be hinged and shall have turned back edges and additional braking where required ensuring rigidity. Hinges shall be of concealed type.

6.6.9 Door latches shall be of three-point type to assure tight closing.

6.6.10 Detachable lifting eyes or angles shall be furnished at the top of each separately shipped section and all necessary provisions shall be made to facilitate handling without damage.

6.6.11 Front and rear doors shall be provided with locking arrangements with a master key for all cabinets. If width of a cabinet is more than 800 mm, double doors shall be provided.

6.6.12 Two spray coats of inhibitive epoxy primer-surface shall be applied to all exterior and interior surfaces.

6.6.13 A minimum of 2 spray coats of final finish colour shall be applied to all surfaces. The final finished thickness of paint film on steel shall not be less than 65-75 micron for sheet thickness of 2 mm and 50 microns for sheet thickness of 1.6 mm.

6.6.14 The Preferable finish colours for exterior and interior surfaces shall conform to following shades:

a) Exterior: - As per RAL 7035 (End panel sides RAL 7035)

b) Interior: - Same as above

6.6.15 Paint films which show sags, checks or other imperfections shall not be acceptable. As an alternative, single coat of anodic dipcoat primer along with single textured powder coating with epoxy polyester meeting the thickness requirement is also acceptable

6.6.16 Control desk shall be free standing tabletop type with doors at the back and shall be constructed of 2 mm thick CRCA steel plates. A 19 mm thick wooden top shall be provided on the desk to keep the monitors at top and computers inside. Control desk shall consist of vertical, horizontal, and base supports with their coverings for work surface, keyboard trays, mouse pads, monitor shelf and concealed cable and wire way management, perforated trays with covers in both horizontal and vertical directions. ASCII Keyboard shall be capable of being pulled out through a tray.

6.6.17 Bidder shall provide the two power supply feeders (DC supply or UPS AC) and one raw supply feeder of suitable rating to cater all the load requirements of SCADA panel/cabinet/control desk. System remains in service in case of single power supply failure/power supply module failure. Suitable alarm shall be generated in case of any power supply failure.

6.6.18 The cabling/wiring between monitor and CPU power supply cable etc. shall be aesthetically routed and concealed from view.

6.6.19 Chairs Industry standard revolving chairs with wheels and with provision for adjustment of height (hydraulically/gas lift) shall be provided for the operators and other personnel in control room area. These shall be designed for sitting for long duration such that these are comfortable for the back. Armrests in one piece shall be of polyurethane and twin wheel castor of glass filled nylon.

6.6.20 One Printer Table made of Laminated Wood or Heavy Duty MDF shall be provided for printer.

6.6.21 All the furniture shall be of reputed make (Godrej or Equivalent).

6.7 FACTORY ACCEPTANCE TEST (FAT)

6.7.1 FAT procedure shall be submitted by bidder for GIPCL approval and after approval of FAT procedure, FAT will be witnessed by GIPCL Engineering or authorized representative of GIPCL.

6.7.2 SCADA shall communicate with all third-party devices which are part of Solar Plant and the same shall be demonstrated during the FAT. ROUTINE TESTS: All acceptance and

routine tests as per the specification and relevant standards shall be carried out. Charges for these shall be deemed to be included in the equipment price

6.7.3 The manufacturer is to furnish a detailed Quality Plan indicating the practice and procedure along with relevant supporting documents.

7.0 DRAWINGS/DOCUMENTS FOR APPROVAL

7.1 Concept Note for SCADA design

7.2 Technical specification / Datasheet for SCADA

7.3 SCADA configuration drawing / system architecture drawing including HMI and third-party interface details

7.4 Control room layout

7.5 Input / Output list (SCADA I/O list) with Alarm/SER points

7.6 Hardware and software design manual of SCADA engineering

7.7 Factory Acceptance Test (FAT) procedure / SAT / Availability test procedure /PG test procedure for SCADA equipment.

7.8 Process and Electrical mimics

7.9 List of logs with point assignment

7.10 Power supply and earthing schemes (Typical)

7.11 Interconnection cable schedule (ICS) and cable schedule

7.12 QAP for all major equipment including SCADA.

7.13 GA / IGA drawings of control desk / panel

7.14 Spares list

7.15 Functional Design specification (including Graphic philosophy, design basis)

7.16 Bill of material for SCADA panel, HMI, Network components

7.17 Datasheet for all bought out items

8.0 Drawing/Models/Documents required for First Time Charging

8.1 Make of PPC

8.2 Datasheet of PPC

8.3 Block diagram of PPC with controller transfer function with suitable parameter sets and the technical documentation for PSSE

8.4 PSS/E MODEL OF GENERIC CONTROLLER FOR PSSE 34 VERSION

8.5 PSSE manual shall be available in English along with OEM model

8.6 *Dyr File of The PPC For Psse Modelling for PSSE 34

8.7 Bidder shall address all the queries of CTU/RLDC with respect to reports and models are answered to their satisfaction.

B10 – FIBER OPTICAL

1.0 FIBER OPTIC CABLE

1.1 Depending on the requirements, armored single mode with minimum 12 fibers shall be used. If required, indoor fiber optic cable shall also be used as required.

Optic Fiber cable shall be of maximum possible continuous length, to avoid joint between termination points as joints shall not be accepted. Bidder shall order the length of optical fiber cable per drum accordingly.

1.2 These cables 154have been foreseen for the interconnection between inverters and "PV Plant, monitoring and spare buildings" (Servers) and redundant armored Single Mode minimum 12F optical fiber cables between "PV Plant, monitoring and spare buildings" (Servers) to owner PSS-2 Common Communication Panel.

1.3 Through the fiber optic (MM F.O. 8 wires 62.5/125) the data collected from the power stations, meter and weather stations will be carried to Main switch panel into the Main Control box located at control room.

1.4 The manufacturing, construction, labeling and testing of the fiber optic cable system shall meet the requirements established in the relevant applicable ITU and IEC codes, standards and recommendations.

1.5 The fiber optic cables shall be moisture, chemical, and rodent protected and no splicing is permitted. The recommended fiber types are:

- Over 800m distance mono mode (SM) 8 fibers.

1.6 The fiber optic cable shall be rated for use under the prevailing environmental conditions. The fiber optic cable shall be installed in conduits buried underground. To meet such conditions, a fully dielectric fiber optic cable rated for ducted or direct buried applications, filled with compound to prevent axial and longitudinal ingress of water and/or soluble. The cable shall have loose tubes as secondary coating of fibers.

1.7 The fiber cables shall be able to withstand temperature cycling in the range -10°C to +60°C without changing the optical values during laying, installation, stocking, and transportation.

1.8 Fiber optic cables shall have no metal screening material but shall be suitably protected against damage by vermin and shall have a waterproof self-healing membrane.

1.9 Fiber optic installation methods, performance, and testing shall be to ISO/IEC 1476-3, ISO/IEC 11801, and ISO/IEC 24764 specifications.

1.10 Fiber optic cables shall be carefully protected and isolated from the environment within which they are installed. For example, fiber optic cables shall be protected against mechanical and chemical damage due to micro cracking caused by stones, acid soils, and over bending.

1.11 Fiber optic cable placement and interim storage shall also be in accordance with the manufacturer's recommendations.

1.12 Technical descriptions detailing the fiber optic cable performance shall be provided.

2.0 CODES AND STANDARD

2.1 Standards not indicated in the specification are acceptable subject to approval by the PURCHASER/PURCHASER's Consultant if they are established to be equal or superior to the standards indicated in the specification. In case of conflicts between the standards and this specification, this specification shall govern.

Codes	**Description**
IEC 60794/IEC 60793 & EIA/TIA 455.	Fiber optic cable
IEC 1034	(a) Low smoke -light transmittance of 80%).
IEC 754	Halogen free 1&2- maximum acid gas generation shall be 2% by weight and PH >4.3
IEC 331, IEEE 383	Fire & flame retarded
EIA -455-41	Crush Resistant
EIA -455-25	Impact Resistant

2.2 Standards not indicated in the specification are acceptable subject to approval by the Purchaser/Purchaser's Consultant if they are established to be equal or superior to the

standards indicated in the specification. In case of conflicts between the standards and this specification, this specification shall govern.

3.0 DESIGN CRITERIA

3.1 UNDERGROUND FIBER OPTIC CABLES

3.1.1 Underground approach fiber optic cable shall be of a loose tube type, with the fibers overfed into buffer tubes which are helically wound around a central strength member. The buffer tubes shall be composed of a suitable polymer and be sufficiently strong to hold their shape and provide protection for the optical fibers against deformation and friction. The buffer tubes shall be fitted with a suitable water blocking compound which shall not freeze or drip out over the temperature range specified for the site. The compound shall not be detrimental to the other cable elements, shall not cause swelling of the buffer tubes, and shall have a relatively low thermal expansion coefficient. The compound shall also be easily removed from the fiber and shall be non-toxic.

3.1.2 The central strength member of the cable can either be of glass reinforced plastic (GRP) type where a metal-free cable is required or a steel wire.

3.1.3 The fiber optic cable shall be designed so that the fibers shall be free from longitudinal strain under all conditions of loads and ambient temperatures specified. The design of the fiber optic cable shall be such that an extension of 0.6% will not produce strain in the fibers and not result in an increase in attenuation.

3.1.4 The fiber optic cable shall be rated to operate at the continuous and intermittent short-term temperatures without degradation of its mechanical or optical performance. The surface of the cable jacket shall be designed to minimize the accumulation of dust and shall resist abrasion.

3.1.5 Polyethylene is the preferred material for sheathing outdoor cables. The use of a laminated aluminum PE sheath is acceptable. The cable shall withstand longitudinal water penetration when immersed to a depth of 1 meter in water at a temperature of 200 ºC for a period of 24 hours and under the conditions specified in IEC 60708.

3.1.6 Armoring shall be used for all direct buried cables or for cables requiring rodent protection. This shall comprise at least one layer of galvanized steel tape 0.2 mm thick, steel laminated sheath applied directly to the cable core, or a fiberglass braid. All armoring shall be protected from corrosion and damage by a polyethylene sheath.

3.2 INDOOR FIBER OPTIC CABLES

3.2.1 Fiber optical cables for indoor use shall be of the tight buffered or composite buffered construction in which the fibers are encased in a tight buffer of a suitable plastic

material. All indoor cables shall be metal free and unfilled. The central strength member shall be composed of a glass reinforced plastic material (e.g. Kevlar) or aromide yarns.

3.2.2 Indoor optical fiber cable sheaths shall be made from halogen free resistant polymers and shall comply with the standard for flame retardant cable material specified by IEC 60332.

3.3 FIBER OPTIC CABLE ACCESSORIES:

3.4.1 A detectable reinforced underground marking and warning tape shall be laid in the ground 300 mm above the protection conduit.

3.4.2 The patch cord consists of a single/multi-phase fiber optic cable with plug connections on both ends. Pigtails are fiber cables pre-assembled with a connector at one end. The fibers of the patch cords and pigtails shall be according to the specified fibers and all components shall have a service life of more than 20 years with a minimum of contact durability of 1000.

3.4.3 OTDR (Optical Time Domain Reflectometer) test report shall be submitted to Client.

3.4 CABLE DRUMS

3.4.1 Cables shall be supplied in non-returnable wooden drums. The wood used for construction of the drum shall be properly seasoned and free from defects and wood preservative shall be applied to the entire drum. All ferrous parts shall be treated with a suitable rust preventive coating to avoid rusting during transit or storage.

3.4.2 The BIDDER shall indicate in the offer, the maximum length for the size of cable, which can be supplied on one drum. The actual length supplied on each drum shall be within tolerance limit of 5 % with an overall ceiling of +5% on total ordered quantity of each size of cable.

3.4.3 Cable drums shall carry following details in printed form:

i. Manufacturer’s name and trademark
ii. Type of cable and voltage grade
iii. Year of manufacture
iv. Type of insulation
v. No. of cores and size of cables
vi. Cable code
vii. Length of cable on drum
viii. Inner Diameter and Outer Diameter of Drum

3.5 OPTICAL FIBER JOINTS

3.5.1 Each cable joint shall include termination box, mounting hardware, optical fiber splice kits, cable entry seals, and all accessories required to produce a permanent optical joint. Details of the proposed optical fiber joints shall be submitted for the approval.

3.5.2 Each termination box shall be capable of being hermetically sealed after jointing, and hermetically sealed after re-opening.

3.5.3 Variations in the quality of workmanship in making the fusion splice shall have a minimal effect on the efficiency and reliability of the joint.

3.6 TERMINATION

3.6.1 Type of connectors shall be of same type all over the plant. Bidder shall decide the used type (ST; SC; FC/PC)

3.6.2 The connecter loss shall not exceed 0.5 dB per connector pair.

3.6.3 All optical terminations between fibers and equipment or other fibers shall be made using low loss de-mountable optical connectors of the plug-in type complying with the requirements of IEC 60874.

3.6.4 All spare fibers shall be terminated with appropriate optical connectors and attached to a coupler. Caps shall be provided for each coupler to prevent dust ingress to the couplers of unused fibers.

3.6.5 All connectors shall be so positioned to facilitate easy cleaning and inspection.

3.7 OPTICAL TERMINATION BOXES

3.7.1 Optical Termination Boxes (OTB) shall be installed at sites to terminate all outdoor optical cables and to provide the interface between the outdoor and indoor optical cables.

3.7.2 All fibers in each optical cable shall be terminated using a terminal block or end sheath; unused fibers shall not be coiled, left unprotected or un-terminated.

3.7.3 The OTBs shall have the following characteristics:

a. The OTB shall be suitably sized for the number of cables to be initially accommodated, including space to manage and retain surplus lengths of optical fiber tails, plus 50% spare capacity.

b. The optical fiber cables shall enter the OTB through appropriately sized cable glands.

c. The OTB housing should be wall-mounted, of rugged construction and provided with fixed covers.

d. The OTBs shall incorporate fixed de-mountable couplers with dust caps of sufficient number to retain all the optical fibers entering the box plus space to

fit 50% additional couplers.

3.8 OPTICAL FIBER DISTRIBUTION FRAMES (OFDFS)

3.8.1 The termination of each fiber in transmit and receive direction shall be provided on an optical fiber distribution frame (OFDF) for access to the transmission equipment. The OFDF for receive and transmit direction shall be configured in accordance to the specified number of fibers.

3.8.2 The OFDF are to be installed in termination cabinets, which may be combined with the communication system.

3.8.3 OFDFs shall be provided, as necessary, to facilitate:

a. The termination of optical fibers and connection of optical circuits to terminal equipment;

b. Testing and isolation of both the optical fiber cable and fiber optic terminal equipment; and

c. Provide interface and/or cross-connect facilities between different sets of optical line terminal equipment.

3.8.4 Sufficient space shall be available on the frame to allow ease of access and minimize the possibility of interference or damage to fibers carrying traffic during maintenance testing on the back-up or spare fibers.

3.8.5 Optical fibers shall be terminated by detachable connectors in the optical fiber distribution frame and shall be properly labeled with fiber identity, destination or source, go or return. It shall be possible to connect each optical fiber to the appropriate point on any terminating equipment. Fixed couplers shall be provided for each fiber comprising a link.

3.8.6 The following basic functions of the fiber distribution frame are required:

a) Circuit re-routing/jumping.

b) Circuit disconnection; and

c) Patching and test connections.

3.8.7 Plug-in connections shall be used and the transmit and receive direction of the transmission shall be segregated. The optical fiber tail cables and connections shall be substantially protected from possibility of damage due to maintenance or installation activity. Facilities shall be provided for termination of any metal cores within the fiber cables.

3.8.8 The capacity of the fiber distribution frame shall be chosen to accommodate the maximum capacity of the fiber optic communication system plus 50% spare capacity to cater for any future expansions. All fiber distribution frames shall have an earth

connection provided and shall be protected from corrosion by painting or galvanizing.

3.8.9 Where space is limited, the functions of OTB and OFDF may be merged into a single unit provided the full requirements of both OTB and OFDF are met by that single unit.

4.0 TECHNICAL PARAMETERS

Sl. No.	Item Description	Technical Requirement
A.	Fiber: a) The optical fiber core shall be of ultra-pure fused silica glass coated with UV cured acrylate suitable to withdraw temperature of about 80 Deg C (continuous). b) Fiber Optic cables shall be suitable for installation on cable tray, duct bank, cable trench, and direct burial as necessary. c) The cable should comply latest CEA technical standard.	
1.	Type	Single mode armoured cable
2.	Core Diameter	50+/- 0.015 µm
3.	Cladding Diameter	125 ± 2 microns
4.	Coating Diameter	245 µm with tolerance of +/-5 µm
5.	Fiber Proof test	As per IEC/EIA & other International Standards
6.	Coating Diameter Test	As per IEC/EIA & other International Standards
7.	Number of Fibers/core	Twelve (Color Coded) with min. 100% spare core (Fibers)
B.	Optical Characteristics Bandwidth, Attenuation & Numerical Aperture	
1.	Bandwidth @ 850 nm Bandwidth @ 1300 nm	500 MHz-Km min 500 MHz-Km min

Sl. No.	Item Description	Technical Requirement	
2.	Attenuation @ 850 nm Attenuation@ 1300 nm	3.0 dB/Km max 0.8 dB/Km max	
3.	Numerical Aperture	0.200 + 0.015	
C.	Optical Characteristics- Attenuation	for Single mode fiber cable outside plant:	for Single mode fiber cable inside plant:
	Attenuation@ 1310 nm Attenuation@ 1550 nm	0.35 dB/Km max 0.2 dB/Km max	1 dB/Km max 1 dB/Km max
D.	Cable Construction: The cable shall be of dual jacket & armored. Optic Fiber cable shall be polymer coated, Electrolytically chrome plated corrugated steel taped (ECCST) armored, fully water blocked with central dielectric material for outdoor/indoor application so as to prevent any physical damage. Two highly visible ripcords are placed under the jacket to aid in sheath removal. A co-polymer coated steel tape is corrugated and wrapped around the inner jacket to provide additional cable compression strength and Termite & rodent protection. A ripcord is also placed underneath the armor for easy outer jacket removal.		
1.	Outer Colour	Orange	
2.	Outer Jacket	Polyethylene minimum 1.5mm thick, Flame retardant & UV resistant.	
3.	Inner Jacket	Core-locked flame-retardant polyethylene	
4.	Filler / Strength member	As per manufacturer standard	
5.	Central Strength member	Fiber Glass reinforced plastic (FRP) and Buckle resistant material to provide both tensile and anti-bucking strength to the cable.	
6.	Life Expectancy	Fiber Optic cable shall provide a long life expectancy of minimum 20 years under continuous operation without degradation to optical or mechanical performance.	

Sl. No.	Item Description	Technical Requirement
E.	Stripping Ability	All layers easily removed with Commercially available tools
F.	Installation:	
1.	Minimum bending radius	20 X D (D=core Diameter) – During Installation, Short Term, loaded. 15 X D (D=core Diameter) Installed, Long Term, No load
2.	Maximum Tensile Load/Strength	During Installation: 2200 N Installed: 1500N
3.	Method of laying	Directly laid in cable trays / duct bank / clamped with available structure
4.	Pulling	Ordinary cable grips
G.	General:	
1.	Maximum Cable weight	46Kg/1km
2.	Maximum cable length	1 km
H.	Data Speed performance	10 Gbps minimum
I.	Test Specification (EIA/TIA)	
1.	Impact Resistance	2000 Impacts minimum
2.	Crush Resistance	4000 N/10cm minimum
3.	Compressive Strength	3000 N minimum
J.	Moisture/Water Resistance as per IEC	Water blocking layer, Cable shall withstand water penetration when tested with a one-meter static head or equivalent continuous pressure applied at one end of a one meter

Sl. No.	Item Description	Technical Requirement
	standard.	length of filled cable for one hour. No water shall leak through the open cable end.
K.	Optical time Domain reflectometer	i. A recording optical time domain reflector meter (OTDR) will be utilized to test for end-to-end continuity and attenuation of each optical fiber. The OTDR shall be equipped with data storage, printer, help feature, compare trace features and OTDR software. The data storage unit must include a built-in floppy disk drive capable of storing a minimum of 100 test traces. ii. Data traces saved to disk shall include the following labels. a) Fiber Identification (ID) with a minimum of 10 characters. b) Cable ID with a minimum of 10 characters c) OTDR location with a minimum of 20 characters d) Far End location with a minimum of 20 characters. e) Test operator initials with a minimum of 3 characters. iii. The printer shall preferable be internal. The printer shall be able to print data traces within 30 seconds or less. The machine setting used to repeat tests later shall include index, range, wavelength, average time, pulse width and scale settings. The test results (on printout) shall provide information including: loss, distance, reflectance, data and time. iv. The requirements for the compare trace feature include the ability to recall two historical traces from a diskette and display them simultaneously for analysis and printing. The compare trace must compute and display a single graph representing any differences between two traces. The compare trace must be

Sl. No.	Item Description	Technical Requirement
		able to recall historical traces from a discrete and perform the same tests on connected live fibers. The compare trace shall perform a two point loss measurement test for any two particular fibers in a comparison analysis. The losses between the two points on the each fiber shall be displayed, and the differences between the two readings clearly shown. v. The OTDR must be equipped with software to support all of the required functions. The software shall provide for printing of whole set of traces (batch print) with minimal commands eliminating the time spent for printing traces individually. vi. Bidder shall provide all mounting accessories, cables and connectors required to establish data communication.
L.	Fiber Optic splicer, terminator and tool kit box	Bidder shall provide new unused tools comprise of splicer and fusion jointer and tool kit comprise of cutter, stripper, polishing tool, handheld microscope, heat shrinkable sleeve, scissor, knife etc. as required for maintenance and Commission.

5.0 DRAWINGS/DOCUMENTS FOR APPROVAL

5.1 Master drawing list (showing all the vendor's submission schedule and revision status)

5.2 Cable reel arrangement drawing

5.3 Detailed cable laying method

5.4 Cable Drum Schedule

5.5 Dimensional detailed drawing of the cable cross-section.

5.6 Installation and termination instructions.

5.7 Catalogue of cables in colour

5.8 Material property reports

5.9 Certified copy of tests

5.10 Overall shop inspection and test schedule

5.11 Shop test and inspection procedure

5.12 Certificate of compliance to contract specification.

B11 – TARIFF METERING SYSTEM

1.0 Tariff Metering System

Introduction

This section covers the requirements of tariff metering system at solar generation plant as per SLDC/ GETCO/GERC/ CEA Regulation / statutory requirement.

2.0 Scope of Work

Scope of work shall be included following equipment but not limited to.

2.1 To supply and installation of Tariff metering system at solar project including tariff meters, CTs, PTs with required all accessories for both ends i.e Solar Project(s) and GECTO Substation(s).

2.2 The responsibility of arranging for the meters, CTs, PTs etc. its approval / inspection/calibration/testing charges etc. rests with the Bidder. All charges incurred on Meter testing, CTs, PTs etc. shall be borne by the Bidder.

2.3 As per CEA Regulation on “Installation and Operation of Meters” Regulations as amended time to time, Bidder shall finalize the scheme with concerned competent authorities (CEA, , , NLDC, STU, DISCOM’s, GUVNL,SLDC, CEI, etc.) and number of meters and its locations shall be as per the approval given by the competent authority.

3.0 CODES, STANDARDS, CEA/SLDC Guidelines, Reports and technical specifications

The equipment to be furnished under this specification shall be in accordance with the applicable section of the latest version of the relevant IS / IEC standards, CEA metering regulations and CBIP publications including amendments, if any, except where modified and / or supplemented by this specification. Some of the applicable standards and publications are listed below

a) IS 14697	Specification for AC static transformer operated watt-hour and var-hour meters, Class 0.2S and 0.5S
b) CBIP Technical Report – 88	Specification for AC static electrical energy meters
c) CBIP Technical Report – 111	Specification for common meter reading instrument
d) IS 9000	Basic environmental testing procedures for electronic & electrical items
e) IS/IEC 60529	Degrees of protection provided by enclosures

f)	IEC 62053-61	Electricity metering equipment (A.C.)
g)	CEA Installation and Operation of meters Regulations 2006, 2010, 2014, 2019 and Draft for 4th amendment.	
h)	CEA Report on SAMAST (Scheduling, Accounting, Metering And Settlement of Transaction) in Electricity -July 2016	
i)		
j)	Guidelines on Cyber Security in Power Sector 2021-1, Dated 7-10-2021.	
k)	CEA - Technical Standards for Connectivity to the Grid	

4.0 TECHNICAL REQUIREMENTS

4.1 General

4.1.1 Tariff metering systems shall meet the requirements of SLDC, GETCO, GIPCL and RLDC**.**

4.1.2 The meters shall be 3-phase, 4 wire, 0.2s accuracy class static electronic energy meters with ABT compatibility.

4.1.3 Tariff metering panel for Transmission lines shall be installed in the switchgear room. If separate panels with dedicated CTs, PTs (to be installed in indoor panel) are required as per requirements of concern statutory authorities then same shall be provided at no extra cost to the Owner with sealing arrangement. The same shall be installed by bidder as per regulatory requirements.

4.1.4 For current transformer (CT) and voltage transformer (VT) circuits 2.5 sq. mm copper conductor wire with FRLSH PVC insulation shall be used. Wiring shall be color coded. Current transformer leads shall be checked for lead burden, VA capacity. In case 2.5 mm2 Copper Conductor is not adequate, conductor of 4 mm2 cross section or higher shall be used. Voltage transformer leads shall be checked for voltage drop In case the voltage drop with 2.5 sq.mm copper conductor exceeds this value, higher conductor sizes shall be used. All control / auxiliary wiring shall be carried out with 1100V grade stranded min. 1.5 sq. mm copper conductor wires with FRLSH PVC insulation.

4.1.5 Terminal blocks shall be clip-on type 600V grade, 10A rated stud type terminals with markings. Terminals for VT secondary leads shall be stud, disconnecting type. CT secondary leads shall be provided with short circuiting and earthing facility. At least 20% spare terminals shall be provided for each terminal station and each type of TB. CT / VT test terminals shall be provided separately.

4.1.6 The energy meters shall be capable of receiving periodic time synchronization signals via proper online system. The meter time shall be in synchronism with GPS time master system. Time synchronization shall be carried out by NTP, and it shall be synchronized with the master time clock. Necessary hardware and software shall be provided for the same.

4.1.7 The accuracy class of standby meter shall be of 0.2s class.

4.1.8 The accuracy class of current transformers (CTs) shall be 0.2s class and voltage transformers (VTs) shall be 0.2 class.

4.1.9 The meter shall be immune to external influences like magnetic induction, vibration, electrostatic discharge, switching transients, surge voltages, oblique suspension, and harmonics and necessary tests shall be carried out in accordance with relevant standard.

4.1.10 The meters shall safely withstand the usual fluctuations arising during faults etc. as per IS 14697. The immunity to external magnetic field shall be strictly as per latest CBIP recommendations.

4.1.11 Lead cables of CTs and VTs shall be of sufficient cross-section for reducing voltage drop to minimum between end connections (connection between cable lead end and CT / VT terminal as well as between cable lead end and meter terminal). No joints and or intermediate junction boxes (lead wires from instrument transformer secondary terminal box shall be directly terminated to metering panel) shall be allowed in lead cables. The burden on metering cores of CTs and VTs including burden of lead cable and meters connected thereto shall not exceed rated burden. The CT wiring shall be of 6 wire type (i.e., Not 4 wire type)

4.1.12 ABT metering system shall be compliant to CEA Guidelines on Cyber Security in Power Sector 2021-1, Dated 7-10-2021

4.2 Functional Requirements

4.2.1 The meter must perform four quadrant measurements. The interface meters suitable for ABT shall be static type, composite meters, as self-contained devices for measurement of active and reactive energy, and certain other parameters as described. The meters shall be suitable for being connected directly to VTs having a rated secondary line-to-line voltage of 110V and to CTs having rated secondary current of 1A. The reference frequency shall be 50Hz.

4.2.2 The active energy (watt-hour) measurement shall be carried out on 3-phase 4-wire principle with accuracy as per class 0.2S of IEC-687 / IEC-62053-22. The VAR and reactive energy measurement shall also be on 3 phase 4 wire principle with accuracy as per class 0.2 of IEC 62053-22 or better.

4.2.3 The meter shall be compatible with time of the day (TOD) tariff. For TOD tariff, meter shall have the provision to define maximum eight (8) TOD registers for different energies.

4.2.4 The meter shall continuously monitor and calculate the average demand in KVA during the integration period and maximum out of these shall be stored along with date and time in the meter's memory. The integration period shall be site

programmable for 5/15/30/60 minutes or as per regulatory requirements on real time basis on block / sliding window principle that shall also be programmable. The meter shall also display maximum demand (MD) reset count. The MD. resetting shall be possible in any of the following ways

a) Automatic reset on a predetermined date and time of the month
b) Resetting through a handheld terminal or computer capable of communicating with the meter with password protection

4.2.5 Meters shall be suitable for working under balanced / unbalanced loads at all power factor as specified in the relevant IS. The display shall indicate direct values without having to apply any multiplying factor.

4.2.6 The meter shall also store the apparent energy (import and export) and cumulative energy. Registers of the same shall be made available on display as well as Base Computer Software (BCS).

4.2.7 There shall be provision for self-check and diagnosis at regular intervals. The meter shall have indication for unsatisfactory functioning of the following:

a) Time and calendar
b) Real time clock battery
c) All display parameters
d) Non-volatile memory

4.2.8 On any programme change, the meter shall reset itself to zero and the previous information shall be stored in the non-volatile memory.

4.2.9 There shall be provision for access to the meter by a computer (desktop, PC or laptop) and remote reading or data storage via communication system.

4.2.10 The meter shall log the time and date of all programme changes in a billing period.

4.2.11 The metering system shall be compatible with suitable BCS.

4.2.12 The meters shall have following facilities

a) ABT meter all data shall be integrated to SCADA System.
b) Communication port: One RS 485, One Ethernet, RS 232 & front optical port and all communication ports of meter shall be available for simultaneous uninterrupted communication.
c) Load survey capability
d) Missing potential indication in case of failure of potential at the meter incoming terminal.
e) Provision for telemetering using common protocol
f) Provision for collection of data by meter reading instrument (MRI)

g) Provision for time synchronizing facility from external clock. Provision for correcting real time by MRI.
h) Sliding integration window/block integration
i) Real time clock
j) Non-volatile memory for 35 days
k) Test output device in the form of a pulse indicator accessible from the front and capable of being monitored by suitable testing equipment
l) CT/VT error compensation

4.2.13 Transformers / transducers required for their functioning shall be in-built in the meters. Necessary isolation and / or suppression shall also be built-in for protecting the meters from surges and voltage spikes that occur in the VT and CT circuits of extra high voltage Substations.

4.2.14 The active energy (watt-hour) meter shall display on demand the export / import energy during programmed integration block (As per prevailing regulation 15 min).

4.2.15 Further the meter shall continuously integrate and display on demand the export / import cumulative active energy sent out / in from / to the substation bus bars up to that time in export and import register. The cumulative energy reading at each midnight shall be stored in the meter memory in respective registers. There shall be separate register for export and import.

4.2.16 The meter shall count the number of cycles in VT output during each successive 15 minutes block and divide the same by 900 to arrive at the average frequency (truncated to second place of decimal). This shall be stored in the meter's memory. The average frequency of the previous programmed integration period (As per prevailing regulation 15 min) shall also be displayed on demand in hertz.

4.2.17 The meter shall continuously compute the average of the root mean square (RMS) values of the three line to neutral VT secondary voltage as a percentage of 63.51V and display the same on demand.

4.2.18 The reactive energy (VARh) meter shall store the values in different registers as below:
a) Above 103% voltage: reactive energy import & export
b) Below 97% voltage: reactive energy import & export
c) Reactive energy import with active energy import
d) Reactive energy import with active energy export

4.2.19 Each meter shall have a test output device (visual) for checking the accuracy of active energy (watt-hour) measurement. The preferred pulsing rate is twenty and four per watt-hour for 1A and 5A CT respectively. It shall be possible to couple this device to suitable testing equipment also.

4.2.20 The accuracy of the meter shall not be affected by harmonics circulating in the system of magnitudes within permissible limits stipulated by CEA Grid Standards

and Regulations. The meter shall indicate and record the total resultant quantities of fundamental frequency and harmonics or alternatively the meter shall record fundamental frequency quantities and harmonics related quantities (such as MWh, MVAh and MVARh) separately. Only fundamental frequency values shall be used for billing purpose.

4.2.21 The meters shall normally operate with auxiliary power and shall have an automatic change over system to draw power from the VT secondary circuits in the case of failure of auxiliary power. The total burden imposed by a meter for measurement and operation shall not exceed 10VA on any of the phases. An automatic back up to continue operation of the meter's calendar clock, and for retaining all data in its memory, shall be provided through a long-life battery, which shall be capable of supplying the required power for at least two years. The meters shall be supplied duly fitted with the batteries, which shall not require to be changed for at least 10 years, as long as total VT supply interruption does not exceed two years. The meters shall not require any separate auxiliary supply for their operation. All displays may disappear on loss of VT supply.

4.2.22 Each meter shall have a built-in calendar and clock having an accuracy of one minute per year or better. The calendar and clock shall be correctly set at the manufacturer's works. The date (day-month-year) and time (hour-min-sec) shall be displayed on the meter front (when VT supply has been connected), on demand. Only limited clock adjustment shall be possible at site, using the data collection device (DCD). When an advance or retard command is given, six subsequent time blocks shall be contracted or elongated by ten seconds each. The meter shall not accept another clock correction command for seven days. All clock correction shall be registered in the meter's memory and suitably shown on print out of collected data.

4.2.23 Each meter shall have a unique identification code, which shall be marked permanently on its front, as well as in its memory.

4.2.24 Each meter shall have at least one nine (9) character, nine-segment electronic display, for indication of the various parameters (one at a time), on demand.

4.2.25 A touch key or push button shall be provided on the meter front for switching on the display and or changing from one indication to the next. The display shall switch off automatically about one minute after the last operation of touch key / push button. When the display is switched on, the parameter last displayed shall be displayed again, duly updated.

4.2.26 The three line-to-neutral voltages shall be continuously monitored, and in case any of these falls below 70%, the condition shall be suitably indicated and recorded.

4.2.27 Each meter shall have an optical port on its front for tapping all data stores in its memory.

4.2.28 Portable or handheld data collection devices shall also be separately provided for this purpose, to serve as the interface between the meters specified above and the local personal computer (PC). The overall intention is to tap the data stored in the meter's memories once in a month and transmit the same to a Substation automation system / Main control station using communication links, through the local PC. It shall also be possible to obtain a printout (hard copy) of all data collected from the meters using the local PC.

4.2.29 The whole system shall be such as to provide a printout (both from the local PC, and from Substation automation system / Main control station) in an easily understandable / self-explanatory format.

4.2.30 All meters of the same model shall be totally identical in all respects except for their unique identification codes. They shall also be totally sealed and tamper-proof, with no possibility of any adjustment at site, except for clock correction.

4.2.31 The meters shall also withstand without any damage any mal-operation, reasonable mechanical shocks, earthquake forces, ambient temperature variations from –20°C to 55°C, relative humidity etc. They shall have an IP 51 category dust tight construction and shall be capable of satisfactory operation in an indoor, non-airconditioned installation.

4.2.32 Portable / hand-held data collection devices (DCD) shall be tailor-made for tapping all data stored in a meter's memory and faithfully transferring it to the local PC. Each device shall at least comprise of the following:

a) A lead with optical head for coupling it to the meter
b) A lead for plugging it to a personal computer
c) A internal battery for powering the devices
d) A case for safely carrying it about
e) A battery charger

4.2.33 The total arrangement shall be such that one (1) operator can carry out the whole operation himself, in a quick and reliable manner.

4.2.34 The meters shall continue to function, as specified above, in case of failure of one or two phases of VT supply. In case of a complete supply failure, the computation of average frequency shall be done only for the period during which the VT supply was available in the programmed integration period (As per prevailing regulation 15 min). Any time block contraction or elongation for clock correction shall also be duly accounted for.

4.2.35 Load Survey Capability:-

a) It shall be possible to store previous minimum 35 days data regarding energy consumed (programmed integration period (As per prevailing regulation 15 min) minutes blocks), demand and frequency. That is load survey is needed for the

demand and energy consumed in every MD integration time cycle (programmed integration period (As per prevailing regulation 15 min)). The demand to be recorded in the load survey shall match with the recorded in display parameters. The demand and energy consumed as discussed shall be recorded separately under energy import / energy export within a programmed integration period (As per prevailing regulation 15 min) minutes time block. It shall be possible to down load and view parameters and load survey data on computers and obtain full details of demand and consumption in statement form and also in graphic form.

b) Necessary software for various programmable features to obtain various details shall be provided by the supplier. The software shall include provision for load survey graphic presentation and other reports generation in BCS from the data collected from the meter through meter reading instruments

4.2.36 Each of the metering system shall measure and display on demand the following quantities / parameters on demand:

a) Meter Serial No.
b) LCD segment check
c) Real Time: HR:MT
d) Date dd/mm/yy
e) Rising Demand in kVA
f) Maximum demand in kW and kVA (export / import)
g) Cumulative active energy import
h) Cumulative apparent energy import (kVAh)
i) Last 15 minutes block average of the active power / load import
j) Cumulative active energy export
k) Cumulative apparent energy export (kVAh)
l) Last 15 minutes block average of the active power / load export
m) Instantaneous three phase average power factor with sign / display / legend for lag / lead.
n) Instantaneous Phase Voltage (R Phase , Y Phase & B Phase)
o) Instantaneous Line Currents (R Phase , Y Phase & B Phase)
p) Instantaneous Frequency
q) Phase Sequence of voltages
r) Instantaneous Active Load in
s) Instantaneous Reactive Load in WVAR
t) Cumulative VARh injection when, average voltage(RMS)>103%Vn
u) Cumulative VARh drawal when ,average voltage(RMS)>103%Vn
v) Cumulative VARh injection when, average voltage(RMS) < 97%Vn
w) Cumulative VARh drawal when , average voltage(RMS) < 97%Vn
x) Cumulative VARh (lag), when watt-hour is import
y) Cumulative VARh (lead), when watt-hour is import
z) Cumulative VARh (lag), when watt-hour is export
aa) Cumulative VARh (lead), when watt-hour is export

4.2.37 A key pad shall be provided on the meter front for switching on the display and for changing from one indication to the next.

4.2.38 ABT meters shall have minimum 10 years of Guarantee directly to the purchaser / GIPCL.

4.2.39 ABT Meter shall be manufactured with specific Serial Numbers allotted by Concerned Authority (WRLDC/NLDC etc.). Serial numbers for all meters are to be obtained by Bidder and communicated to OEM before commencement of manufacturing. Serial numbers are to be obtained by Bidder from the concerned authorities.

4.2.40 ABT Meter Software shall be compatible with MDP software's of concerned authorities and "dummy data file" of each ABT meter is to be furnished well in advance as a part of FTC compliance. Bidder shall line up this with the OEM of the meter at ordering stage.

4.2.41 Each ABT meters shall be provided with AMR faculty (Automated Meter Reading or Remote Metering) with GPS and GPRS Modem, along with its supply adaptor and antenna, software's/ driver etc. Required SIM card of the meters are to be arranged by Bidder with one year subscription.

4.2.42 ABT Metering panels shall have provision of dedicated 230 V UPS supply. UPS supply shall have separate MCB with signaling contact integrated to SCADA

4.2.43 Auxiliary supply of each ABT Meter shall be from two sources (110 V DC Main-1 and 110 V DC-Main-2) with selection scheme. Each meter shall have dedicated MCB with it's trip status monitoring at SCADA as well as at local annunciator. In case of non-availability of auxiliary supply, meter shall draw auxiliary power from PT (self powered).

4.2.44 Auxiliary supply systems of ABT meters are to be monitored (NO Volt relay) in SCADA and local annunciator.

4.2.45 Each ABT meter shall have separate / dedicated TTB and shall be connected in such a way that it facilitates testing / checking / removal / replacement activates without affecting other ABT meter connected to same core of CT/PT. TTB shall be of 3 phase-4 wire type. TTB shall be mounted below the meter and in front of the panel. Rear side of TTB shall have tamperproof sealing arrangement. TTB shall be of large size and shall be of SCREW type (Tightening of the screw shall short the CT circuit and loosening will open the current path of CT circuit)

4.2.46 Required BCS software, probes, cable and all required accessories to be provided for downloading, configuration and time drift correction of ABT Meters same shall be installed and configured in desktop provided by bidder and place at SCADA room for further process.

4.2.47 In case, time drift correction of more than 1 minute or changes as per statutory requirement is required, Meter OEM shall extend this facility to GIPCL for the period of five years from the date of commissioning of the meters without any cost to GIPCL. Same shall be given in writing to GIPCL by OEM of the meter.

4.2.48 Indication circuit of Tariff metering panel is to be protected with dedicated MCB's.

4.2.49 For Metering CT/PT, terminals shall have proper sealing arrangements, preferably with high quality transparent polycarbonate covers.

4.2.50 All ABT meters and all CT/PT's including spare metering system are to be tested at approved NABL accredited laboratory in presence of /STU/DISCOM/SLDC/GETCO and owners representative at appropriate stage without any cost to GIPCL.

4.2.51 Site testing and sealing of metering system (ABT meters and CT/PT's, TTB's, Terminal boxes, Panel doors etc.) by concerned authorizes and applicable charges, if any, is in scope of Bidder.

4.2.52 Terminal Block Station (TB's) shall have proper sealing arrangements. Comprehensive memory mapping and documentation (User manual, testing and commissioning manual etc.) of ABT meters to be provided.

4.2.53 Required software, equipment's with all accessories for ABT Meter configuration at site shall be provided.

4.2.54 All software's and Meters permanent passkeys (Pass Words) of all level shall be provided.

4.2.55 ABT meters shall be compatible for future regulatory requirements (e.g. Time Block from 15 minute to 05 minute etc.)

4.2.56 Instrument transformers burden, ratio, CT secondary amp (1A or 5A) and accuracy limit factors shall be proposed by Bidder in consolation and approval with concerned authorities at detail engineering stage.

4.2.57 Tariff metering core of 33 KV Instrument Transformers (CT's/CVT's or EMVT's) shall have separate sealable, terminal box for secondary connections.

4.2.58 Indication circuit of Tariff metering panel is to be protected with dedicated MCB's.

4.2.59 Flush mounted ABT meters are preferred or wall / projection mounting. In case projection mounted / wall mounted type meters are used than the metering panel and mounting of the meter requires special consideration and design.

a) Projection / Wall mounted meters are to be installed in the panel in such a way that no part of the meter is projected outside the panel.

b) Wires to Meter terminals TTB etc. shall not be projected outside the panel.

c) Optical port and display of meter, operating control of meters shall be easily accessible for day-to-day operation

d) Overall design shall be esthetically very good and highly functional.

e) Bidder shall extend fullest co-operation to purchaser for finalization of design of "projection mounting meter" during detail engineering stage.

5.0 CONSTRUCTIONAL FEATURES

5.1 General

5.1.1 Meters shall be designed and constructed in such a way so as to avoid causing any danger during use and under normal conditions. However the following shall be ensured:
a) Personnel safety against electric shock
b) Personnel safety against effects of excessive temperature
c) Protection against spread of fire
d) Protection against penetration of solid objects, dust and water in normal working condition

5.1.2 All the materials and electronic power components used in the manufacture of the meters shall be of highest quality and reputed make to ensure higher reliability, longer life and sustained accuracy.

5.1.3 The meters shall be designed with application of specific integrated circuits. The electronic components shall be mounted on the printed circuit board using latest surface mount technology (SMT).

5.1.4 All insulating materials used in the construction of meters shall be non-hygroscopic, non-aging and of tested quality. All parts that are likely to develop corrosion shall be effectively protected against corrosion by providing suitable protective coating.

5.1.5 The meters shall have an operation indication device such as a blinking LED. The operation indicator shall be visible from the front window.

5.1.6 The front surface of meters once mounted in panel shall conform to the degree of protection IP 51 for protection against ingress of dust and moisture.

5.2 Sealing of the Meter

Proper sealing arrangement shall be provided on the meter to make it tamper-proof and to avoid mishandling by un-authorized person. At least two (2) seals on the body, two (2) seals on terminal blocks and one seal each on maximum demand resetting device and communication ports shall be provided. Meter base and cover shall be tightened from rear

side with at least two nos. unidirectional screws so that meter body could not be opened at site in any case and two nos. sticker seals bearing serial no., which shall not be repeated shall be provided between meter base and cover.

A tracking and recording software for all new seals shall be provided by the manufacturer of the meter so as to track total movement of seals starting from manufacturing, procurement, storage, record keeping, installation, series of inspections, removal and disposal. The meter shall be totally sealed and tamper-proof with no possibility of any adjustment at site, except for a restricted clock correction. The harmonics shall be filtered out while measuring Wh, VAR and VARh and only fundamental frequency quantities shall be measured / computed. Polycarbonate or acrylic seals or plastic seals or holographic seals shall be used. Lead seals shall not be used.

5.3 **Marking of the Meter**

The marking on every meter shall be in accordance with IS 14697 / IEC 687. The basic marking on the meter name plate shall be as follows:

i) Manufacturer's name and trade mark
ii) Type designation
iii) Number of phases and wires
iv) Serial number
v) Month & year of manufacture
vi) Reference voltage / VT ratio / frequency
vii) Rated secondary current of CT (-/1A or -/5A)
viii) Principal unit(s) of measurement
ix) Meter constant (impulse/kWh)
x) Class index of meter
xi) Text "Property of ……..
xii) P.O. No. & Date
xiii) Guarantee period

5.4 **Connection Diagram & Terminal Marking**

The connection diagram of the metering module shall be clearly shown in the inside portion of the terminal cover and shall be of permanent nature. The meter terminals shall also be marked, and this marking shall appear in the above diagram. In case any special precautions need to be taken at the time of testing the meter the same may be indicated along with the circuit diagram.

5.5 **Display**

The display shall be LCD type display with back lit. Minimum height of the characters shall be 6mm.

5.6 **Real Time Clock**

Each of the meters shall have an independently built-in calendar and clock having an accuracy of ± 5ppm at 25 0C or better. The calendar and clocks shall be correctly set to Indian Standard Time. The time keeping accuracy of the metering shall be maintained according to the time of load dispatch clock, synchronized with LDC.

Tamper Detection Features

5.7

There shall be an appropriate display system by which any attempt at tampering with the meter is promptly displayed with date and time tagging. The meter shall have features to detect the occurrence and restoration of, at least, the following:

5.7.1 The meter shall not get damaged or rendered non-functional even if any phase and neutral are interchanged.

5.7.2 The meter shall register energy even when the return path of the load current is not terminated back at the meter and in such a case the circuit shall be completed through the earth. In case of metallic bodies, the earth terminal shall be brought out and provided on the outside of the case.

5.7.3 The meter shall work correctly irrespective of the phase sequence of supply (only for polyphase).

5.7.4 In the case of 3 phase 4 wire system, the meter shall keep working even in the presence of any two wires ie. even in the absence of neutral and any one phase or any two phases.

5.7.5 The registration must occur whether input phase or neutral wires are connected properly, or they are interchanged at the input terminals.

5.7.6 The meter shall be factory calibrated and shall be sealed suitably before dispatch.

5.7.7 The meter shall be capable of recording occurrences of a missing potential (only for VT operated meters) and its restoration with date and time of first such occurrence and last restoration along with total number and duration of such occurrences during the above period for all phases.

5.7.8 Additional anti-tampering features including logging of tampers such as current circuit reversal, current circuit short or open and presence of abnormal magnetic field shall be provided as per the regulations.

5.7.9 Last 100 such events in total with date and time shall be stored in the meter memory on first in first out basis.

5.7.10 There shall be four separate compartments for logging of different type of tampers as follows:

a) Compartment no.1: 20 events of missing potential

b) Compartment no.2: 20 events of CT polarity reversal
c) Compartment no.3: 40 events shall be allocated for current / voltage unbalance
d) Compartment no.4: 20 events of power ON/OFF

5.7.11 The logging of various tampers in each compartment shall be as under: Once one or more compartments have become full, the last tamper event pertaining to the same compartment will be entered and the earliest (first one) tamper event shall disappear Thus, in this manner each succeeding tamper event will replace the earliest recorded event, compartment-wise. Events of one compartment / category shall overwrite the events of their own compartment / category only.

5.7.12 Tamper count shall increase as per occurrence (not restoration) of tamper events. Tamper data shall be available on meter display as:

a) Date of first occurrence of tampering
b) Time of first occurrence of tampering
c) Time of last restoration of tampering
d) Date of last restoration to normal condition
e) Number of occurrences of tampering events

6.0 DRAWINGS, DATA AND MANUALS

6.1 To be submitted after award of contract:

a) Technical data sheets
b) Dimensional general arrangement drawing
c) Scheme diagram
d) Catalogues
e) Quality plan
f) Test certificates
g) Operation and maintenance manual
h) Comprehensive memory mapping and communication settings including normal and ABT parameters

7.0 TESTS

7.1 The equipment offered shall be type tested proven type and approved by the transmission Utility / authorities / regulatory bodies. Type test reports shall be furnished for approval. All routine and acceptance tests in accordance with the latest version of applicable standards shall be conducted.

7.2 The meter shall be duly calibrated with ESS meter of class 0.1 accuracy or better.

7.3 The energy meter offered shall be fully type tested for the properties / requirement, listed below at independent approved test laboratories as per relevant standards described in this specification.

7.4 All tariff meter with CT and PT shall be approved and tested in presence of statutory authority as per statutory requirement. All Fees shall be in scope of bidder.

7.5 Following is a list of various tests that shall be conducted

a) Test of insulation properties:

i. Impulse voltage test
ii. AC high voltage test
iii. Insulation test

b) Test of accuracy requirement

i. Test on limits of error
ii. Test on starting condition
iii. Test on no load condition
iv. Test of ambient temperature influence
v. Test of repeatability of error
vi. Test of influence quantities

c) Test of electrical requirement

i. Test for power consumption
ii. Test for influence of supply voltage
iii. Test of influence short time over current
iv. Test of influence of self-heating
v. Test of influence of heating

d) Test of electromagnetic compatibility

i. Radio interference measurement
ii. Fast transient burst test
iii. Test of immunity to electrostatic discharges
iv. Test of immunity to electromagnetic HF field

e) Test for climatic influences

i. Dry heat test
ii. Cold test
iii. Damp heat cyclic test
iv. Test for mechanical requirements
v. Vibration test
vi. Shock test
vii. Spring -hammer test
viii. Protection against penetration of dust and water
ix. Test of resistance to heat and fire

7.6 **Submission of Laboratory and site testing reports.**

Test reports of instruments transformers, ABT meters (Including instrument transformers) at NABL accredited / approved laboratory and site testing reports shall be submitted to purchaser as well as to the concerned competent authority at appropriate stage

B12 – SWITCHYARD & OVERHEAD LINE

1. SCOPE AND GENERAL INFORMATION

1.1. GENERAL INFORMATION

This specification intends to cover the following activities, services and work in respect of Switchyard & Overhead (O/H) lines.

a. Complete design and engineering of all the systems, sub-systems, equipment, material and services.
b. Providing engineering data, drawings and O&M manuals for Owner's review, approval and records.
c. Manufacturing, supply, testing, packing, transportation and insurance from the manufacturer's work to the site including port and customs clearance, if required.
d. Receipt, storage, insurance, preservation and conservation of equipment at the site.
e. All civil works as required.
f. Fabrication, pre-assembly (if any), erection, testing and putting into satisfactory operation of all the equipment/material including successful commissioning.
g. Furnishing of spares on FOR site basis.
h. Reconciliation with customs authorities, in case of foreign supplies.
i. Satisfactory completion of the system

In addition to the requirements indicated in this section (Technical specifications), all the requirements as stated in other sections shall also be considered as a part of this specification as if completely bound herewith.

The Bidder shall be responsible for providing all material, equipment and services specified or otherwise which are required to fulfill the intent of ensuring operability, maintainability and the reliability of the complete work covered under this specification. The systems, sub-systems and equipment shall conform in all respect to high standards of engineering, design and workmanship, and shall be capable of performing in continuous commercial operation.

1. The scope of work comprises of Power evacuation of the proposed Solar PV project at the identified STU Substation (as per interconnection point/metering point mentioned).

a. Substation and Switchyard will be designed for 33 kV Incoming Voltage and outgoing voltage level matching the voltage of the STU substation incomer side. The switching scheme for Substation shall be as per the latest Technical Standard for Construction of Substation and Switchyard published by CEA.
b. Transmission line network including RoW for 25 years from Substation at solar plant to STU substation, following latest STU technical standards by CEA and connectivity regulations.
c. Switchyard Bay and bus extension (if applicable) at STU substation along with necessary control, protection and interfacing panels.

The scope of work shall comprise, but not limited to the design, engineering, manufacture, testing and inspection at manufacturer's works, packing, supply, transportation, transit insurance, delivery to site, unloading, storage and equipment erection, associated civil and structural works. Further, it shall include cabling, lighting, lightning protection, earthing, association of sub vendors if any in the erection, supervision, site testing, inspection and commissioning of Switchyard & O/H lines.

2. This scope covers all the work required for detailed soil investigation. It shall include mobilization of necessary equipment, providing necessary engineering supervision and technical personnel, carrying out field investigation and tests, laboratory tests, analysis and interpretation of data and results, collecting data regarding geographical conditions from local sources, giving flood details of the area (past history), preparations for the type of foundations and the safe bearing capacity for different sizes of foundations, different founding strata for the various locations along the transmission lines.

3. The equipment and materials to be supplied by the Contractor shall form a complete Switchyard & O/H lines. The equipment and services as detailed in all sections of the bidding documents shall be within the scope of supply of the Contractor.

4. The following is the list of items under the scope of contractor. However any items though not specifically mentioned but which are required to make the Switchyard & O/H lines complete in all respects for its safe, efficient, reliable and trouble free operation shall be supplied and erected by the Contractor, unless they are specifically excluded in the text of exclusions given elsewhere in this chapter.

Switchyard:

a. Equipment: Circuit Breakers, Isolators (with earth switches), Current Transformers, Surge arresters, Bus post insulators and Capacitor voltage transformers.
b. Switchyard Civil Works.
c. Civil works associated with Tie-Transformer.
d. Switchyard materials:
   i) 3”/4”EHIPS Aluminum tube
   ii) ACSR Conductor or equivalent
   iii) 10.98 dia. G.S. Earthwire
   iv) Insulator, Insulator string and hardware
   v) Clamps, connectors and spacers
   vi) Bay Marshalling kiosks
e. Complete earthing grid (inclusive of supply of 40mm dia. MS rod and GI flat), earthing of all switchyard equipment and its connection to existing earthing grid.
f. Direct Stroke Lightning Protection of Switchyard either through LM or through Shield wire based on detail engineering as applicable.
g. Armoured Power, Control and Screen cables, cabling (including interpole and interpanel).
h. Armoured Power, Control cables, optical fiber cable and screen cable.

i. Cable support angles & accessories necessary for cable erection such as glands, lugs, clamps for cables, ferrules, cable ties, hume pipe etc. cable route markers for buried cable trench are also included in the scope.
j. Power & Control cable schedule & termination schedules, optical fiber cable & screened cable shall be prepared by the Contractor.
k. Outdoor lighting system for Switchyards as applicable.
l. BCU and BPU for all the bays including Time synchronizing equipment for bays under present scope and owners use as well.
m. Interfacing with RTU for extending the data from bays under present scope to LDC.
n. Relay setting calculations shall be prepared by the Contractor and approved by Owner.
o. Supply, erection, commissioning of Automatic start/ stop type centrifugal pump for sump pit.

Overhead line:

a. Galvanised RSJ Pole (9/11 m) & its pole accessories.
b. Towers and its associated accessories.
c. Overhead line materials
    - ACSR conductor
    - 10.98 dia. G.S. Earthwire
    - Insulator, Insulator string (Porcelain/Polymer) and hardware
    - Clamps & connectors
    - OPGW Cable with required accessories and hardware
d. Civil works associated with Poles (SP, DP & FP) & Towers (Tangent suspension/Angle)
e. Structural works associated with Poles & Towers.
f. Pole Earthing as per REC std. CS-J2 including civil works ▪ 33 kV Outdoor Equipment such as Isolator, LA etc.
g. Cable termination kits (cable to conductor)

5. Services and Items
    a. The scope also include but not limited to the following services/items described herein and elsewhere in specification:
    b. System design and engineering
    c. Supply of equipment and material
    d. Civil works
    e. Structural works
    f. Erection works
    g. Project management and site supervision
    h. Testing and commissioning
    i. Interface coordination
    j. Performance testing
    k. Clearance from statutory authority. Owner shall provide support for this activity.

6. System Design and Engineering
    a. The Contractor shall be responsible for detailed design and engineering of overall system, sub-systems, elements, system facilities, equipment, auxiliary services,

etc. It shall include proper definition and execution of all interfaces with systems, equipment, material and services of Owner for proper and correct design, performance and operation of the project.

b. Contractor shall provide complete engineering data, drawings, reports, manuals, etc. for Owner's review, approval and records.
c. The scope shall also include the design and engineering as per details elaborated elsewhere in this specification.
d. For all structural works, the Contractor shall prepare design and fabrication drawings. Similarly, for civil works, the detailed construction drawings shall be prepared for those items whose design is to be done by the Contractor.

7. Supply of Equipment and Material

a. The Contractor shall be responsible for design, engineering, manufacture, testing, inspection at manufacturer's works, supply, transportation, insurance, delivery at site, unloading, storage, in plant transportation at site, complete erection & supervision, site testing & inspection, and successful commissioning of all the equipment and material as detailed elsewhere in specification and as shown on the tender drawings. Any item though not specifically mentioned, but is required to complete the project works in all respects for its safe, reliable, efficient and trouble free operation shall be supplied and erected by the Contractor unless it is explicitly excluded as given elsewhere in the chapter.

b. All consumables, wastage and damages shall be to the account of Contractor.

8. Civil & Structural Works

The scope of civil works shall include design, engineering & construction of all civil, structural and architectural works including supply of all materials complete for all equipment, gantry structural and associated facilities for the Outdoor Switchyard & O/H lines.
The nature of work generally involves earthwork in excavation and filling in all types of soils/ rock, dressing to the required profile, dewatering till the structures are constructed/erected up to required level or as directed by the engineer, shoring, backfilling around completed structures and plinth filling, disposal of surplus earth, concreting including reinforcement and formwork, fabrication and erection of all structures steel and miscellaneous steel (i.e. cable/pipe supports, ladders, railings, inserts, embedments, gratings, chequered plate covers, platforms, anchor bolts, etc.), rail track for movement of transformers, fabrication, galvanizing & erection of Gantry structure, Lighting Mast & Equipment supporting structures, R.C.C. cable trench & precast covers, cable ducts / duct banks, soil sterilization / anti-weed treatment, gravel filling, drainage, fencing, gates, final grading, supplying and laying earthing mat and any other work required for completion and proper functioning of the switchyard.
All material including cement, reinforcement steel and structural steel required for completion of the work covered under this package are in the scope of the bidder.

The scope of work described below is general in nature. The Bidder shall provide all structures/ facilities required for the effective functioning of switchyard of the power plant,

whether or not they are specifically mentioned. The scope of Bidder for civil, structural and architectural works shall include but not limited to the following:

a. Detailed design criteria including basis of design shall be prepared by the Bidder based on various requirements specified elsewhere in the specifications. All the above documents shall be finalized after Owner's approval and the same shall form the basis of Detailed Engineering Work.
b. Civil and structural works associated with switchyard gantry structures (Towers & Beams) and Lightning Mast including proto assembly and structures as required complete.
c. Civil and structural works associated with switchyard equipment supporting structures and cable sealing ends including proto assembly and substructure as required complete.
d. Installation of Control & protection panels etc. in Switchyard control room building and all other related works complete as per system requirement.
e. Civil and structural works associated with foundations Power Transformer including oil pit, stone filling, laying and fixing of rails for movement of Transformers, rail cum road and jacking pad as required, arrangement for cabling etc. all complete.
f. Civil & structural works associated with 11/66/132/220/400 kV Overhead lines, 11/33/66/132/220/400 kV Outdoor equipment, Cable sealing ends etc. if applicable.
g. Civil & structural works associated with Overhead lines from solar plant substation to STU substation.
h. All necessary embedment, inserts, supporting structures, supporting members as per requirement. All cable tray supporting s structures including angles/bends/insert plates etc. inside control room building are also in scope of bidder.
i. All pipe and cable supporting arrangement/structures, pipe and cable trenches etc.
j. All culverts (i.e. box culverts/ pipe culverts/ duct-banks) at the crossing of cable trenches/drains with roads, railway lines and drains, etc. as required.
k. Supply of all materials for the construction of structures / facilities in the Switchyard bay area. Bidder has to make arrangements for supply of all materials. Owner will not supply any material to the Bidder.
l. Storm water drainage system for switchyard area and connecting to the Owner's nearby storm water drains along road side.
m. Site Preparation, soil sterilization /anti-weed treatment including gravel filling but excluding major leveling.
n. Fencing along with gates for switchyard area.
o. Foundation for Lighting Poles as applicable
p. Disposal of surplus excavated soil as directed by the Engineer.
q. Any other facility / structures that would be required as per system requirements.
r. All protection measures to prevent any damage to the adjoining structures / facilities.
s. Scope of the Bidder shall also include supply and laying of 40mm dia. MS Rods as earthing mat as per requirement.
t. Geotechnical investigation for switchyard area is also in the scope of the Bidder.

All works relating to design, preparation of drawings including fabrication drawings, procurement of material, fabrication, proto assembly, mass fabrication, transportation to site, handling, storage and erection of all Towers & Beams, Lightning Mast and Equipment supporting structures (both lattice type and pipe type) for the Switchyard bay area as per design and drawings to be prepared by the Contractor and approved by the Owner. This shall also include all types of bolts, nuts, hangers, shackles, clamps, step bolts etc. and any other items those are required to complete the job.

The Contractor shall construct, erect and install all structures, equipment and material of Switchyard bay area. Bidder shall be responsible for provision of all labour, tools and plant, and supervisory staff for safe, reliable, proper and correct erection of project components.

The tools and plant shall include, but not limited to, special hoisting equipment, cranes, stringing equipment, slings, consumables and all other articles and supplies as required.

The Contractor shall ensure periodic cleaning of work sites and removal of all waste material, packing material, surplus earth and left-overs and their proper disposal.

9. Testing and Commissioning
    a. The scope includes testing and commissioning of all equipment, sub-systems and systems of the project and putting them into successful commercial operation. The scope shall include but not limited to the requirements given elsewhere in the specification.
    b. The Contractor shall be responsible to provide all necessary testing and commissioning personnel, tools and plant, test equipment, etc.

10. Interface Coordination
    a. The Contractor shall identify all interface issues with Owner and other agencies, and shall be responsible for such interfacing, coordination and exchange of all necessary information.
    b. b. The Contractor shall submit to the Owner all drawings for review. He shall list the detailed requirements of interface required.

11. Spares

All spares supplied under this contract shall be strictly interchangeable with the parts for which they are intended for replacement. The spares shall be treated and packed for long term storage in the climatic conditions prevailing at the site. Small items shall be packed in sealed transparent plastic covers with desiccant bags as necessary.

Each spare part shall be clearly marked and labelled on the outside of the packing together with the description when more than one spare part is packed in single case. A general description of the contents shall be shown on outside of the case and detailed list enclosed. All cases, containers and other packages must be suitably marked and numbered for the purpose of identification.

Commissioning spares: The Bidder shall include in his scope of supply all commissioning spares. List of such spares along with the quantities shall be indicated in the bid.

The Contractor shall supply spares which he expects to consume during installation testing and commissioning of system. The quantity of these spares shall be decided based on his previous experience, such that site works shall not be hampered due to non-availability of these spares. Contractor shall submit a complete list of such spares along with the bid, the cost of which shall be deemed to have been included in the lump sum proposal price of the package. The unused commissioning spares may be left at the site for use by the Owner, if so agreed at a cost to be negotiated.

a. No mandatory or recommended spares will be used during the commissioning of the equipment/plant before take over by the Owner.

1.2. DETAILED SCOPE OF WORK – ELECTRICAL

1. Contractor shall be responsible for design and engineering of overall system/station, and all elements, systems, sub-systems, facilities, equipment, material, etc. The Contractor shall submit design calculations, drawings, codes, codes of practices, construction drawings, etc. for Owner's approval.
2. The basic design shall include, but not limited to, the following:
   a. Development of general arrangement.
   b. Development of detailed layout (plan & section/elevation) drawings.
   c. Development of single line diagram with parameters of equipment and details of protection.
   d. Protection and control philosophy and selection of protection, control and annunciation schemes.
   e. Development of interlocking schemes.
   f. Development of switchyard structures loading details.
   g. Development of earthing system
   h. Development of direct stroke lightning protection system.
   i. Insulation coordination of the HV equipment.
   j. Calculation of static and dynamic force load, and selection of spacer spans equipment terminal loading.
   k. Development of clearance diagrams.
   l. Lighting design, Lux Level calculation and conduit wiring diagram.
   m. Development of power & control cable laying and termination schedules.
   n. Relay setting calculations.
   o. Development of erection key diagram with bill of material.
   p. Foundation design and construction drawings.
   q. Development of cable trench layout and sections and construction drawings.
   r. Effect of nearby conductors due to electric field adjoining building and providing shielding.

3. Contractor shall furnish detailed drawings for the various equipment covered in their scope for Owner's approval. The equipment shall conform to type tests as per specification and applicable standards and reports of the same shall be furnished for approval.

4. Contractor shall furnish design calculations and construction drawings for all civil works showing details of pockets to be left in foundations and embedment to be provided in cable trenches.
Contractor shall furnish the schematics, general arrangement drawings, cable schedules, interconnection schedules, panel wiring diagrams, etc. for various control and relay panels for Owner's approval. Contractor shall also furnish the recommended relay settings to be adopted.

5. The Contractor shall note that the list of standards specified elsewhere in this specification is not complete. Whenever necessary the list of standards shall be considered in conjunction with specification, IS & IEC. In case governing standards for the equipment is different from IS or IEC, the salient points shall be clearly brought out along with English language version of the same.

6. Exposed live parts shall be placed high enough above ground to meet the requirements of Indian Electricity Rules and other statutory codes. All responsibilities regarding co-ordination with Electrical Inspection Agencies and obtaining clearance certificate from them rests with the Contractor.

7. The outdoor bus-bars in Switchyard shall either of the rigid type with tubular aluminium bus conductor or flexible stranded conductor with aluminium conductor steel reinforced (ACSR) or all aluminium alloy conductor (AAAC) or other suitable conductors. The conductor of appropriate rating and the number of conductors to be used in case of bundle conductors shall be selected considering power flow requirements, corona effect and ambient conditions. For the rigid bus- bar arrangement, aluminium pipes conforming to relevant standard shall be used.

8. For Switchyard, the equipment interconnections shall be through IPS Al. tube/ ACSR conductor or equivalent. All the interconnections with Main Bus shall be through ACSR conductor or equivalent conductor. All the 'T' off connections shall be provided with a bye pass utilizing two PG clamps for each 'T' off. As far as possible, the conductor shall pass without cut/joints unless otherwise necessary for planned shutdown/ maintenance.
All equipment shall be supplied with suitable terminal connectors. The terminal connector shall be well coordinated with the type/size of conductor and equipment to be connected. The conductor terminations for equipment shall be either rigid or expansion type suitable for IPS Al. tube or horizontal or vertical take-off suitable for ACSR conductor or other suitable conductors. The exact requirement & type of terminal clamps would be finalized by the Contractor in consultation with Owner based on layout requirement. The terminal pads shall preferably be capable of taking the required conductor span under normal, short circuit and meteorological conditions, without effecting the performance of the equipment.

9. The rigid bus bars for equipment inter connections shall have rigid connections at one end and expansion /flexible at other end. The tubular Al connections shall have not more than one joint per span. Since no wastages are permissible, the bidder shall workout the cut lengths of Aluminium tube based on the finalized layout & dispatch the same to site without requiring Owner's approval. Corona Bell shall be provided at

the end of the rigid busbars. The connectors and clamps shall be rated same as the connected equipment.

10. The minimum vertical distance from the bottom of the lowest porcelain part of the bushing, porcelain enclosures or supporting insulators to the bottom of the equipment base, where it rests on the foundation pad shall be 2.55 meters.
    The bidder to note that the total height of the equipment such as CT, CVT, LA, Isolator, BPI etc. along with structures shall meet the min. electrical clearances.
11. Circuit breakers shall be supplied with necessary inter pole cabling, and its cost shall be included in the cost of equipment.
12. All equipment shall be suitable for hot line washing.
13. The Contractor shall cooperate in all respects and exchange the necessary technical data/drawings with other agencies and Owner's other Contractors under intimation to Owner to ensure proper coordination and completion of work in time.
14. Short circuit force calculation shall be submitted by the bidder as per relevant IEC for flexible & rigid bus as applicable. This short circuit force shall be considered for designing of Tower, Girder and equipment structures and their foundation as applicable.
15. The sag tension, conductor spacing, short circuit forces, spacer location, conductor swing and clearances shall be carried out in accordance with IEC 60865 to achieve the specified clearances.
16. All overhead stringing shall be carried out by minimum double tension String insulator assembly.
17. Gravel filling shall be provided in the Tie-transformer Switchyard bay area with broken stone filling which shall consist of two layers. The first layer shall be 75mm thick base course of 20mm of normal size and second layer shall be 75 mm thick surface course of 40 mm nominal size.
18. All the cables used for the switchyard shall be armored type.
19. The Shield wire tension shall be min. 0.8T. The foundations and structures etc. shall be designed accordingly.
20. The pit size of transformer shall be designed for minimum 1000 mm beyond the physical dimensions of the transformer.
21. In Switchyard per feeder one bay marshaling box (BMK) is to be provided. The duplicated power supplies for BMK shall be extended.
22. The switchyard shall be provided with roads for approach for major equipment for maintenance purpose.
23. The location Switchyard Control Room Building is indicated in the tender drawings. The control & protection panels shall be located in this building.
24. The cable trenches shall be extended to the proposed Bays. The Contractor shall construct the common sections suitably of appropriate sizes up to common points so that the same can be extended in future.
25. For earthing 50x6 mm GS flat shall be used in all cabinets, MOM boxes, panels and balance all other earthing such as all equipment, towers, LM, cable trenches etc. shall be through 75x12mm GS Flat.
26. Two (2) nos. of suitable industrial socket and suitable power cable for oil filtration equipment for Transformers shall be provided.
27. The illumination level shall be 20 lux in general and 50 lux on equipment boxes. Lighting Mast/Lightning Mast shall be used for mounting lighting fixtures for outdoor switchyard lighting. No lighting fixture shall be mounted on towers/gantries.

28. Voltage drop for sizing of power cables shall not be more than 6%. The connectors and clamps shall be rated same as the connected equipment.
29. The sag tension, conductor spacing, short circuit forces, spacer location, OPGW Cable swing and clearances shall be carried out to achieve the specified clearances.

1.3. LAYOUT DETAILS

1. Clearances

The minimum clearances shall be as given below, complying with technical standards/manuals published by CEA:
Clearance

Clearance	**400 KV**	**220 KV**	**132 KV**	**33 KV**
Phase - earth clearance (mm)	3500	2100	1300	320
Phase - phase clearance (mm)	4000* 4200**	2100	1300	320
Section Clearance (mm)	6500	5000	4000	3000
Ground Clearance (mm)	8000	5500	4800	3700

* Conductor configuration, ** Rod conductor configuration.

The contractor shall supply the structures suitable to meet the above clearances.

2. Bay Width

The Bay width (Beam Span) for Switchyard Gantry structures for different voltage level following the necessary clearances shall be as indicated below/as per CEA technical standards/Manuals.

Voltage Level	Width (m)
400 kV	27
220 kV	17
132 kV	12

3. Switching Schemes

The switching schemes shall generally be adopted at different voltage levels in Switchyard as per latest Technical Standard for Construction of Substation and Switchyard published by CEA.

Main and transfer bus or double bus scheme	132 kV
Double main and transfer bus scheme or double bus scheme	220 kV
Breaker and a half scheme	400 kV

4. The various minimum height of switchyard from plinth level shall be as follows/as per CEA technical standards/Manuals;

Voltage Level	1st Level/ Eqpt. Level	2nd Level/ Bus Level	3rd Level/ Jack Bus Level
132 kV	4600 mm	8500 mm	12500 mm
220 kV	6000 mm	12000 mm	17000 mm
400 kV	8000 mm	16000 mm	23000 mm

1.4. SYSTEM PARAMETERS

The system parameters shall be as under/as per CEA technical standards/Manuals:

Parameter		**400 kV**	**220 kV**	**132 kV**	**33 kV**
a)	Highest system voltage (kV)	420	245	145	36
b)	Lightning Impulse voltage (kV_{peak})	1425	1050	650	170
c)	Switching impulse withstand voltage	1050	-	-	-
d)	Power frequency withstand for 1 min.	630	460	275	70
e)	Maximum Radio Interference Voltage for any frequency between 0.5 MHZ to 2.0 MHZ in all positions (micro volts)	1000 (at 320 kV rms)	1000 (at 156 kV rms)	1000 (at 500 kV rms)	
f)	Rated temperature	50 deg. C			
g)	System earthing	Effectively earthed			
h)	Rated frequency ambient	50 Hz			

The rated breaking current capability of switchgear and breakers to be installed at different voltage levels shall be in line with latest Technical Standard for Construction of Substation and Switchyard published by CEA and match with the existing GETCO substation.

Parameter	**400 kV**	**220 kV**	**132 kV**	**33 kV**
System fault level (kA for 1 sec)	40/50/63	40/50	31.5/40	12.5/25
Dynamic withstand current	2.5 times system fault level			

If the fault level at a sub-station exceeds or is likely to exceed the permissible fault level with the addition of more generators and termination of new transmission lines, adequate measures to limit the fault level like sectionalization/splitting of the sub-station bus or installation of series reactors on the line or bus or installation of Fault Current Limiter

(FCL) on Line or bus or transformer or reactor at the respective sub-stations shall be resorted to.

The minimum specific creepage distances of insulators shall be 25 mm/kV line to line voltage or 31 mm/kV line to line voltage depending on the site and shall be decided for the maximum pollution condition level in the area of installation.

1.5. SERVICES TO BE PERFORMED BY THE EQUIPMENT BEING SUPPLIED

All the equipment/materials covered in this specification shall perform all its function satisfactorily without undue strain, restrike etc. under such over voltage conditions.

The contractor shall ensure that, erection, testing and commissioning of, Circuit Breaker, Isolator, Instrument Transformers, Surge Arrestor, Control & Protection System and Protective relays is carried out, under the supervision of manufacturer of respective equipment.

1.6. TYPE TEST REQUIREMENTS FOR EQUIPMENT

a. All equipment to be supplied shall be of type tested design. During detail engineering, the contractor shall submit for Owner's approval the reports of all the type tests as listed in this specification and carried out not earlier than ten years prior to the date of techno–commercial bid opening. These reports should be for the test conducted on the equipment similar to those proposed to be supplied under this contract and the test(s) should have been either conducted at an independent laboratory or should have been witnessed by a Client.

b. However if contractor is not able to submit report of the type test(s) conducted within last ten years from the date of bid opening, or in the case of type test report(s) are not found to be meeting the specification requirements, the contractor shall conduct all such tests under this contract at no additional cost to the owner either at third party lab or in presence of client/ owners representative and submit the reports for approval.

c. All acceptance and routine tests as per the specification and relevant standards shall be carried out. Charges for these shall be deemed to be included in the equipment price.

1.7. RIV TESTS

The RIV tests shall confirm to the requirements as per below:

General

Unless otherwise stipulated, all equipment together with its associated connectors where applicable shall be tested for measurement of radio interference voltage (RIV).

Test Levels

The test voltage levels for measurement of external RIV are listed under the relevant clauses of the specification.

Test Methods for RIV:

RIV tests shall be made according to measuring circuit as per International Special – committee on Radio Interference (CISPR) Publication 16 -1 (1993) Part – I. The measuring circuit shall preferably be tuned to frequency with 10 % of 0.5 MHz but other frequencies in the range of 0.5 MHZ to 2 MHz may be used, the measuring frequency being recorded. The result shall be in microvolts.

Alternatively, RIV tests shall be in accordance with NEMA standard Publication No. 107 – 1964 except otherwise noted herein.

In measurement of RIV temporary additional external corona shielding may be provided. In measurement of RIV only standard fittings of identical type supplied with the equipment and a simulation of the connections as used in the actual installation will be permitted in the vicinity within 3.5 meters of terminals.

Ambient noise shall be measured before and after each series of tests to ensure that there is no variation in ambient noise level. If variation is present, the lowest ambient noise level will form basis for the measurements. RIV levels shall be measured at increasing and decreasing voltages of 85%, 100%, 115% and 130% for the specified RIV test voltage for all equipment unless otherwise specified. The specified RIV test voltage is listed in the detailed specification together with maximum permissible RIV level in microvolts.

The metering instruments shall be as per CISPR recommendations or equivalent device so long as it has been used by other testing authorities.

The RIV measurement may be made with a noise meter. A calibration procedure of the frequency to which noise meter shall be tuned shall establish the ratio of voltage at the high voltage terminal to the voltage read by the noise meter.

1.8. MAIN EQUIPMENT CIRCUIT BREAKERS

1.8.1. CIRCUIT BREAKERS

1. General

Circuit Breakers shall be outdoor type, comprising three identical single pole units, complete in all respects with all fittings and wiring. The circuit breakers and accessories

shall conform to IEC- 62271-100 or equivalent Indian Standard. The requirement of control switching is at Annexure- II of this chapter.

2. Duty Requirements

a. Circuit breaker shall be totally restrike free (C-2 class) under all duty conditions and shall be capable of performing their duties without opening resistor. Circuit Breaker shall meet M1 class of mechanical endurance requirements as per IEC. The circuit breaker shall meet the duty requirement of any type of fault or fault location and shall be suitable for line charging and dropping when used on effectively grounded or ungrounded systems and perform make and break operations as per the stipulated duty cycles satisfactorily.

b. The circuit breaker shall be capable for breaking the steady & transient magnetizing current corresponding to Tie-transformers upto250 MVA 3 phase rating. It shall be capable of breaking line charging currents as per IEC-62271- 100 with a voltage factor of 1.4. The rated transient recovery voltage for terminal fault and short line faults shall be as per IEC: 62271-100.

c. The Bidder may note that total break time of the breaker shall not be exceeded under any duty conditions specified such as with the combined variation of the trip coil voltage, pneumatic/hydraulic pressure and arc extinguishing medium pressure, etc. While furnishing the proof of the total break time of complete circuit breaker, the Bidder may specifically bring out the effect of non-simultaneity between same pole and poles and show how it is covered in the guaranteed total break time. While furnishing particulars regarding the D.C. component of the circuit breaker, the Bidder shall note that IEC-62271-100 requires that this value should correspond to the guaranteed minimum opening time under any condition of operation.

3. Constructional Features

a. All making and breaking contacts shall be sealed and free from atmospheric effect. In the event of leakage of extinguishing medium to a value, which cannot withstand the dielectric stresses specified in the open position, the contacts shall preferably self-close. Main contacts shall be easily accessible for inspection and replacement. If there are no separately mounted arcing contacts, then the main contacts shall be easily accessible for inspection and replacement. Main contacts shall have ample area and contact pressure for carrying the rated current under all conditions. The interrupter sectional drawing showing the following conditions shall be furnished for information with the bid:

i. Close position
ii. Arc initiation position
iii. Full arcing position
iv. Arc extinction position
v. Open position.

b. The three poles of the breaker shall be linked together either electrically/pneumatically or electro hydraulically.

c. Circuit breakers shall be provided with two (2) independent trip coils, suitable for trip circuit supervision. The trip circuit supervision relay would also be provided. Necessary terminals shall be provided in the central control cabinet of the circuit breaker.

4. Sulphur Hexafluoride (Sf6) Gas Circuit Breaker

a. Circuit breakers shall be single pressure type.

b. Each pole shall form an enclosure filled with SF6 gas independent of two other poles. Common monitoring of SF6 gas can be provided for the three poles of circuit breaker having a common drive. The interconnecting pipes in this case shall be such that the SF6 gas from one pole could be removed for maintenance purposes.

c. The SF6 gas density monitor shall be adequately temperature compensated to model the density changes due to variations in ambient temperature within the body of circuit breaker as a whole. It shall be possible to dismantle the monitor without removal of gas. Temperature compensated SF6 pressure gauge shall be provided which will be visible from ground level.

d. Sufficient SF6 gas shall be supplied to fill all the circuit breakers installed plus an additional 20% of the quantity as spare.

5. Operating Mechanism

a. Circuit breaker shall be operated by pneumatic mechanism or electrically spring charged mechanism or electro-hydraulic mechanism or a combination of these. It shall be gang operated for 3-phase reclosing operation.

b. The pneumatically operated mechanism shall offer unit compressor with each circuit breaker with the breaker local air receivers having a capacity for two ‘CO’ operations of the breaker at the lowest pressure for reclose duty without refilling.

c. The spring operated mechanism shall be complete with motor, opening spring & closing spring with limit switch for automatic charging and other necessary accessories to make the mechanism a complete operating unit. As long as power is available to the motor, a continuous sequence of closing and opening operations shall be possible. The motor shall have adequate thermal rating for this duty. After failure of power supply to the motor, one close-open operation shall be possible with the energy contained in the operating mechanism. Motor ratings shall be such that it requires not more than
30 seconds for fully charging the closing spring.

d. The hydraulic mechanism shall be suitable for at least two close open operations after failure of ac supply to the motor starting at pressure equal to lowest pressure of auto-reclose duty. All hydraulic joints shall have no oil leakage under the site

conditions and joints shall be tested at factory against oil leakage at a minimum of 1.5 times maximum working pressure.

6. Fittings And Accessories

a. The insulators and terminal connectors shall conform to requirements stipulated elsewhere. All routine tests shall be conducted on the insulators as per relevant IEC.

b. Unit Compressed Air System

i. The unit compressed air system for each breaker shall be provided with compressed air piping, piping accessories, control and non-return valves, filters, coolers of adequate capacity, pressure reducing valves(if any), isolating valves, drain ports, etc. The air compressor shall be driven by automatically controlled motor. It shall be of air cooled type complete with preferably oil- less cylinder lubrication. The compressors or pumps shall be mounted within the operating mechanism housing or a separate weather-proof and dust-proof housing. Each compressor shall be equipped with a time totaliser.

ii. The compressor size shall be such that it is capable of performing following operations satisfactorily:

- Total running time of compressor not exceeding 45 minutes per day, considering 2% leakage and 2 CO-operations.
- Air charging time not exceeding 20 minutes after one CO operation of the breaker.

iii. Air Receivers:

- The capacity of receivers shall be sufficient for two (2) CO operations of the breaker.
- Air receiver shall be designed in accordance with the latest edition of the ASME Code for Pressure Vessel - Section VIII of BS:5179. A corrosion allowance of 3.0 mm shall be provided for shell and dished ends. Receivers shall be hot dip galvanized.

iv. Controls and Control Equipment:

- The compressor control shall be of automatic start stop type initiated by pressure switches on the receiver. Supplementary manual control shall also be provided.
- All control equipment shall be housed in a totally enclosed cabinet. Pressure gauges and other indicating devices, control switches shall be mounted on the control cabinet.

- Facility to annunciate failure of power supply to the compressor control shall also be provided.

v. Compressed Air Piping, Valves and Fittings:

- The flow capacity of all valves shall be at least 20% greater than the compressor capacity.
- The high pressure system shall be such that after one 0 - 0.3 Sec - CO operation, the breaker shall be capable of performing one CO operation within 3 minutes.
- All compressed air piping shall be bright annealed, seamless phosphorous Deoxidized Non-Arsenical Copper alloy or stainless steel pipe (C-106 of BS:2871).

7. Tests

a. Type Tests

Circuit breaker shall confirm to type tests as per IEC in accordance with the requirement stipulated under clause no. 1.05.00.

b. Routine Tests

Routine tests as per IEC-62271-100 on the complete breaker/ pole along with its own operating mechanism and pole column shall be performed on all circuit breakers.

c. Site Tests

All routine tests except power frequency voltage dry withstand test on breaker shall be repeated on the completely assembled breaker at site.

8. Parameters
General

a)	Type of circuit breaker	Outdoor SF6, single pressure, Live tank type
b)	Rated frequency	50 Hz
c)	Number of poles	Three (3)
d)	Rated operating duty cycle	O - 0.3 sec. - CO - 3min. – CO

e)	Reclosing	Single Phase & Three phase high speed auto reclosing (As per requirement)
f)	Total closing time	Not more than 150 ms
g)	Maximum difference in the instants of closing/opening of contacts	As per IEC
h)	Trip and closing coil voltage	110/220V DC
i)	Auxiliary contacts	As required plus 10 NO and 10 NC contacts per pole as spare. The contacts shall have continuous rating of 10A and breaking capacity of 2A with circuit time constant of minimum 20 millisecond at 220V DC
j)	Noise Level	Maximum 140dB at 50m distance from base of circuit breaker
k)	Rated terminal load	Adequate to withstand 100kg static load as well as wind, seismic and short circuit forces without impairing reliability or current carrying capacity
l)	Temperature rise over ambient	As per IEC: 62271-100
m)	Type of operating mechanism	Pneumatic/spring/hydraulic/or a combination of these
n)	Rated ambient temp.	50°C
o)	System neutral earthing	Effectively earthed
p)	Support structures height	Adequate so that lowest part of support insulator of equipment is minimum 2550 mm from plinth level

1.8.2. DISCONNECTOR

1. General

a. The isolators and accessories shall conform in general to IEC 62271- 102 (or equivalent Indian standard) except to the extent explicitly modified in specification.

b. Earth switches shall be provided on isolators wherever called for.

c. The isolators and earth switches shall be A. C. motor operated.

d. Isolators shall be Double Break type up to 420kV

2. **Duty Requirements**

a. Isolators and earth switches shall be capable of withstanding the dynamic and thermal effects of the maximum possible short circuit current of the system in their closed position. They shall be constructed such that they do not open under influence of short circuit current and wind pressure together. The earth switches wherever provided shall be constructional interlocked so that the earth switches can be operated only when the isolator is open and vice-versa.

b. In addition to the constructional interlock, isolator and earth switches shall have provision to prevent their electrical and manual operation unless the associated and other interlocking conditions are met. All these interlocks shall be of failsafe type. Suitable individual interlocking coil arrangements shall be provided. The interlocking coil shall be suitable for continuous operation from DC supply and within a variation range as stipulated in relevant section. The interlock coil shall be provided with adequate contacts for facilitating permissive logic for 'DC' control scheme of the isolator as well as for AC circuit of the motor to prevent opening or closing of isolators when the interlocking coil is not energised.

c. The earthing switches shall be capable of discharging trapped charges of the associated lines. Isolator and earth switches shall be able to bear on the terminals the total forces including wind loading and electrodynamic forces on the attached conductor without impairing reliability or current carrying capacity.

The isolator shall be capable for making/breaking normal currents when no significant change in voltage occurs across the terminals of each pole of the isolator on account of making/breaking operation.

d. All isolators of class 72.5 kV above shall be of mechanical endurance class M2 as per IEC. All earth switches shall be of class M1 duty.

3. **Constructional Features**

i. **Contacts:**

a. The contacts shall be self-aligning and self-cleaning type and shall be so designed that binding cannot occur after remaining in closed position for prolonged period in a heavily polluted atmosphere.

b. No undue wear or scuffing shall be evident during the mechanical endurance tests. Contacts and spring shall be designed so that

readjustments in contact pressure shall not be necessary throughout the life of the isolator or earthing switch. Each contact or pair of contacts shall be independently sprung so that full pressure is maintained on all contacts at all time.

c. Contact springs shall not carry any current and shall not loose their characteristics due to heating effects.

d. The moving contact of double break isolator shall have preferably turn-and twist type or other suitable type of locking arrangement to ensure adequate contact pressure.

e. Flexible braided copper, where used, shall have corrosion resistant coating such as tinning or silvering.

ii. Base:

Each single pole of the isolator shall be provided with a complete galvanised steel base provided with holes and designed for mounting on a standard supporting structures. Common base frame shall be provided for 400/220/132/66kV isolators suitable for mounting on pipe structures.

iii. Blades:

a. All metal parts shall be of non-rusting and non-corroding material. All current carrying parts shall be made from high conductivity electrolytic copper/ aluminum. Bolts, screws and pins shall be provided with lock washers. Keys or equivalent locking facilities if provided on current carrying parts shall be made of copper silicon alloy or stainless steel or equivalent. The bolts or pins used in current carrying parts shall be made of non-corroding material. Ferrous parts, other than stainless steel shall not be used in close proximity of main current path. All ferrous castings, if used elsewhere shall be made of malleable cast iron or cast-steel. No grey iron shall be used in the manufacture of any part of the isolator.

b. The live parts shall be designed to eliminate sharp joints, edges and other corona producing surfaces, where this is impracticable, adequate corona rings shall be provided. Corona shields are not acceptable. Corona rings shall be made up of aluminum/aluminum alloy.

c. Isolators and earthing switches including their operating parts shall be such that they cannot be dislodged from their open or closed positions by short circuit forces, gravity, wind pressure, vibrations, shocks, or accidental touching of the connecting rods of the operating mechanism.

d. The isolator and earth switch shall be designed such that no lubrication of any part is required except at very infrequent intervals. i.e. after every 1000 operations or after 5 years whichever is earlier.

iv. Insulator:

a. The insulator shall conform to IS: 2544, IEC-60168 and IEC-60815.
The porcelain of the insulator shall have minimum cantilever strength of 600 kg (below 132 kV) and 1000 kg (more than 132 kV level).

b. Pressure due to the contact shall not be transferred to the insulators after the main blades are fully closed.

4. Earthing Switches

Where earthing switches are specified these shall include the complete operating mechanism and auxiliary contacts. The earthing switches shall form an integral part of the isolator and shall be mounted on the base frame of the isolator. Earthing switches shall be suitable for local operation only. The earthing switches shall be constructional interlocked with the isolator so that the earthing switches can be operated only when isolator is open and vice versa.

5. Operating Mechanism And Control

a. The Contractor shall offer, motor operated switches having padlock arrangement for both ‘ON’ and ‘OFF’ positions.

b. Limit switches for control shall be fitted on the isolator/ earth switch shaft, within the cabinet to sense the open and close positions of the isolators and earth switches.

c. It shall not be possible, after final adjustment has been made for any part of the mechanism to be displaced at any point in the travel sufficient enough to allow improper functioning of the isolator when the isolator is opened or closed at any speed.

d. Control cabinet/operating mech. box shall conform to requirements stipulated under auxiliary equipment mentioned elsewhere in the chapter and IS: 5039/IS: 8623/IEC 60439 as applicable.

6. Operation

a. Isolator shall be electrically/mechanically gang operated for main blades and earth switches. The operation of the three poles shall be well synchronized and interlocked.

b. The design shall be such as to provide maximum reliability under all service conditions. All operating linkages carrying mechanical loads shall be designed for negligible deflection. The length of inter insulator and interpole operating rods shall be capable of adjustments.

c. The design of linkages and gears be such so as to allow one man to operate the handle with ease for isolator and earth switch.

7. Tests

a. In continuation to the requirements stipulated elsewhere the isolator along with operating mechanism shall conform to the type tests and shall be subjected to routine tests and acceptance tests in accordance with IEC 62271-102. During final testing of isolator sequential closing/ opening of earth switch shall also be checked only after isolator is fully open/close.

b. The insulator shall conform to all the type tests as per IEC 60168. In addition to all type, routine and acceptance tests, as per IEC-60168, the following additional routine/ acceptance tests shall also be carried out:

i. Bending load test in four directions at 50% min. bending load guaranteed in all insulators.

ii. Bending load test in four directions at 100% min. bending load guaranteed on sample insulators in a lot.

iii. Torsional test on sample insulator of a lot.
iv. Ultrasonic test as a routine test.

8. Parameters

General

a)	Type of isolator	Outdoor type, Horizontal Double Break
b)	Rated frequency	50 Hz
c)	Number of poles	Three (3)
d)	Operating Time	Not more than 12 sec
e)	Control Voltage	110/220V DC
f)	Auxiliary contacts	As required plus 8NO and 8NC contacts per pole/isolator as spare. The contacts shall have continuous rating of 10A and breaking capacity of 2A with circuit time constant of minimum 20 millisecond at 220V dc. Additionally MBB contacts as required shall also be provided.

g)	Auxiliary contacts on earth	Total 6NO and 6NC
h)	Rated mechanical	As per table III of IEC 62271 102
i)	Temperature rise over ambient	As per IEC: 62271-102
j)	Rated ambient temperature	50°C
k)	System neutral earthing	Effectively earthed
l)	Support structures height	Adequate so that lowest part of support insulator of equipment is
m)	Operating mechanism of Isolator and Earth	AC/DC/Universal Motor operated
n)	Temperature rise	As per Table III of IEC 60694 for an ambient of

1.8.3. SURGE ARRESTOR

1. General

a. The surge arrestors shall conform in general to IEC-60099-4 and IS:3070 except to the extent modified in the specification.

b. Arrestors shall be hermetically sealed units, self-supporting construction, suitable for mounting on lattice/tubular type support structures.

2. Duty Requirements

a. The Surge Arresters (SAs) shall be capable of discharging over- voltages occurring due to switching of unloaded transformers, reactors and long lines.

b. The reference current of SAs shall be high enough to eliminate the influence of grading and stray capacitance on the measured reference voltage.

c. The SAs shall be fully stabilised thermally to give a life expectancy of one hundred (100) years under site conditions and take care of effect of direct solar radiation.

d. The SAs shall be suitable for circuit breaker duty cycle in the given system. The SAs shall be capable of withstanding meteorological and short circuit forces under site conditions.

e. The SAs shall protect power transformers, circuit breakers, disconnecting switches, instrument transformers, etc. with insulation levels specified in this specification.

f. The SAs shall be capable of withstanding meteorological and short circuit forces under site conditions.

3. Constructional Features

a. Each Surge Arrester (SA) shall be hermetically sealed single phase unit.

b. The non-linear blocks shall be sintered metal oxide material. The SA construction shall be robust with excellent mechanical and electrical properties.

c. SAs shall have pressure relief devices and arc diverting ports suitable for preventing shattering of polymer housing and to provide path for flow of rated fault currents in the event of SA failure.

d. The SA shall not fail due to insulator contamination.

e. Seals shall be effectively maintained even when SA discharges rated lightning current.

f. Polymer shall be so coordinated that external flashover will not occur due to application of any impulse or switching surge voltage up to maximum design value for SA. The cantilever strength of the insulator shall be minimum 150kg (upto 245 kV) / 350kg (above 245 kV).

g. The end fittings shall be non-magnetic and of corrosion proof material.
The Contractor shall furnish the following:

i. The heat treatment cycle details with necessary quality checks used for individual blocks along with insulation layer formed across each block.

ii. Metalizing coating thickness for reduced resistance between adjacent discs along with procedure for checking the same.

iii. Details of thermal stability test for uniform distribution of current on individual discs.

iv. Detailed energy calculations to prove thermal capability of discs.

4. Fittings And Accessories

a. Each SA shall be complete with insulating base for mounting on structures.
b. SAs shall be provided with grading and/or corona rings as required.
c. Self contained discharge counters, suitably enclosed for outdoor use (IP: 55 degree of protection) and requiring no auxiliary or battery supply shall be fitted with each SA along with necessary connections to SA and earth. Suitable leakage current meters shall also be supplied in the same

enclosure. The reading of milliammeter and counter shall be visible through an inspection glass panel to a man standing on ground. A pressure relief vent/suitable provision shall be made to prevent pressure build up. The earth connection for the Surge Arrester shall be carried out in such a manner so that the discharger current path is diverted to earth and the path through structures is avoided.

5. Parameters

General

a)	System neutral earthing	Effectively earthed
b)	Installation	Outdoor
c)	i) Nominal discharge current	10 kA of 8/20 micro-sec.
d)	d) Rated frequency	50 Hz
e)	Long duration discharge class	3
f)	Current for pressure relief test	As per Clause 1.04
g)	Prospective symmetrical fault	As per Clause 1.04
h)	Low current long duration test value	As per IEC
i)	Pressure relief class	Class A of Table VII of
j)	Partial discharge at 1.05 MCOV	Not more than 50 p.C.
k)	Seismic acceleration	0.3 g horizontal
l)	Reference ambient temp.	50°C

The surge arrestors are provided to protect the following equipment whose insulation levels are indicated elsewhere. The contractor shall carry out the insulation coordination studies for deciding the location of the surge arrestors.

6. Tests

a. Surge Arrestors shall conform to all type tests as per IEC and shall be subjected to routine and acceptance tests in accordance with IEC-60099-4.

b. The resistive current drawn by the arrestor at rated voltage shall be indicated in the routine test report.

1.8.4. POST INSULATOR

1. General

The post insulators shall conform in general to latest IS: 2544 and IEC – 60815, 60168.

2. Constructional Features

a. Post type insulators shall consist of a porcelain part permanently secured in a metal base to be mounted on the supporting structures. They shall be capable of being mounted upright. They shall be designed to withstand any shocks to which they may be subjected to by the operation of the associated equipment. Only solid core insulators shall be accepted. Height of post insulator shall be preferably as given under parameters of this part.

b. The other requirements of insulator as given under auxiliary requirements shall also be applicable.

c. The total minimum cantilever strength shall be 600kgf for 132kV and 800kgf for 220kV & above.

3. TESTS

a. In accordance with the stipulations elsewhere the post insulators shall conform to type tests and acceptance, sample and routine tests as per IS: 2544, IEC-60168 shall be carried out.

b. In addition to acceptance/sample/routine tests as per IS: 2544, IEC-60168, the following tests shall also be carried out.

i. Ultrasonic tests on all cut shells as routine check.

ii. Visual examination and magnaflux test on all flanges prior to fixing.

iii. Check for uniformity of thickness and weight of zinc coating as a sample test from each lot of flanges prior to fixing.

iv. Bending load test shall be carried out at 50% minimum failing load in four directions as a routine test.

v. Bending load in four directions at 100% minimum bending load guaranteed on samples as per clause-2.3 of IEC. Subsequently this post insulator shall not be used.

vi. Tests for deflection measurement at 20, 50, 70% of specified minimum failing load on sample.

c. The post insulator shall conform to following type tests as applicable according to voltage class:

i. Switching Impulse withstand test (dry & wet)

ii. Lightning Impulse withstand test (dry)

iii. Power frequency withstand test (dry & wet)

iv. Test for deflection under load.
v. Test for mechanical strength
vi. Measurement of RIV

1.8.5. WAVE TRAP

1. General
The Wave Trap covered under the package shall conform to IEC 353 or IS: 8792, IS: 8793 and relevant IEC/IS Specifications except to the extent modified by the specification.

2. Location of Equipment

Wave Traps as specified under this section shall be installed at the respective transmission line bays in two phases as required. The foundation shall be provided for all the three phases however, the location of wave trap shall be decided based on the attenuation results.

3. Technical Requirements

a. Wave Trap shall be inserted into high voltage transmission line to prevent undue loss of carrier signal for all power system conditions. Its impedance shall be negligible at power frequency (50 Hz) so as not to disturb power transmission but shall be relatively high over the frequency band appropriate to carrier transmission. Wave trap shall consist of a main coil designed to carry continuously the rated current without exceeding the limit of temperature rise. It shall be supplemented with a protective device and tuning device.

b. Wave trap shall be Broad Band tuned for its entire carrier frequency range. Resistive component of impedance of the Wave trap within its carrier frequency blocking range shall not be less than 570 ohms.

c. Wave trap shall be provided with a protective device in the form of lightning arrestor which shall be designed and arranged such that neither significant alternation in its protective function nor physical damage shall result from either temperature rise or the magnetic field of the main coil at continuous rated current or rated short time current. The protective device shall neither enter into operation nor remain in operation, following transient actuation by the power frequency voltage developed across the line trap by the rated short time current. The protective device shall be shunt connected to the main coil and tuning device.

d. The lightning arrestor shall be of gapless type. Its rated discharge current shall be 10 kA.

e. The lightning arrestor provided with the Wave trap of each rating shall fully comply with the requirements of IS-3070-Part-I (1974)/IEC- 60099-4. It shall conform to type tests as applicable and type test certificate for the same shall be submitted by the Bidder.

f. The lightning arrester provided with the Wave trap shall be subject to routine and acceptance tests as per IEC – 60099.

g. Wave trap shall be equipped with bird barriers.

h. Wave trap shall preferably be spray painted with Grey paint.

i. Wave trap shall conform to IEC - 60353 (latest) fulfilling the following technical particulars.

j. The Bidder shall indicate continuous current rating of the Wave trap at 65 deg C ambient.

k. In accordance with the requirements stipulated under Part-I, the Wave Trap shall confirm to following type tests and shall be subjected to routine and acceptance tests as per IEC-60353.

i. Measurement of inductance of the main coil
ii. Measurement of temperature rise
iii. Insulation tests
iv. Short time current tests
v. Radio Interference Voltage measurement

4. Wave Trap Mounting

a. The Wave Trap for shall be suitable for outdoor pedestal mounting and shall be mechanically strong enough to withstand the stresses due to maximum wind pressure of 195 kg/square meter.

b. For pedestal mounting, each Wave trap shall be mounted on a tripod structures formed by three solid core type insulators shall be of non- magnetic material.

5. Terminal Connector

a. The Wave traps shall be suitable for connecting to IPS tube or ACSR or equivalent conductor as required.

b. Terminal Connectors shall conform to IS-5561

c. Terminal Connectors for conductor(s) shall be suitable for either horizontal or vertical take-off of the conductor(s).

d. Clamps/connectors shall conform to type test and shall be subject to routine tests as per IS: 5561.

1.8.6. INSTRUMENT TRANSFORMER

1. Codes and Standards

Current Transformers IEC 60044, BS:3938, IS2705, IEC 61869 Voltage transformers IEC 60044 IEC 60358, IS:3156 IEC 61869 Insulating oil IS: 335

2. General Requirements

a. The instrument transformers i.e. Current & voltage transformers shall be single phase transformer units and shall be supplied with a common marshaling box for a set of three single phase units.

b. The tank as well as top metallics shall be hot dip galvanised or painted with shade RAL 7035.

c. The instrument transformers shall be hermetically sealed units. The instrument transformers shall be provided with filling and drain plugs.
d. Polarity marks shall indelibly be marked on each instrument transformer and at the lead terminals at the associated terminal block.

e. The insulators shall have a cantilever strength of more than 350 kg.

f. No Oil shall come into direct contact with Zinc galvanized surface.
g. Metering terminal box shall be provided in a separate compartment for Instrument Transformers with locking facility.

3. Current Transformers (Oil Filled CTs)

a. The CTs shall have single primary of either ring type or hair pin type or bar type. The Wound Primary type CT is only acceptable for Metering CTs (0.2s) where metering CT ratio required is below 400/1.

   In case of inverted type/line tank design CTs, the following requirements shall be met:

   The secondaries shall be totally encased in metallic shielding providing a uniform equipotential surface for even electric field distribution.

   The lowest part of insulation assembly shall be properly secured to avoid any risk of damage due to transportation stresses.

   The upper part of insulation assembly sealing on primary bar shall be properly secured to avoid any damage during transportation due to relative movement between insulation assembly and top dome.

   The insulator shall be one piece without any metallic flange joint

b. The CT shall be provided with oil sight glass which should be clearly visible to maintenance personnel standing on ground.

c. The core lamination shall be of cold rolled grain oriented silicon steel or other equivalent alloys. The cores shall produce undistorted secondary current under transient conditions at all ratios with specified parameters. The CTs shall be suitable for high speed auto- reclosing.

d. Different ratios shall be achieved by secondary taps only, and primary reconnections shall not be accepted.

e. The guaranteed burdens and accuracy class are to be intended as simultaneous for all cores.

f. The instrument security factor at all ratios shall be less than five (5) for metering core. If any auxiliary CT/reactor is used, then all parameters specified shall be met treating auxiliary CTs/reactors as integral part of CT. The auxiliary CT/reactor shall preferably be in-built construction of the CT. In case it is separate, it shall be mounted in secondary terminal box.

g. The physical disposition of protection secondary cores shall be in the same order as given under CT requirement table(s) given below.

h. The secondary terminals shall be terminated on stud type suitable no's of non-disconnecting and disconnecting terminal blocks as required inside the terminal box of degree of protection IP:55 at the bottom of CT. The CTs shall be suitable for horizontal transportation.

i. The CTs shall have provision for taking oil samples from bottom of CT without exposure to atmosphere to carry out dissolved gas analysis periodically. Contractor shall give his recommendations for such analysis, i.e. frequency of test, norms of acceptance, quantity of oil to be withdrawn, and treatment of CT.

j. The CT shall have provision for measurement of capacitance and tan delta as erected at site.

4. Voltage Transformers (CVTs)

a. Voltage transformers shall be of capacitor voltage divider type with electromagnetic unit.

b. The CVTs shall be thermally and dielectrically safe when the secondary terminals are loaded with guaranteed thermal burdens.

c. The electro-magnetic unit (EMU) shall comprise of compensating reactor, intermediate transformer and protective and damping devices. The oil level indicator of EMU with danger level marking shall be clearly visible to maintenance personnel standing on ground.

d. The secondaries shall be protected by HRC cartridge type fuses for all windings In addition fuses shall also be provided for protection and metering windings for connection to fuse monitoring scheme. The secondary terminals shall be

terminated on stud type non- disconnecting terminal blocks via the fuse inside the terminal box of degree of protection IP: 55. The access to secondary terminals shall be without the danger of access to high voltage circuit.

e. The damping device shall be permanently connected to one of the secondary winding and shall be capable of suppressing ferro- resonance oscillations.

f. CVTs shall be suitable for high frequency (HF) coupling for power line carrier communication. Carrier signals must be prevented from flowing into potential transformer (EMU) metering circuit by means of RF choke/reactor suitable for effective blocking the carrier signals over the entire frequency range of 40 to 500 kHz. HF terminal shall be brought out through a suitable bushing and shall be easily accessible for connection to the coupling filters of the carrier communication equipment. The HF terminal shall be provided with earthing link with fastener.

g. A protective surge arrester/spark gap shall preferably be provided to prevent break down of insulation by incoming surges and to limit abnormal rise of terminal voltage of shunt capacitor, tuning reactor, RF choke, etc. due to short circuit in transformer secondary. The details of this arrangement (or alternative arrangement) shall be furnished by Contractor for Owner's review.

h. The protection cores shall not saturate at about 1.5 times the rated voltage for a min. duration of 30 secs.

i. The accuracy of metering core shall be maintained through the entire burden range upto rated value without any adjustments during operations

5. Marshalling Box

Marshaling box shall conform to all requirements as given elsewhere. The wiring diagram for the interconnection of three phase instrument transformer shall be pasted inside the box. Terminal blocks in the marshaling box shall have facility for star/delta formation, short circuiting and grounding of secondary terminals. The box shall have enough terminals to wire all control circuits plus 20 spare terminals.

6. Parameters for Current Transformers

General Parameter

a)	One-minute power frequency withstand voltage between secondary terminal and earth	5kV
b)	Partial discharge level	10 pico Coulombs max.
c)	Temperature rise	As per IEC 60044

d)	Type of insulation	Class A
e)	Number of cores	Protection & Metering CT- Five (5) (PS/PS/0.2s/PS/PS) Metering CT -- Two (2) (0.2s/0.2s). The rated extended primary current of all CTs shall be 120 % continuous rated current.
f)	Installation	Outdoor (up right)
g)	Number of terminals in marshalling box	All terminals of control circuits wired upto marshalling box plus 20 terminals spare.
h)	System Neutral earthing	Effectively earthed

7. Parameters for CVTs

General Parameter

a)	Installation	Outdoor
b)	Standard reference range of frequencies for which the accuracies are valid	96% to 102% for protection and 99% to 101% for measurement
c)	High frequency capacitance for rated entire carrier frequency range	Within 80% to 150% of capacitance
d)	Equivalent resistance over entire carrier frequency range	Less than 40 ohms
e)	Stray capacitance and stray conductance of LV terminal over entire carrier frequency range	As per IEC:60358
f)	One minute power frequency withstand voltage between LV (HF) terminal and earth For secondary winding	10kV rms for exposed terminals or 4 kV rms for terminals enclosed in a weather proof box 2 kV rms
g)	Temp. rise over an ambient temp. of 50 deg. C	As per IEC 60044-2

h)	Number of terminals in control cabinet	All terminals of control circuits wired upto marshalling box plus 10 terminals spare
i)	Rated total thermal burden	As per Sl (k) of this table
j)	Partial discharge level	10 pico Coulombs max.
k)	Number of cores	Protection & Metering CVT – 3 (3P/3P/0.2) Metering CVT – 2(0.2/0.2) Burden for each protection core – 50 VA (min)/as per actual requirement, and burden of metering core 15VA (min)/as per actual requirement. The accuracy of 0.2 on metering should be maintained through the entire burden range up to rated value without any adjustments during operation.
l)	Rated Voltage factor	1.2 continuous, 1.5 – 30sec

8. Tests

The current and voltage transformers shall confirm to type tests and shall be subjected to routine & acceptance tests in accordance with the relevant IS/IEC. CTs & CVTs shall also conform to the following additional type tests as applicable:

a. Radio Interference Voltage test

b. Thermal withstand test i.e. application of rated voltage and rated current simultaneously by synthetic test circuit (For CT only)

c. Thermal co-efficient test i.e. measurement of Tan-Delta as function of temperature (at ambient and between 80 deg. C and 90 deg. and voltage (at 0.3, 0.7, 1.0 and 1.1 Um/√3) (For CT only)

e. Multiple chopped impulse test on Primary winding.

1.9. 33 kV OUTDOOR EQUIPMENT

1.9.1. CIRCUIT BREAKER (if applicable)

Circuit Breakers shall be outdoor type, comprising three identical single pole units, complete in all respects with all fittings and wiring. The circuit breakers and accessories shall conform to IEC- 62271-100 or equivalent Indian Standard.

1. Duty Requirements
   a. Circuit breaker shall be totally restrike free under all duty conditions and shall be capable of performing their duties without opening resistor. The circuit breaker shall meet the duty requirement of any type of fault or fault location and shall be suitable for line charging and dropping when used on 33 kV effectively grounded or ungrounded systems and perform make and break operations as per the stipulated duty cycles satisfactorily.
   b. The circuit breaker shall be capable for breaking the steady & transient magnetizing current corresponding to 33 kV transformers. It shall also be capable of breaking line charging currents as per IEC- 62271-100 with a voltage factor of 1.4.
   c. The rated transient recovery voltage for terminal fault and short line faults shall be as per IEC:62271-100.
   d. The circuit breaker shall be reasonably quiet in operation. Noise level in excess of 140 dB measured at base of the breaker would be unacceptable. Bidder shall indicate the noise level of breaker at distance of 50 to 150 m from base of the breaker.
   e. The Bidder may note that total break time of the breaker shall not be exceeded under any duty conditions specified such as with the combined variation of the trip coil voltage, pneumatic pressure etc. While furnishing the proof of the total break time of complete circuit breaker, the Bidder may specifically bring out the effect of non-simultaneity between same pole and poles and show how it is covered in the guaranteed total break time.
   f. While furnishing particulars regarding the D.C. component of the circuit breaker, the Bidder shall note that IEC-62271-100 requires that this value should correspond to the guaranteed minimum opening time under any condition of operation.
   g. The critical current which gives the longest arc duration at lock out pressure of extinguishing medium and the duration shall be indicated.
   h. All the duty requirements specified above shall be provided with the support of adequate test reports to be furnished along with the bid.
2. Operating Mechanism
   a. Circuit Breaker shall be operated by electrically spring charged mechanism only.
   b. The operating mechanism shall be anti-pumping and trip free (as per IEC definition) electrically and either mechanically or pneumatically under every method of closing. The mechanism of the breaker shall be such that the position of the breaker is maintained even after the leakage of operating media and/or gas. The circuit breaker shall be able to perform the duty cycle without any interruption.
   c. Electrical tripping shall be performed by shunt trip coil. Provision shall also be made for local electrical control. ‘Local / remote’ selector switch and close & trip

push buttons shall be provided in the breaker central control cabinet. Remote located push buttons and indicating lamps shall also be provided.

d. Operating mechanism and all accessories shall be in local control cabinet. A central control cabinet for the three poles of the breaker shall be provided along with supply of necessary tubing, cables, etc.

3. General Parameter

Type of circuit breaker	Vacuum/SF6 type
Highest system Voltage	36 kV
Rated continuous current	Min. 630 A at rated ambient temperature current capacity
Rated frequency	50 Hz
Number of poles	Three (3)
Rated/minimum power frequency Withstand voltage	As per Clause 1.04
Rated lightning Withstand voltage	As per Clause 1.04
Minimum distance impulse Creepage	As per Clause 1.04
Rated operating duty cycle	O - 0.3 sec. - CO - 3min. – CO
Rated line charging breaking Current (voltage factor of 1.4)	As per IEC
Reclosing	Three phase high speed auto reclosing
Maximum fault level	As per Clause 1.04
Total closing time	Not more than 150 ms.
Auxiliary contacts	As required plus 4NO and 4NC contacts per pole as spare.
Noise level	Maximum 140dB at 50m distance from base of circuit breaker
Seismic acceleration	0.3g horizontal

1.9.2. ISOLATORS

The isolators and accessories shall conform in general to IEC 62271-102 (or equivalent Indian standard) except to the extent explicitly modified in specification.

Earth switches shall be provided on isolators wherever called for.

Operating mechanism of Isolator and earth switch	Manual/ Electrically Operated
Nominal system voltage	33kV
Highest system voltage	36kV
Type	Min. 630 A at rated ambient temperature current capacity
Rated continuous current	As per Clause 1.04
Rated short time current of isolator and earth switch	As per Clause 1.04
Impulse withstand voltage with 1.2/50 micro sec. wave	170 kVp to earth & 195 kVp across isolating distance
One minute power frequency withstand Voltage	70 kV (rms) to earth & 80 kV (rms) between isolating distance
Temperature rise	As per Table-IV of IS: 9921
Rated mechanical terminal load	As per 62271-102
Creepage distance (Total)	As per Clause 1.04
No. of Auxiliary Contacts	2NO+2NC for each Isolator & 2NO+2NC for each earth switch
Material of fixed contact & moving blade	Silver plated electrolytic copper flat

Isolator shall be gang operated for main blades and earth switches. The operation of the three poles shall be well synchronised and interlocked.

The design of linkages and gears shall be such so as to allow one man to operate the handle with ease for isolator and earth switch.

They shall be constructed such that they do not open under influence of short circuit current and wind pressure together. The earth switches wherever provided shall be constructional interlocked so that the earth switches can be operated only when the isolator is open and vice-versa. The insulator of the isolator shall have a min. cantilever strength of 350 kg.

In addition to the constructional interlock, isolator and earth switches shall have provision to prevent their electrical and manual operation unless the associated and other interlocking conditions are met. All these interlocks shall be of failsafe type. Suitable individual interlocking coil arrangements shall be provided. The interlocking coil shall be suitable for continuous operation from DC supply and within a variation range as stipulated in relevant section. The interlock coil shall be provided with

adequate contacts for facilitating permissive logic for 'DC' control scheme of the isolator as well as for AC circuit of the motor to prevent opening or closing of isolators when the interlocking coil is not energised.

1.9.3. INSTRUMENT TRANSFORMER

1. General Requirement

The instrument transformers i.e. current and voltage transformers shall be single phase transformer units and shall be supplied with a common marshaling box for a set of three single phase units.

The tank as well as top metallics shall be hot dip galvanised or painted as per RAL 7035. No oil shall come in contact with zinc galvanized surface.

The instrument transformers shall be oil filled hermetically sealed units. The instrument transformers shall be provided with filling and drain plugs.

Polarity marks shall indelibly be marked on each instrument transformer and at the lead terminals at the associated terminal block.

The insulators (porcelain/polymer) shall have cantilever strength of more than 350 kg.

2. Marshalling Box

The wiring diagram for the interconnection of three phase instrument transformer shall be pasted inside the box in such a manner so that it is visible and it does not deteriorate with time. Terminal blocks in the marshaling box shall have facility for star/delta formation, short circuiting and grounding of secondary terminals. The box shall have enough terminals to wire all control circuits plus 20 spare terminals.

3. Current Transformers (CTs)

The CTs shall have single primary of either ring type or hair pin type or bar type. In case of "Bar Primary" inverted type CTs, the following requirements shall be met:

The secondaries shall be totally encased in metallic shielding providing a uniform equi-potential surface for even electric field distribution.

The lowest part of insulation assembly shall be properly secured to avoid any risk of damage due to transportation stresses. The upper part of insulation assembly sealing on primary bar shall be properly secured to avoid any damage during transportation due to relative movement between insulation assembly and top dome.

The insulator shall be one piece without any metallic flange joint. The CT shall be provided with oil sight glass/oil level indicator.

The core lamination shall be of cold rolled grain oriented silicon steel or other equivalent alloys. The cores shall produce undistorted secondary current under transient conditions at all ratios with specified parameters.

Different ratios shall be achieved by secondary taps only, and primary reconnections shall not be accepted.

The guaranteed burdens and accuracy class are to be intended as simultaneous for all cores.

The instrument security factor at all ratios shall be less than five (5) for metering core. If any auxiliary CT/reactor is used, then all parameters specified shall be met treating auxiliary CTs/reactors as integral part of CT. The auxiliary CT/reactor shall preferably be in-built construction of the CT. In case it is separate, it shall be mounted in secondary terminal box.

The secondary terminals shall be terminated on stud type suitable no's of non-disconnecting and disconnecting terminal blocks inside the terminal box of degree of protection IP:55 at the bottom of CT.

The CTs shall be suitable for horizontal transportation.

The CTs shall have provision for taking oil samples from bottom of CT without exposure to atmosphere to carry out dissolved gas analysis periodically. Contractor shall give his recommendations for such analysis, i.e. frequency of test, norms of acceptance, quantity of oil to be withdrawn, and treatment of CT.

The CT shall have provision for measurement of capacitance and tan delta as erected at site.

Parameters for Current Transformers

General Parameters

Highest system Voltage(Um)	36kV
Rated frequency	50 Hz
System neutral earthing	Effective earthed
Installation	Outdoor
Rated short time thermal current	As per Clause 1.04
Rated dynamic current	As per Clause 1.04
Rated min power frequency withstand voltage (rms value)	70 kV

Rated lightning impulse withstand voltage (peak value)	170 kV
Partial discharge level	10 pico Coulombs max.
Minimum Creepage distance	As per Clause 1.04
Temperature rise	As per IEC 60044
Type of Insulation	Class A
Number of cores	Tariff CTs shall be single metering core with 0.2S accuracy class.
Number of terminals in marshalling box	All terminals of control circuits wired upto marshalling box plus 20 terminals spare

4. Voltage Transformers (VTs)

Voltage transformers shall be of Outdoor type, Oil filled, bottom and dead Tank type electromagnetic, with sealing arrangement as per IS-316-1992. It is also to be equipped with protective and damping devices Oil level indicator with danger level marking is also to be provided.

They shall be of the oil immersed, self-cooled type and provided alternatively with an inert gas cushion or with metallic bellows above the- insulating oil level. A pressure relief device valve type may also be provided if permitted to design.

The VTs may be built up of high-grade non ageing cold rolled grain oriented silicon steel lamination, conforming to IS: 3024, of low hysterisis losses and high permeability to ensure high accuracy at both normal rated and above rated voltages.

The limits of temperatures rise shall not exceed the values specified in Table 3 of IS: 3156 (Part-1) 1998. However, if the voltage transformers has an inert gas cushion above the oil at the top of the tank or housing shall not exceed 50o C. The oil shall be mineral insulating oil conforming to IS:335-1983.

The HV neutral end terminal shall not be earthed directly to the metal body of the VT but shall be brought out through a porcelain 2 KV class bushing. A tinned copper link of the bolted type shall be provided to connect the HV neutral end terminal and the earth bushing. Both the HV neutral end bushing and the earth bushing shall be housed in a. dust tight, vermin proof box with a front access bolted type gasketted cover.

Parameters for Voltage Transformers

General Parameters

Highest system Voltage(Um)	36kV
System neutral earthing	Effective earthed
Installation	Outdoor
System Fault level (1 Sec)	As per Clause 1.04
Rated min power frequency withstand voltage (rms value)	As per Clause 1.05
Rated lightning impulse withstand voltage (peak value)	As per Clause 1.05
Standard reference range of frequencies for which the accuracy are valid	96% to 102% for protection and 99% to 101% for measurement
Rated voltage factor	1.2 continuous & 1.5 for 30 sec
Class of Accuracy	For tariff metering VT - 0.2 Other VTs – 0.2
Stray capacitance and stray conductance of LV terminal over entire carrier frequency range	As per IEC:358
One Minute Power frequency Withstand voltage for secondary winding	2 kV rms
Temp. rise over an ambient temp. of 50°C	As per IEC 60044
Number of terminals in control spare.	All terminals of control circuits wired Cabinet upto marshalling box plus 10 terminals
Min Creepage distance	As per Clause 1.04
Rated total thermal burden	150 VA
Partial discharge level	10 pC max

1.9.4. SURGE ARRESTOR

The surge arrestors (SAs) shall conform in general to IEC 60099-4 or IS: 3070 except to the extent modified in the specification. Arresters shall be of hermetically sealed units, self-supporting construction, suitable for mounting on lattice type support structures. Bidder shall furnish the technical particulars of Surge arrester.

The SAs shall be of heavy duty station class and gapless Metal Oxide type without any series or shunt gaps. The SAs shall be capable of discharging over- voltages occurring during switching of unloaded transformers, and long lines.

Arrestors shall be complete with insulating base for mounting on structures. Self-contained discharge counters, suitably enclosed for outdoor use and requiring no auxiliary or battery supply for operation shall be provided for each single pole unit with necessary connection. Suitable leakage current meters should also be supplied within the same enclosure. The reading of millimeter and counters shall be visible through an inspection glass panel.

The surge arrestors shall conform to type tests and shall be subjected to routine and acceptance tests in accordance with IEC-60099-4. The cantilever strength of the insulator shall be min. 350 kg (porcelain) /150kg (polymer) for 33 kV level.

General Parameters

Rate System Voltage	36 kV
Rate Arrester Voltage	30 kV
Nominal discharge current	10 kA of 8/20 micro-sec wave
Minimum discharge capability	5 kilo joule/kV(referred to rated arrestor voltage corresponding to minimum discharge
Maximum continuous operating voltage	24 kV rms
Max. residual voltage (1 kA)	70 kVp
Max. residual voltage at 10 kA nominal discharge current (8/20 micro sec wave)	85 kVp
Max. switching impulse residual Voltage at 500A peak	70 kVp
Max. steep current residual voltage	93 kVp at 10 kA
Long duration discharge class	2

High current short duration test value (4/10 micro-sec-wave)	100 kAp
Low current long duration test value (2000 micro sec.)	As per IEC
Current for pressure relief test	As per Clause 1.04
Pressure relief class	Class A
One minute power frequency withstand voltage of arrestor housing (dry and wet)	70 kV (rms)
Impulse withstand voltage of arrestor housing with 1.2/50 micro sec. Wave	170 kVp
Nominal creepage distance	As per Clause 1.04
Partial discharge at 1.05 MCOV	Not more than 50 pc

1.9.5. POST INSULATOR

The post insulators shall conform in general to latest IS:2544 and IEC – 60815, 60168.

Post type insulators shall consist of a porcelain part permanently secured in a metal base to be mounted on the supporting structures. They shall be capable of being mounted upright. They shall be designed to withstand any shocks to which they may be subjected to by the operation of the associated equipment. Only solid core insulators shall be accepted. Height of post insulator shall be preferably as given under parameters of this part.

Other requirements of insulator as given under auxiliary requirements shall also be applicable.

In accordance with the stipulations elsewhere the post insulators shall conform to type tests and acceptance, sample and routine tests as per IS: 2544, IEC-60168 shall be carried out.

Type	Solid core
Voltage class	36 kV
Rated one minute power frequency withstand Voltage	As per Clause 1.04

Rated Lightning Impulse withstand voltage with 1.2/50 micro sec. wave	As per Clause 1.04
Total min. cantilever strength	As per IEC 60273
Min. torsional moment (Nm)	As per IEC 60273
Creepage distance (Total)	As per Clause 1.04
i) Top p.c.d (mm) ii) Bottom p.c.d (mm)	76 76
No. of bolts: Top: Bottom:	4
Diameter of bolt holes (mm) Top: Bottom:	M12

1.10. REQUIREMENT OF AUXILIARY ITEMS

1. ALUMINIUM TUBULAR CONDUCTOR

a. The aluminium tube shall be grade 63401 WP (range2) as per IS 5082.

b. There shall be no negative tolerance on OD and thickness of the tube. Other tolerances shall be as per IS: 2678 and 2673.

c. Tests: In accordance with stipulations of specification routine tests shall be conducted on tubular conductor as per IS:5082. Also, the wall thickness and ovality shall be measured by ultrasonic method. In addition 0.2% proof tests on both parent material and aluminium tube after welding shall be conducted.

2. FLEXIBLE CONDUCTOR

The conductor shall be Aluminium Core Steel Reinforced (ACSR) type or equivalent. The conductor shall confirm to IS:398 (Part-II) except where otherwise specified herein.

3. CLAMPS AND CONNECTORS

a. The material of clamps and connectors shall be Aluminium alloy casting conforming to designation A6 of IS: 617 for connecting to equipment terminals and conductors of aluminium. In case equipment terminals are of copper, the same clamps/connectors shall be used with 2mm thick bimetal.

b. The material of clamps and connectors shall be Galvanised mild steel for connecting to G.S. shield wire.

c. Bolts, nuts and plain washers shall be hot dip galvanised mild steel for sizes M12 and above. For sizes below M12, they shall be electro- galvanised mild steel. The spring washers shall be electro-galvanised mild steel.

d. All castings shall be free from blow holes, surface blisters, cracks and cavities. All sharp edges and corners shall be rounded off to meet specified corona and radio interference requirements
e. They shall have same current rating as that of the connected equipment. All current carrying parts shall be at least 10 mm thick. The connectors shall be manufactured to have minimum contact resistance.
f. Flexible connectors, braids or laminated strips shall be made up of copper/aluminium.
g. Current rating and size of terminal/conductor for which connector is suitable shall be put on a suitable sticker on each component which should last atleast till erection time.

4. INSULATORS & INSULATOR STRING HARDWARES

a. Insulators used in string may be porcelain /polymer /glass ceramic type. Polymer/Glass ceramic type insulator shall be as per IEC 60815 - 2//3 .Porcelain insulator shall comply IS: 731-1976 or equivalent international standard and shall be homogenous, free from laminations, cavities and other flaws or imperfections that might affect the mechanical or dielectric quality and shall be thoroughly vitrified, tough and impervious to moisture. Hollow porcelain should be in one integral piece in green & fired stage.
b. Pin insulators shall be used on all poles in straight line and disc or shackle insulators on angle and dead end poles.
c. Strain insulators shall be used at line sectionalizing locations, dead end locations, major crossings and locations where the angle of deviation of line is more than 100.
d. For 33 kV lines Ball & Socket type strain insulators with fittings shall be used.
e. The pins for insulators shall be fixed in the holes provided in the cross- arms and the pole top brackets. The insulators shall be mounted in their places over the pins and tightened. In the case of strain or angle supports, where strain fittings are provided for this purpose, one strap of the strain fittings is placed over the cross-arm before placing the bolt in the hole of cross-arms. The nut of the straps shall be so tightened that the strap can move freely in horizontal direction.
f. The insulator hardware shall be of bolted type and shall be of forged steel except for insulator cap, which can be of malleable cast iron. It shall also generally meet the requirements of clamps and connectors as specified above.
g. In one span, Tension string assembly at one end shall be supplied with suitable turn buckle.
h. DISC INSULATOR

The disc insulator shall meet the following parameters:

a)	Type	Antifog type insulator
b)	Size of insulator	255x145
c)	Electro mechanical strength	120 kN

d)	Leakage distance (mm)	430 mm minimum or as required to meet the total creepage.
e)	Power frequency withstand voltage	85 kV (dry), 50kV (wet)

5. 33 kV POLES

All 33 kV pole shall be of galvanised RSJ poles of appropriate grade & size with min. galvanisation thickness of 610 gm/sq.m or 86 microns. All other structural members associated with the pole shall be Hot dip galvanised unless
& otherwise specified.

Maximum span of HT Lines with proposed conductors shall be as per REC construction standards or as specified in the table below.

The following types of pole configurations shall be used at respective locations given below after finalization of survey & pole spotting

a	SP (Single Pole support)	i) 0^o-10^o deviation.
b	DP (Double Pole support)	ii) 10^o - 60^o deviation.
c	FP (Four Pole support)	iii) 60^o - 90^o deviation

DESIGN PARAMETERS

a. Factor of safety 2.0 in normal condition for 33 kV.
b. Wind Pressure on Pole & conductor– As per IS 802
c. Wind load on cross-arms, insulators guy-wire etc. shall be considered.
d. Wind load on full projected area of conductors and pole is to be considered for design.
e. Ground clearance shall be minimum 5.2m for 33 kV line for bare conductor at locations other than along and across road crossings.
f. All other clearance shall be as per IE Rules.
g. The live metal clearance shall be as per IS: 5613 and shall be min.320 mm for 33 kV line.

Pole accessories like danger plates, phase plates, anticlimbing device, shall be provided.

1) Excavation of pole pit

Excavation cost for pits shall be included by the contractor in the bid for following type of soils inclusive of dewatering of pits and shoring and shuttering wherever necessary.

i. All type of soils and soil conditions but excluding hard rock

For the purpose of pole planting, normally pit size shall be 600x500x1500 (mm). In case bidder employs Earth augers, the Pit size can be considered 0.7 meter dia with 1.5 meter depth.

ii. Hard rock

For hard rock locations, 1 meter deep hole of diameter 20% in excess of the longest dimension of the bottom most portion of pole shall be excavated. The pole shall be grouted in the pit with 1:2:4 nominal concrete mix at the time of pole erection. For hard rock, the excavation cost per location shall remain same for all type of foundations. Controlled blasting shall be permitted only in case of hard or rocky soil.

The contractor shall be responsible for any damage or accidents arising out of the process of blasting. Blasting shall not be permitted if the area around location is inhabited. In such case, the contractor shall have to follow other methods like drilling etc.

2) PCC footing and compaction of soil

The planting depth of pole shall be 1500 mm in the ground except in wet soil and black cotton soil where depth shall be increased by 0.2m to 0.3m with reduced wind span.

3) Earthing of Poles

In 33 kV, each pole shall be earthed as per REC Construction Standard CS-J-2.

In rocky areas where digging of earth pits up to 1500mm is not possible spike earthing in horizontal configuration buried at a depth of not less than 800mm may be used.

In rocky areas where individual earthing of poles is not possible, an overhead GI earth wire shall be run as per REC construction standard drawing- A5. This earth wire shall be earthed at three different points in one km using pipe earthing as per REC construction standard J2. The dimension of overhead GI earth wire 6mm dia. for 33kV lines.

4) Providing of Guys/Strut Poles to Supports

The arrangement for guys shall be as per REC Construction. Strut poles/flying guys wherever required shall be installed on various pole locations as per REC construction standards. For selection of guying locations REC guidelines & construction practices & IS:5613 shall be followed. The stay rod should be placed in a position so that the angle of rod with the vertical face of the pit is 300/450 as the case may be.

In this work anchor type guy sets are to be used. These guys shall be provided at

i. Angle locations
ii. Dead end locations
iii. T-off points
iv. Steep gradient locations.
v. Double Pole & Four poles
vi. Wind stays along tangent locations at 40% of pole locations
vii. For double pole structures (DP), four stays along the line, two in each direction and two stays along the bisection of the angle of deviation (or more) as required depending on the angle of deviation are to be provided. Hot dip galvanized stay sets are to be used.

G.I. stay wires of size 7/4 mm with GI turn buckle rod of 20 mm dia & 20 mm dia GI stay rods shall be used for 33 KV line.

Precast RCC anchor plate as per REC construction standard K1 shall be used for the purpose of anchoring the guy rod with a bolt arrangement at one end and other end is given shape of 40mm dia circle to bind one end of the stay wire.

The size of the stay pit shall be 500mmx500mmx1600mm with concrete mix of 1:2:4 having volume in stay pit of 800x500x500=0.2 cubic mtr for embedding RCC stay plate assembly and the balance pit to be filled with earth duly rammed.

In case of firm soil, concreting is not required.

The turn buckle shall be mounted at the pole end of the stay and guy wire so fixed that the turn buckle is half way in the working position, thus giving the maximum movement for tightening or loosening.

If the guy wire proves to be hazardous, it should be protected with suitable asbestos pipe filled with concrete of about 2 m length above the ground level, painted with white and black strips so that, it may be visible at night.

5) Cross Arms

Cross Arms for 33 kV Overhead Power Lines shall be made out of 100x50x6 mm M.S. channel.

For 33 kV line, cross arms a MS strip of 100x50x5 mm shall be welded for providing additional mechanical strength at the seat of the pin insulator.

All types of cross arms & clamps shall be hot dip galvanized as per IS 2629 with galvanization thickness min. 610 gm/sq.m or 86 microns.

Fixing of Cross Arms

After the erection of supports and providing guys, the cross-arms are to be mounted on the support with necessary clamps, bolts and nuts. The practice of fixing the cross arms before the pole erection can also be followed. In case, the cross-arm shall be mounted after the pole is erected, the lineman should climb the pole with necessary tools. The cross-arm shall then tied to a hand line and pulled up by the ground man through a pulley, till the cross-arm reaches the line man. The ground man should station himself on one side, so that if any material drops from the top of the pole, it may not strike him. All the materials should be lifted or lowered through the hand line, and should not be dropped.

6) EARTHING CONDUCTOR

a. The main conductor buried in earth shall be 40 mm dia MS rod for main and auxiliary mat. The earthing conductors over the ground shall be of 75x12 mm GS flat. The earthing leads for columns and auxiliary structures, cable trenches shall be of 75x12 mm GS flat. The earthing of the lighting fixtures shall be carried out by 16 SWG wire.

b. All earthing conductors above the ground level shall be galvanized steel only.

c. Earthing terminal of each surge arrester, capacitor voltage transformer and lightning down conductors shall be directly connected to earth rod (with earth pit) which in turn, shall be connected to station earthing grid.

d. Earthing mat comprising of closely spaced (300mm x 300mm) conductors shall be provided at 300 mm below ground the operating handles of the isolators/earth switch.

e. Earthing conductor shall be buried 2000 mm outside the switchyard fence. Every post of the fence and gates shall be connected to earthing loop.

7) LIGHTNING PROTECTION

Direct stroke lightning protection (DSLP) shall be provided in the switchyard by LM/shield wires.

Lightning protection System down conductors shall not be connected to other conductors above ground level. Also, no intermediate earthing connection shall be made to Surge arrester, Voltage Transformer, earthing leads for which shall be directly connected to earth electrode.

Every down conductor shall be provided with a test joint at about 1000 mm above ground level. The test joint shall be directly connected to the earthing system. Down conductors shall be cleated on the structures at 2000 mm interval.

The lightning protection system shall not be in direct contact with underground metallic service ducts and cables.

Lightning protection system installation shall be in strict accordance with the latest editions of Indian Electricity Rules, Indian Standards and Codes of practice and Regulations existing in the locality where the system is installed.

1. Earthwire for Lightning Protection

a)	Number of strands	7 of steel
b)	Strand diameter	3.66 mm
c)	Overall diameter	10.98 mm
d)	Weight	583 kg/km approx.
e)	Ultimate tensile strength	68.4 kN minimum
f)	Total cross-sectional area	73.65 sq.mm.
g)	Calculated DC resistance	2.5 ohms/km at 20°C.
h)	Direction of lay of outer layer	Right hand
i)	Protective coating for storage	Boiled linseed oil to avoid wet storage stains (white rust)

The earth wire shall be preformed and post formed quality.

2. Earthwire Compression type Tension Clamp & Flexible Copper Bond Tension Clamp For Earthwire

The details shall be as per IS: 2121 part-3. Compression type tension clamp shall be used to hold 7/3.66 mm galvanised steel earthwire. Anchor shackle shall be supplied which shall be suitable for attaching the tension clamp to strain plates. The strain plates supplied with the towers will have a minimum thickness of 8 mm with a hole of 17.5 mm diameter. Suitable lugs for jumper connection shall also be supplied alongwith necessary bolts and nuts.

The dimensions and the dimensional tolerance of the tension clamp shall be as given below:

Item	Dimensions before		Dimensions after	
	Inner Dia (mm)	Outer Dia (mm)	Corner to Corner width (mm)	Face to Face width
Steel Dead - end	11.1±0.2	21±0.5	20.2±0.5	17.5±0.5

Flexible copper bond: as detailed in is: 2121 part 3. The flexible copper bond shall be fitted with 2 nos. Tinned copper connecting lugs which will be pressed jointed to either ends of the bond. One lug shall be suitable for
12 mm dia bolt and other for 16 mm dia bolt. The complete assembly shall also include one 16 mm dia 40 mm lug with ms bolt hot dip galvanised with nut and lock washer.

8) BUSHINGS, HOLLOW COLUMN INSULATORS, SUPPORT INSULATORS, AND DISC INSULATORS

1. Bushings shall be manufactured and tested in accordance with IS: 2099 & IEC: 60137 while hollow column insulators shall be manufactured and tested in accordance with IEC 62155/IS 5284. The support insulators shall be manufactured and tested as per IS: 2544 / IEC 60168/IEC 60273. The insulators shall also conform to IEC 60815 as applicable having alternate long and short sheds.
   Support insulators/ bushings/ hollow column insulators shall be designed to have ample insulation, mechanical strength and rigidity for the conditions under which they will be used.

2. Porcelain used shall be homogenous, free from laminations, cavities and other flaws or imperfections that might affect the mechanical or dielectric quality and shall be thoroughly vitrified, tough and impervious to moisture.
3. Glazing of the porcelain shall be uniform brown in colour, free form blisters, burns and other similar defects.
4. The design of the insulator shall be such that stresses due to expansion and contraction in any part of the insulator shall not lead to deterioration. All ferrous parts shall be hot dip galvanised.
5. Post type insulators shall consist of a porcelain part permanently secured in metal base to be mounted on supporting structures. They shall be capable of being mounted upright. They shall be designed to withstand all shocks to which they may be subjected to during operation of the associated equipment.
6. Bushing porcelain shall be robust and capable of withstanding the internal pressures likely to occur in service. The design and location of clamps, the shape and the strength of the porcelain flange securing the bushing to the tank shall be such that there is no risk of fracture. All portions of the

assembled porcelain enclosures and supports other than gaskets, which may in any way be exposed to the atmosphere shall be composed of completely non hygroscopic material such as metal or glazed porcelain.

7. All iron parts shall be hot dip galvanised and all joints shall be air tight. Surface of joints shall be trued, porcelain parts by grinding and metal parts by machining. Insulator/ bushing design shall be such as to ensure a uniform compressive pressure on the joints.
8. In accordance with the requirements stipulated elsewhere, bushings, hollow column insulators and support insulators shall conform to type tests and shall be subjected to routine tests and acceptance test/ sample test in accordance with relevant standards.

9) SPACERS

1. Spacers shall conform to IS: 10162. They shall be of non-magnetic material except nuts and bolts, which shall be of hot dip galvanised mild steel.

2. Spacers shall generally meet the requirements of clamps and connectors as specified above. Its design shall take care of fixing and removing during installation and maintenance.
3. In addition to the type tests as per IS:10162, clamp slip test should have been conducted. In this test the sample shall be installed on test span of twin/quad bundle string at a tension of 44.2 kN (4500 kg). One of the clamps when subjected to a longitudinal pull of 2.5 kN (250 kg) parallel to the axis of conductor shall not slip, i.e. permanent displacement between conductor and clamp after the test shall not exceed 1.0 mm. This test should have been performed on all other clamps of the sample.

10) CABINETS, BOXES, KIOSKS, PANELS, ETC.

1. All types of control cabinets, junction boxes, marshaling boxes, lighting panels, terminal boxes, operating mechanism boxes, Kiosks etc. shall generally conform to IS:5039, IS:8623 and IEC:439 as applicable.
2. They shall be of Stainless steel or Aluminium. The thickness of Stainless steel sheet shall be 1mm.The thickness of aluminium shall be 3mm and shall provide rigidity. Top of the boxes shall be sloped towards rear of the box. However, the junction and switch boxes shall be of hot dip galvanised sheet steel of 1.6mm thickness. The paint shade shall be RAL 7035 outside and glossy white inside.
3. The cabinets/boxes/kiosks/panels shall be free standing or wall mounting or pedestal mounting type. They shall have hinged doors with padlocking arrangement. All doors, removable covers and plates shall be gasketed all around with neoprene gaskets.
4. The degree of protection of all the outdoor boxes shall not be less than IP 55 as per IS 2147.
5. The cable entry shall be from bottom, for which removable gasketed cable gland plates shall be provided.

6. Suitable 240V, single phase, 50Hz ac heaters with thermostats controlled by switch and fuse shall be provided to maintain inside temperature 10deg. above the ambient.
7. The size of enclosure and the layout of equipment inside shall provide generous clearances. Each cabinet/box/kiosk/panel shall be provided with a 15A, 240V AC, 2 pole, 3 pin industrial grade receptacle with switch. For incoming supply, MCB of suitable rating shall be provided. Illumination of each compartment shall be with door operated incandescent lamp. All control switches shall be of rotary switch type.
8. Each cabinet/box/kiosk/panel shall be provided with two earthing pads to receive 75mmx12mm/50mmx6mm GS flat. The connection shall be bolted type with two bolts per pad. The hinged door shall be connected to body using flexible wire. The cabinets/boxes/kiosks/panels shall also be provided with danger plate, and internal wiring diagram pasted on inside of the door. The front label shall be on a 3mm thick plastic plate with white letters engraved on black background.

11) BAY MARSHALLING BOX

1. Bay Marshaling Box located at a convenient location to receive and distribute cables shall be provided as required. It shall meet all the requirements as specified for cabinets/boxes.
2. It shall have three separate distinct compartments for following purposes:
   a. To receive two incoming 415V, three phase, AC supplies controlled by 100A four pole MCBs with auto changeover provision, and to distribute five (5) three phase ac supplies controlled by 32A four pole MCBs. It shall also be provided with 63A, 3 phase 4 pin industrial grade receptacle with rotary switch.
   b. To receive three phase incoming from first compartment and to distribute ten (10) single phase ac supplies controlled by 16A two pole MCBs.
   c. min. 200 nos. terminal blocks in vertical formation for interlocking facility.

12) AUXILIARY SWITCH

The auxiliary switch shall conform of following type tests:

a. Electrical endurance test - A minimum of 1000 operations for 2A. D.C. with a time constant greater than or equal to 20 milliseconds with a subsequent examination of mV drop/ visual defects/ temperature rise test.

b. Mechanical endurance test - A minimum of 5000 operations with a subsequent checking of contact pressure test/ visual examination

c. Heat run test on contacts

d. IR/HV test, etc.

Type tests Requirement for Auxiliary Items

All equipment with their terminal connectors, control cabinets, main protective relays, etc. as well as insulators, insulator strings with hardwares, clamps and connectors, marshalling boxes, etc., shall conform to type tests as per relevant standards and shall be subjected to routine and acceptance tests in accordance with the requirements stipulated under respective equipment sections.

13) TERMINAL BLOCKS

1. They shall be non-disconnecting stud type of extensible design equivalent to Elmex type CAT-M4.
2. The terminal blocks shall be of min. 650 V grade, and rated to continuously carry maximum expected current. The conducting part shall be tinned or silver plated.
3. They shall be of moulded, non-inflammable thermosetting plastic. The material shall not deteriorate with varied conditions of temperature and humidity. The terminal blocks shall be fully enclosed with removable covers of transparent, non- deteriorating plastic material. Insulating barriers shall be provided between the terminal blocks so that the barriers do not hinder the wiring operation without removing the barriers.
4. The terminals shall be provided with marking tags for wiring identification.
5. Unless otherwise required (expected current rating) or specified, terminal blocks shall be suitable for connecting the following conductors on each side:

   All CT & VT circuits - Min. four 2.5 sq.mm. copper flexible conductor
   AC & DC power supply -Two 16 sq.mm. aluminium conductor Circuits
   Other control circuits - Min. two 2.5 sq.mm. copper flexible conductor
6. The terminal blocks for CT and VT secondary leads shall be provided with test links and isolating facilities. CT secondary leads shall also be provided with short circuiting and earthing facilities.

14) WIRING

1. All wiring shall be carried out with 1100 V grade stranded copper wires.

The minimum size of the stranded conductor used for internal wiring shall be as follows:

a. All circuits except CT circuits 2.5 sq.mm

b. CT circuits 4 sq. mm (minimum number of strands shall be 3 per conductor).

2. All internal wiring shall be securely supported, neatly arranged readily accessible and connected to equipment terminals and terminal blocks.
3. Wire terminations shall be made with solderless crimping type of tinned copper lugs which firmly grip the conductor and insulation. Insulated sleeves shall be provided at all the wire terminations. Engraved core identification plastic ferrules marked to correspond with the wiring diagram shall be fitted at both ends of each wire. Ferrules shall fit tightly on the wires shall not fall off when the wires and shall not fall off when the wire is disconnected from terminal blocks.
4. All wires directly connected to trip circuit breaker shall be distinguished by the addition of a red coloured unlettered ferrule. Number 6 & 9 shall not be included for ferrules purposes.
5. All terminals including spare terminals of auxiliary equipment shall be wired upto terminal blocks. Each equipment shall have its own central control cabinet in which all contacts including spare contacts from all poles shall be wired out. Interpole cabling for all equipment's shall be carried out by the Contractor.

1.11. INSTALLATION

1. EARTHING

The earthing shall be done in accordance with requirements given in Annexure- I of this section and drawing enclosed with the specifications. Earthing of panels shall be done in line with the requirements given in respective equipment section of this specification.

2. CIVIL WORKS

The civil works shall be done in accordance with requirements stipulated elsewhere in the specification.

3. STRUISTSRAL STEEL WORKS

The structural steel works shall be done in accordance with requirements stipulated elsewhere in the specification.

4. BAY EQUIPMENT

The disposition of equipment to be supplied are shown in enclosed tender drawings.

The Contractor shall prepare layout drawings and submit the same for approval of the Owner. The approval of drawings shall not absolve Contractor from his responsibility regarding designing & engineering of switchyard and Contractor shall be fully responsible for all works covered in the scope of this specification.

5. EQUIPMENT ERECTION NOTES

All support insulators, circuit breaker interrupters and other fragile equipment shall be handled with cranes with suitable booms and handling capacity.

Where, assemblies are supplied in more than one section, Contractor shall make all necessary mechanical and electrical connections between sections including the connection between buses. Contractor shall also do necessary adjustments/alignments necessary for proper operation of circuit breakers, isolators and their operating mechanisms. All components shall be protected against damage during unloading, transportation, storage, installation, testing and commissioning. Any equipment damaged due to negligence or carelessness or otherwise shall be replaced by the Contractor at his own expense. The contractor shall strictly follow manufacturer's recommendations for handling and erection of equipment.

The slings shall be of sufficient length to avoid any damage to insulator due to excessive swing, scratching by sling ropes etc. Handling equipment, sling ropes etc. should be tested before erection and periodically thereafter for strength.

Bending of piping should be done by a bending machine and through cold bending only. Bending shall be such that inner diameter of pipe is not reduced. The pipes shall be thoroughly cleaned before installation.

Cutting of the pipes wherever required shall be such as to avoid flaring of the ends. Hence only a proper pipe cutting tool shall be used. Hack saw shall not be used.

For cleaning the inside and outside of hollow insulators only Muslin or leather cloth shall be used.

The rigid busbars for equipment interconnections shall have rigid connections at one end and expansion / flexible at the other end. The tubular aluminium connections shall have not more than one joint per span. Since no wastages are permissible, the bidder shall work out the cut lengths of aluminum tube based on finalized layout and dispatch the same to site without requiring owners's approval. Corona bells shall be provided at the end of the rigid busbars.

6. CABLING

1. Cabling shall be on cable racks, in trenches, vertical shafts, excavated trenches for direct burial, pulled through pipes and conduits run clamped on steel structures etc. in accordance with the requirements specified elsewhere in the specification.

2. Cables inside the switchyard shall be laid on GI angle supports at 600mm spacing with separate tiers for control and power cables. The GI angles shall be bolted / welded to galvanized insert plates inside RCC trenches
3. Cables shall be generally located adjoining the electrical equipment through the pipe insert embedded in the ground. In the case of equipment located away from cable trench either pipe inserts shall be embedded in the ground connecting the cable trench and the equipment or in case the distance is small, notch/opening shall be provided. In all these cases necessary bending radii as recommended by the cable supplier shall be maintained.
4. Cabling in the control room shall be done on ladder type cable trays with supports at an interval of 2000mm.
5. All interpole cables (both power & control circuit) for equipment shall be laid in cable trenches/G.I. Conduit Pipe of NB 50/100mm which shall be buried in the ground at a depth of 300mm.

1.12. SITE TESTING AND COMMISSIONING

1. INTRODUCTION

An indicative list of tests is given below. Contractor shall perform any additional test based on specialties of the items as per the field QP/ instructions of the equipment supplier or Owner without any extra cost to the Owner. The Contractor shall arrange all instruments required for conducting these tests along with calibration certificates and shall get the list of instruments approved from the Owner.

2. GENERAL CHECKS

a. Check for physical damage.

b. Visual examination of zinc coating/ plating

c. Check from name plate that all items are as per older/ specification.

d. Check tightness of all bolts, clamps and connecting terminals using toque wrenches.

e. For oil filled equipment check for oil leakage, if any. Also check oil level and top up.

f. Check ground connections for quality of weld and application of zinc rich paint over weld joint of galvanized surfaces.

g. Check cleanliness of insulator and bushings.

h. All checks and tests specified by the Manufacturers in their drawings and manuals as well as all tests specified in the relevant code of erection.

i. Pressure test on all pneumatic lines at 1.5 times the rated pressure shall be conducted.

3. CIRCUIT BREAKERS

a. Insulation resistance of each pole.

b. Check adjustments, if any, suggested by manufacturer.

c. Breaker closing and tripping time.
d. Slow and power closing operation and opening
e. Trip free and anti-pumping operation.
f. Minimum pick up volts of coils
g. Contact resistance
h. Functional checking of compressed air plant and all accessories

i. Functional checking of control circuits, interlocks, tripping protective relays through
j. Insulation resistance of control circuits, motor etc.
k. Resistance of closing and tripping coils.

4. ISOLATORS

a. Insulation resistance of each pole

b. Manual and electrical operation on interlocks

c. Insulation resistance of control circuits and motors.

d. Ground connections

e. Contact resistance

f. Proper alignment to minimise the vibration to the extreme possible during operation.

g. Measurement of operating torque for isolator and Earth switch

h. Resistance of operating and interlocking coils.

5. CURRENT TRANSFORMERS

a. Insulation Resistance Test
b. Polarity test.

c. Ratio identification test-checking of all ratios on all cores by primary injection of current.

d. Dielectric test of oil (wherever applicable).

e. Magnetizing characteristics test.

f. Capacitance and tan delta measurement at minimum 10kV.

6. CAPACITOR VOLTAGE TRANSFORMERS

a. Insulation resistance test.

b. Polarity test.

c. Ratio test.

d. Dielectric test of oil (if applicable).
e. Capacitance and tan delta measurement at minimum 10kV.

7. SURGE ARRESTER

a. Grading leakage current.

b. Resistance of ground connection.

c. Resistive current drawn at rated voltage after energisation.

8. PHASING OUT

The phasing out of all supplies in the station system shall be carried out.

9. STATION EARTHING

a. Check soil resistivity

b. Check continuity of grid wires
c. Check earth resistance of the entire grid as well as various sections of the same.

d. Check for weld joint and application of zinc rich paint on galvanised surface.

e. Dip test on earth conductor prior to use.

10. CONDUCTOR STRINGING AND POWER CONNECTORS

a. Physical check for finish

b. Electrical clearance check

c. Testing of torque by torque by torque wrenches on all bus power connectors and other accessories.

d. Sag and tension check on conductors.

11. INSULATORS

Visual examination for finish damage, creepage distance, etc.

Annexure -I

EARTHING NOTES FOR SWITCHYARD GENERAL

1. Earthing of operating boxes, cubicles shall be done by 50 X 6 mm GS flat while cable trenches, equipment and structures by 75 X 12 mm GS flat.

2. Neutral points of systems of different voltages, metallic enclosures and frame works associated with all current carrying equipment and extraneous metal works associated with electric system shall be connected to a single earthing system unless stipulated otherwise.

3. Earthing system installation shall be in strict accordance with the latest editions of Indian Electricity Rules, relevant Indian Standards and Codes of practice and Regulations existing in the locality where the system is installed.

4. DETAILS OF EARTHING SYSTEM Item

Item	**Size**	**Material**
Main Earthing conductor	40mm dia rod	Mild steel
Conductor above ground & earthing leads (for equipment)	75X12/50X6 mm	Galvanized steel
Rod Electrode	40mm dia, 3000mm	Mild steel
Pipe Electrode	40mm dia, 3000mm	GS
G.I. Earthwire	7/8 SWG	GI

5. For Step and Touch Potential the following parameters shall be considered
i) Current distribution factor – 1 (one)
ii) Duration of fault current – 0.5 sec
iii) Human body weight – 50kg
Grid resistance shall be less than 1(one) ohm.

6. EARTHING CONDUCTOR LAYOUT

   i. Earthing conductors in outdoor areas shall be buried atleast 600mm below finished grade level unless stated otherwise.

   ii. Spacing between rod electrodes shall be provided based on the earthmat design calculations.

   iii. Wherever earthing conductors cross cable trenches, underground service ducts, pipes, tunnels and railway tracks etc., it shall be laid atleast 300mm below them and shall be re-routed in case it fouls with equipment/structures foundations.

iv. Tap connections from the earthing grid to the equipment/structures to be earthed, shall be terminated on the earthing terminals of the equipment/structures, if the equipment is available at the time of laying the grid. Otherwise, “earth insert” with temporary wooden cover or “earth riser” shall be provided near the equipment foundation/pedestal for future connections to the equipment earthing terminals.

v. Earthing conductor along their run on cable trench ladder columns, beams, walls, etc. shall be supported by suitable welding/cleating at intervals of 750mm. Earthing conductors along cable trenches shall be on the wall nearer to the equipment. Wherever it passes through walls, floors etc. galvanized iron sleeves shall be provided for the passage of the conductor. Both ends of the sleeves shall be sealed to prevent the passage of water through the sleeves.

vi. Earthing conductor around the building shall be buried in earth at a minimum distance of 1500mm from the outer boundary of the building. In case high temperature is encountered at some location, the earthing conductor shall be laid minimum 1500mm away from such location.

vii. In outdoor areas, tap connections shall be brought 300mm above ground level for making connections in future, in case equipment is not available at the time of grid installations.

viii. Earthing conductors crossing the road shall be either installed in hume pipes or laid at greater depth to suit the site conditions.

ix. Earthing conductors embedded in the concrete fibre shall have approximately 50mm concrete cover.

7. EQUIPMENT AND STRUCTURES EARTHING

i. The connection between earthing pads and the earthing grid shall be made by short and direct earthing leads free from kinks and splices. In case earthing pads are not provided on the item to be earthed, same shall be provided in consultation with engineer.

ii. Metallic pipes, conduits and cable tray sections for cable installation shall be bonded to ensure electrical continuity and connected to earthing conductors at regular interval. Apart from intermediate connections, beginning points shall also be connected to earthing system.

iii. Metallic conduits shall not be used as earth continuity conductor.

iv. A separate earthing conductor shall be provided for earthing lighting fixtures, lighting poles, receptacles, switches, junction boxes, lighting conduits, etc.

v. Wherever earthing conductor crosses or runs along metallic structuress such as gas, water, steam, conduits, etc. and steel reinforcement in concrete it shall be bonded to the same.

vi. Cable and cable boxes/glands, lockout switches etc. shall be connected to the earthing conductor running alongwith the supply cable which, in turn, shall be connected to earthing grid conductor at minimum two points, whether specifically shown or not.

vii. Railway tracks within switchyard area shall be bonded across fish plates and connected to earthing grid at several locations.

viii. Earthing conductor shall be buried 2000mm outside the switchyard fence. Every post of the fence and gates shall be connected to earthing loop by one lead.

ix. Flexible earthing connectors shall be provided where flexible conduits are connected to rigid conduits to ensure continuity.

x. Equipment earthing (Riser & welding of two conductors) shall be done as per standard drawing enclosed in this part.

8. JOINTING

i. Earthing connections with equipment earthing pads shall be of bolted type. Contact surfaces shall be free from scales, paint, enamel, grease, rust or dirt. Two bolts shall be provided for making each connection. Equipment bolted connections, after being checked and tested, shall be painted with anti-corrosive paint/compound.

ii. Connection between equipment earthing lead and between main earthing conductors shall be welded/brazed type. For rust protections, the welds should be treated with red lead and afterwards thickly coated with bitumen compound to prevent corrosion.

iii. Steel to copper connections shall be brazed type and shall be treated to prevent moisture ingression.

iv. Resistance of the joint shall not be more than the resistance of the equivalent length of the conductor.

v. All ground connections shall be made by electric arc welding. All welded joints shall be allowed to cool down gradually to atmospheric temperature before putting any load on it. Artificial cooling shall not be allowed.

vi. Bending of large diameter rod/thick conductor shall be done preferably by gas heating.

vii. All arc welding with large diameter conductors shall be done with low hydrogen content electrodes.

9. POWER CABLE EARTHING

Metallic sheaths and armour of all multi core power cables shall be earthed at both equipment and switchgear end. Sheath and armour of single core power cables shall be earthed at switchgear end only.

Annexure - II

Switchyard D.C. Systems

1. Complete DC system, comprising of batteries, battery charges, relays, contactors, timers etc shall be suitable for continuous operation at the maximum continuous float voltage including suitable temperature correction factors.

2. The battery sizing shall be done based on different types of continuous and intermittent loads including motor starting (wherever applicable) under complete blackout condition, for the duration specified so as to meet the system requirement. All intermittent loads shall be considered with minimum
1-minute duration. The battery shall be sized considering a minimum electrolyte temperature as mentioned in Auxiliary Power Supply System Chapter with temperature correction factors as per relevant standard. An ageing factor of 1.25 shall be considered. The no. of cells, end cell voltage shall be considered based on the minimum and maximum voltage window (220V/110V/48 V DC -15% to +10%) and cable drop etc as per system requirement.

3. Each system shall comprise of two nos. of batteries and two nos. of float-cum- boost chargers each rated for 100% capacity. DC scheme shall ensure that each critical consumer is fed from two different bus sections. DCDBs shall be provided with adequate number of feeders on each section.

4. Boost/ fast charging time shall be as per worst operating condition and would satisfy technical requirements recommended by battery manufaISTSrer. Each battery charger must be capable of supplying all the continuous D.C. loads (fed through both section of DCDB) plus the trickle charging current of both the batteries. Battery charger should also be capable of boost/ fast charge the battery from completely discharged condition to fully charged condition without imposing any limitations under worse operating conditions.

The DC systems at Switchyard envisaged as follows;

110/220 V battery (Ungrounded) with DC health monitoring system	(a) Emergency lighting in Switchyard control room for a period of 1 hour plus (b) All continuous DC loads of relay & control panels/PLCC panels for a duration of 3 hours plus (c) Interlocking coils of isolators/earth switches shall be considered including requirement of future bay for a duration of 3 hours plus (d) loads in worst of the following conditions (i) Simultaneous operation of the maximum number of breakers & associated equipment in case of bus fault in the switchyard. (ii) Operation of Breaker failure relay(LBB relay)	Bidder can offer Common DC system for both Switchyard and CMCS but their individual requirement must met.
48V Battery (Grounded Type) with DC health monitoring system.	Supply total DC load of the PLCC system at an acceptable voltage for at least 3 hours. (e) Closing load of all bays except bus coupler bay.	This requirement can be met with suitable rated DC/DC converter (duplicate) fed from 110/220 V DC system if complied under CEA (technical standards for construction of Electrical plants and electric Lines) Regulation 2010 and amendment thereof. In that case 110/220 DC system shall be designed suitably take care above 48V load (3 hours)

B.13 CONTROL AND PROTECTION

1) GENERAL REQUIREMENTS

1.1. The Substation Automation System (SAS) shall be based on the communication protocol IEC61850 and meet the requirements stipulated herein as a minimum.

1.2. For major information exchange, following gateways (stand-alone/in-built in network controller), as specified elsewhere in the specification shall be provided:

a. RLDC/SLDC & Owner's remote-control room
b. Solar SCADA

It is the Contractor responsibility to send the all required data of solar plant and switchyard to SLDC/RLDC. All required hardware's, software's, communication links and modification as per requirement shall be in the Contractor scope.

1.3. The point-to-point testing of all signals for the HV AND EHV network at the plant end, protection equipment end and the terminal end (Substation Controller and Operator Workstations) at the substation shall be the responsibility of the contractor.

1.4. The contractor shall be responsible for all the works on switchyard SAS.

1.5. The architecture for the SAS shall be finalized during details engineering stage and same shall be in line with industry practices for HV AND EHV switchyards SAS system.

1.6. The SAS shall be a computer-based system that shall integrate independently operating subsystems, such as Bay Control Units, Bay Protection Units, Metering and alarm annunciation into a unified data acquisition, monitoring, protection and control system in the substation. The Substation Controllers, Bay Control Units, Bay Protection Units, disturbance recorders, time synchronizing equipment, Energy Metering System and relay test kit offered should meet the proven-ness criteria specified elsewhere.

1.7. The SAS architecture shall be flexible to allow future extensions in switchyard. Only IEC 61850 protocols shall be used for inter-device communication.

1.8. The SAS at substation level and the communication network(s) shall be designed in a dual redundancy configuration. No single failure of any component/module of the SAS, including the communication links, shall cause loss of functionality of the SAS of more than a single bay.

1.9. Each component/module of SAS, including all the communication links, shall be provided with built-in supervision and self-diagnostic features and any failures shall be alarmed to the operator.

1.10. The SAS shall be designed such that no periodic testing and maintenance is required for various subsystems comprising SAS. On-line testing routines for various subsystems of SAS shall be provided.

1.11. SAS shall be designed such that maintenance, modification or extension of its components/modules shall not cause shutdown of the complete SAS.
The SAS and all its components shall be synchronized from a GPS time referenced clock receiver. The Time Synchronization Equipment shall also be in Contractor's scope of supply. A timing accuracy of better than 1 millisec shall be achieved for all thedevices within the SAS except PMU.

1.12. The Contractor shall provide all the documentation required during project implementation and during the life cycle of SAS for operation and maintenance. A list of such documentation shall be reviewed and approved by the Owner during detailed engineering.

1.13. Owner intends to ensure interoperability of any third party IEC61850 compatible IEDs to be incorporated in future with the offered SAS. Contractor to provide all necessary data, configuration files, information in this regard.

1.14. The SAS supplied as per this specification shall be designed and constructed to meet all specification requirements for 15 years. Further, the Contractor should guarantee for hardware and software support for 15 (fifteen) years to guard against obsolescence. All requirements / devices of the SAS that are not listed under recommended spares shall have a normal life expectancy exceeding the specified expected life of the SAS.

1.15. Contractor shall offer the Bay Level Units for the HV AND EHV system (each circuit breaker with associated dis-connector, Earth switches and instrument transformer shall comprise one bay) complete with Bay Control Units (BCUs) and Bay Protection Units (BPUs). Bay Level Units, common panels like bus bar protection/ metering panels, Station HMI, LVS and other work stations/gateways etc. shall be located in SWITCHYARD control room.

1.16. Dedicated Bay Control Unit and Bay Protection Units shall be provided for each bay in the Contractor's scope of work as per offered bay configuration.

2) SAS RELIABILITY REQUIREMENTS

2.1. Each component and equipment offered by the Contractor shall be of established reliability. The minimum target reliability of each piece of equipment like each electronic module/card, power supply, peripheral etc. shall be established considering its failure rates/meantime between failures (MTBF), meantime to repair (MTTR), such that the availability of the complete system is assured. The guaranteed annual system availability shall not be less than 99.9%.

2.2. The Contractor shall submit reliability and maintainability values including detailed calculation for the projected overall system availability along with all assumptions supported by relevant standard for each device/equipment/system module which, with the help of a schematic of various systems connected in series or in parallel as the case may be, and Mean Time Between Failures (MTBF) & Mean Time to Repair (MTTR) values for the various equipment shall show that availability calculation is as specified in IEEE standard-P-1046 or equivalent.

2.3. The contractor shall furnish during details engineering stage composite list of bought out items (i.e. items not from his own manufacturing range) which the Contractor has included in his proposal along with the name of proposed sub- vendors, as a part of his proposal. However, the make and model of all bought out items supplied by the Contractor shall be as approved by the Owner during the detailed engineering stage.

3) SAS Performance Requirements

3.1. It shall be the responsibility of the Contractor to predict and indicate in the bid, the worst case loading conditions and design the system accordingly to meet the same. The worst case loading conditions shall include the following tasks as a minimum:

a. All analog inputs scanning and processing is in progress and all the data is being transmitted over the system bus every one second.

b. Four operator comments for information from any Operator Workstation within a base period of one minute.
c. A burst of 100 alarms is generated over a period of 10 s.
d. One operator control is generated every 10 s.
e. Data collection for logs/reports is in progress.
f. Data collection for historical storage and trend function in progress.
g. Data collection of fault records is in progress.
h. All health monitoring functions/diagnostics in progress.
i. All output devices are in operation with rated performance/speed.
j. All data are transferred to the Operator Workstations.

3.2. Duty Cycle Time:

The Substation Controller processor spare duty cycle (free time): Under the worst case loading conditions, each processor shall have:

a. 40% free time when measured over any two second period
b. 60% free time when measured over any one minute period

3.3. Inter Bay Bus and Substation Network Spare Duty (free time)

The Inter bay Bus and Substation Network shall have minimum 50% free time during the worst case loading conditions measured over any two- second period.

The Contractor shall furnish all necessary data to fully satisfy the Owner that the processor spare duty cycle figures quoted by the contractor are realistic and based on configuration and computational capability of the offered system and these shall be actually implemented system as commissioned at project site.

3.4. Display Response Time

The display response time under worst case conditions for all displays shall not be worse than 1.5secs for HMI displays. The display response time is defined as the time interval between the pressing of the last key demanding a display and completion of the requested display on CRT with full foreground and background information, and/or the updating of status indications according to plant changes, and/or the updating of event / alarm register according to alarm conditions.

4) Software License and Upgrades

4.1. The contractor shall provide all software licenses for all the software being used in SAS system. The license shall be provided on a site license basis and shall be valid for the plant / equipment life cycle. The license shall not be hardware / machine specific i.e. if any hardware / machine is changed / upgraded, the same software license shall be valid and the Owner shall not have to seek fresh license or renewal of license. The contractor shall provide the license considering sufficient number of I/O s catering to the complete switchyard as shown in tender SLD including future bays.

In the case of anti-virus software, the license shall include regular updates until the end of warranty.

The Contractor shall guarantee that all software are defect free and meet the system specifications, and undertake to fix any defects which may arise during the life of the system at no cost to the Owner.

4.2. All software versions in components of the SAS shall be the latest official releases as on the date of shipment from works and shall include all software updates etc. released till that date. A certificate to this effect shall be furnished by the contractor at the time of pre-dispatch inspection for each software package. All new software revisions and/or patch updates that are released before the end of the warranty period which addresses system defects shall be implemented on site and the system re-tested to validate system integrity by the contractor at no cost to the Owner (This excludes new revisions which provides additional functionality). The contractor shall periodically inform the designated officer of the Owner about software updates / new releases that would be taking place after the system is commissioned.

5) Design and Operating Requirements of SAS

5.1. The control hierarchy and control levels of the SAS shall be based on the logical structures of the SAS, which is as follows:

Control Level 3	Remote Control Center (OS Control Room)
	↑↓
Control Level 2	Substation Level (HMI)
	↑↓
Control Level 1	Bay Control Units
	↑↓
Control Level 0	Switchyard Equipment

5.2. The data exchange between Control Level 3 and Control Level 2 shall take place via the communication links provided by the Owner for remote telemetry and control of the substation using the IEC60870-5- 101/104/OPC protocol.

5.3. The data exchange between Control Level 2 and Control Level 1 shall take place via the inter-bay/ Station communication bus using the IEC61850 protocol. The inter-bay communication bus shall support peer-to-peer communications capability.

5.4. The data exchange between Control Level 1 and Control Level 0 shall be by means of hard-wired status / control signals between Switchgear Equipment and Bay Control /Protection Units and analog signals from CTs / CVTs.

6) Substation Level Functionality

6.1. Control Functions:-

a. The SAS shall perform control functions on various switchyard equipment based on the status, analog and logical inputs acquired by SAS from various bay control units.

b. It shall be possible to monitor and control all the switchyard bays in the Bidder's scope and the status of the plant (status and analog signals such as MW, MVAR, information etc) from any of the Operator Workstations at Control Level 2 i.e. from switchyard Control Room. However, in the case of maintenance, failure or emergency, it shall be possible to control the individual bays from the Bay Control Units at Control Level 1.

c. Clear control priorities shall ensure that operation of particular bay equipment (Circuit Breaker or Isolator) cannot be initiated simultaneously from more than one of the control levels. The priority shall always be on the lowest enabled control level. The selected control level shall be indicated at all the levels so that the operator is aware of his control capabilities.

d. The SAS shall have provision of Device Tagging for all the substation devices. This function is to block the control of any substation device in such a manner that its command is prevented from Operator's Workstations.

e. Interlocking shall be implemented and shall ensure that no illegal switch operation can be performed by any control initiated from Control Level 3, Control Level 2 or Control Level 1. Interlocking shall be implemented on bay level as specified in relevant section of this specification.

6.2. Sequence of Events and Alarm Management

a. The SAS shall be capable of reporting on all Operator Workstation and printers, the time sequenced record of events occurring in the substation. Separate logs shall be created for alarms and events and both the logs shall be time-tagged. Suitable filters, based on date and time, bay number, device number, function etc. shall be provided for both alarm as well as event logs for ease of viewing.

b. The SAS shall record in non-volatile memory all changes of alarms and plant statuses of switchyard equipment, including the alarms generated by Bay Control and Bay Protection units. It shall be possible to print historic events and real-time (unacknowledged and non-cleared) alarms after a system failure or reset with no loss of information.

c. All the alarms and events shall be time tagged at the Bay Controller or Bay Protection unit with a time resolution of 1 ms.

d. The SAS shall include all the alarms and changes of plant statuses of the HV AND EHV networks.

e. The SAS shall acquire the alarm signals from Bay Control Units and Bay Protection Units with preset priorities and on receipt of an alarm shall generate an audible signal and report it either upon request or automatically to the respective printer.

f. The Owner shall approve the list of alarms and plant statuses to be wired for Sequence of Events log and Alarm Management, during detailed engineering stage.

6.3. Historical Data Management and Trending

a. The SAS shall maintain historical data in bulk non-volatile memory.
b. The historical data shall be available for review and editing by authorized user.

c. The SAS shall monitor specified incoming information for historical data base, perform calculations on some of the incoming data and store incoming and calculated data in the non-volatile memory as historical data.

d. The historical data shall include Digital Fault Records and Sequence of Event logs received from bay protection units and bay control units.

e. It shall be possible to trend any measurement signal or summation of signals available in real time or data available in the historical database, in the shape of trend curves.

6.4. Operations Log

It shall be possible to create a daily operations log, in a user-defined format, about the substation operations as well as any failures / tripping therein. It shall also be possible to include on daily basis all the information required to keep a historical record of equipment behavior.

6.5. Reports

The SAS should be capable of generating different types of reports, which can be presented in the operator interface screens upon request or programmed for automatic presentation in printers. It shall be possible to generate reports with information from both historical data base and real time information.

6.6. Mass Storage Back up

Either an industry standard DVD writer or tape streamer shall be provided to permit mass storage of all information existing in the computer hard disks such as application programs, database configuration, historical data, operations log etc.

6.7. System Security

a. Security features shall be provided at each level for safeguarding against unauthorized access. An alarm message will be displayed at the Control Centre and recorded in the logs for any unauthorized access attempts. The contractor shall provide software locks and passwords to the Owner’s engineers at site for all operating and application software at all levels.

b. The system shall maintain a SYSTEM CHANGE log, recording all system changes made along with the identification of the person making the change, date, time and area of the system modified. The format and details of this log shall be finalized during detailed engineering.

c. No single failure either of equipment or power source shall result in rendering any part/subsystem of SAS inoperative, except that the information related to failed part/component is not available.

d. To ensure system security, the complete functionality of SAS shall be divided into various system security levels, to be decided by Owner during detailed engineering. Each security level shall offer certain functionality of the SAS to users e.g.

Security Level 0 – Display only of Graphics, Real Time data and Historical Data

Security Level 1 – Normal Control Operations, Access to acknowledge alarm logs

Security Level 2 – Restricted Control Operations; access to edit / defeat bay interlocks

Security Level 3 – Complete access, engineering and maintenance of configurations and databases.

e. The users shall be grouped into various user-groups with each user having a user name and password. The level of accessibility to each user group shall be pre-defined.

f. The system administrator group shall have complete access to SAS and shall be able to add / remove users and redefine access rights.

g. The various system security levels and various user groups shall be defined by the Owner during detailed engineering.

6.8. Remote Interface with RLDC/SLDC

a. The SAS shall interfacing with remote RLDC through suitable gateways with adequate number of ports along with modems at Substation Level as shown in the tender drawing. The modems shall be suitable for use with PLCC/ OPGW Communication, being provided for HV AND EHV lines and to be used for data communication between switchyard and RLDC using communication protocol IEC 60870-5-101 and on IEC 60870-5-104 in future. Each port shall allow for remote telemetry and control of the HV AND EHV networks in the substation using IEC 60870-5-101/104. The interface ports for communication with RLDC shall use V.24/V.28 communication standard (CCITT Std.) for interfacing with modems. The interoperability requirements for above shall be furnished during detailed engineering. One (1) number of suitable modem shall also be supplied as loose item for each of the above serial ports for the remote end.

b. Only selected information such as bus voltage, frequency, active / reactive power through various feeders, status of OLTC, open / close status of circuit breakers, isolators etc is required to be shared with SLDC/RLDC. However, actual list of information to be shared shall be finalized during detailed engineering.
c. Necessary hardware/software (both end) to ensure Remote Interface with SLDC/RLDC shall also be provided by the contractor. All required communication with SLDC/RLDC shall be in the scope of the contractor.

6.9. Technical Requirements for Standalone Network Firewall

6.10. Substation Controllers and Operator Workstations

6.10.1. General

a. Redundant Controllers and Operator Workstations shall be provided and shall be based on the latest state of the art workstations and servers and technology suitable for industrial applications and switchyard environments.

b. The main memory shall be sized sufficient to meet the functional and parametric requirements as specified. The bulk memory shall be sized at least 1.5 times the capacity required sufficient to meet the functional and parametric requirements. However, both the main and the bulk memory shall be subject to minimum hardware specification. The exact system configuration and sizing shall be approved by the Owner during detailed engineering.

c. Graphic Mimic display for entire switchyard shall be provided in each OWS.

d. All operators' functions shall be possible from any of the OWS at any point of time regardless of which controller is active. Each OWS shall be able to access all the substation information related data under all operating conditions.

e. Single failure in any Controller shall not lead to non-availability of any of the OWS.

f. The Workstation shall be based on industry standard hardware and software which will ensure easy connectivity and portability of all the software being provided for various IEDs under this contract.

g. Power Fail Auto Restart (PFAR) facility, with automatic time synchronization to GPS time shall be provided. The only operation required will be the login of operators.

h. All AC powered Workstations, Communication and/or other SAS devices shall be powered from 2X100% Inverter Supply connected to the 110V/220V DC rated batteries, so as to have bump less changeover in case of failure of one of the UPS. Each UPS shall consist of 1x100% charger and inverter, 1 x 100% station Battery bank for providing minimum three hours backup and LT switchgear. Details specification are provided elsewhere in the specification.

i. All DC (Station Battery) powered SAS components shall also be acceptable.

j. A color wall mounted rear projection MIMIC display shall be provided in the SWITCHYARD control room on which a dynamic substation overview display screen is projected. The MIMIC shall be flat. The rear projection MIMIC display shall be on a reputed make 50 inches (diagonal) LED monitor. The MIMIC shall be suitable for continuous operation in a substation control room environment, and shall be clearly visible during all hours from the operator positions at the control desk. Display of Mimic view selected from any of the OWS in the SWITCHYARD Control Room shall be possible. Details of the MIMIC shall be finalized during detail engineering stage.

6.10.2. Functional Requirements of the HMI Software

a. The HMI shall have an intuitive graphical design to ensure effective use of the SAS with minimal confusion. The amount of keyboard typing needed for using the SAS shall be minimized.

b. The HMI shall be strictly divided into various levels depending on the system security levels.

c. The complete Single Line Diagram of the HV AND EHV network, including the status of the plant equipment, shall be displayed on one or more graphical displays. A high-level overview display shall be provided, with the ability to zoom to more detailed displays. Different colors shall be used to differentiate voltage levels, earthed network components, selected object on screen, selected object for command, blocked / tagged equipment etc. on the graphical displays. A library of standard symbols shall be used to represent switchyard equipment on the graphical displays. The same symbols and colors used on the HV and EHV network SAS shall be used. The graphic displays shall be subject to Owner's approval.

d. The process status of the complete switchyard in terms of actual values of currents, voltages, frequency, active and reactive powers, as well as the positions of the circuit breakers, isolators and earth switches, tap positions, winding temperature etc, shall be displayed on the station single line diagram.

e. All the Substation Level Functionality described in relevant Clause of this specification shall be possible through HMI.

f. Highest degree of security shall be provided to prevent unwanted operation of any equipment through SAS. Simultaneous switching of more than one device from the same or different Control Levels shall not be possible. The security features to achieve these requirements shall be clearly brought out in appropriate project-specific documentation of SAS, which shall be approved by Owner. Once a device is "Selected" for operation, the operator shall be able to recognize the "Selected" device on all the graphical and other displays. All other devices shall be blocked as long as a device is selected for operation. The "execution" of a command shall be possible only if the device is not blocked and no interlocking condition is being violated. The interlocking scheme, implemented at the Bay

Level, shall be checked before releasing the "execute" command. The operator shall receive suitable feedback about the successful or unsuccessful execution of the command. In case of unsuccessful execution, the reason for non-execution of command shall be indicated to the operator, which shall include details of the blocking condition in the interlocking logic. In case of successful execution, the operator shall receive confirmation about the new switching position of the equipment depending on the command. The ability to override the interlocking shall also be available, subject to the security access.

g. The following functionality shall be available at the Engineer and Fault Recording Workstation.

   i. Formulation and Implementation of interlocking logic for various bay equipment into Bay Control Units.

   ii. Downloading or altering the protection relay settings in the Bay
   iii. Protection Units.

   iv. Automatically upload, archive, review and analyze graphically the Digital Fault Data available from the BCU and Bay Protection Units.

   v. Ability to export fault records in COMTRADE format.

h. All workstations shall work on the same Operating system, preferably Windows (latest version). Latest anti-virus software shall be supplied on all workstations.

6.11. Communication Network Bus General

6.11.1. General

a. The data communication network (substation/ inter-bay bus) shall have bus configuration with either ring or star topology. The dual redundant buses, in case of star topology, shall be physically separate and shall be routed separately.
b. The contractor shall submit details regarding the communication system like communication protocol, bus utilization calculations etc. during detailed engineering.

c. Built-in diagnostics shall be provided for easy fault detection and to alarm any single bus failures. The design and installation of the main communication bus shall take care of the environmental conditions and hazardous area classification as applicable to similar services.

d. The system architecture shall allow a number of application protocols to co- exist on the application layer of the LAN stack.

6.11.2. Substation Network Bus

a. The substation network LAN shall be an Ethernet LAN based on IEEE802.3 Ethernet standard using the IP protocol. It shall allow inter- operability with LANs from other vendors or with IEDs (Intelligent Electronic Devices) from other vendors in future, supporting IEC 61850.

b. CAT5e or better UTP cables or fiber optic cables shall be employed for all Ethernet data communication bus. The data exchange between the electronic devices on bay and station level shall take place via the communication infrastructures. This shall be realized using fiber-optic cables, thereby guaranteeing disturbance free communication. Data exchange is to be realized using IEC 61850 protocol with a redundant managed switched Ethernet communication infrastructures. The communication shall be made in 1+1 mode, excluding the links between individual bay IEDs to switch, such that failure of one set of fiber shall not affect the normal operation of the SAS. Each fiber optic cable shall have four (4) spare fibers.

   Fiber optic cables shall be used wherever the Ethernet connection is in excess of 50m, or where the connection extends between rooms/ buildings. The Contractor shall ensure that structuresd cabling philosophy and good engineering practices as per internationally accepted standards are followed, for ease of maintenance and traceability, and that fiber-optic cables are adequately protected. Armored Fiber Optic cables shall be used in all cable routes containing other armored electrical cables. The armoured fiber optic cables shall be run in G.I. conduit wherever laid underground or without trays.

c. The LAN shall have a data communication speed of minimum 1 GBPS. It shall be sufficient to meet the responses of the system in terms of displays, monitoring and control commands according to the design.

d. Suitable hardware and software interface shall be provided to link solar plant SCADA bus.

6.11.3. Inter bay Network Bus

a. An Inter bay Communication bus shall be provided for the HV and EHV network, which shall support peer-to-peer communication, and communication to the Substation Controller.

b. The communication protocol used for all devices including Bay Control Units and Bay Protection Units shall be the IEC61850 protocol. No hardwiring of alarms shall be permitted between Bay Protection Units and Bay Control Units. As a minimum, all Bay Controller Units and primary relays i.e. Distance, Differential, Bus-Bar protection and multi-functional Over current and Earth fault protection relays, etc. offered shall support the IEC61850 protocol.

c. Fiber optic cables shall be used for Inter bay/Station Level Communication Bus. Contractor shall ensure that structured cabling philosophy and good engineering practices as per internationally accepted standards are followed, for ease of maintenance and traceability. Electrical data connections may only be used within a cubicle of the same bay.

6.12. Bay Level Functionality

6.12.1. General

a. All the Bay Level Functionality shall be built into Bay Control Units (BCUs) and Bay Protection Units (BPUs).

b. BCUs and Bay Protection Units shall be provided at Control Level 1 i.e. Bay Level of Logical Architecture, to facilitate control, monitoring and protection of switchyard equipment. One Bay Control Unit shall provide complete functionality for one HV and EHV bay. Each set of BCUs shall have sufficient analog and digital inputs to acquire the status of each and every circuit breaker, isolator, earth switch, Transformer gas parameters / tap position etc. of all the bays in Contractor's scope. A minimum of 64 Digital Inputs and 24 Digital Outputs per bay shall be provided in associated Bay Control Units. A minimum number of 16 Analogue input channels per bay shall also be provided in the associated BCU. Rating of the various analogue input channels (110 V /1 A /4-20 mA) shall be decided during detail engineering.

c. All the Bay Control Units and Bay Protection Units at Plant end shall be installed in AC SWITCHYARD control room. BCU & BPU shall be mounted in different panels.

d. All BCUs and Bay Protection Units shall be provided with self-diagnosis and supervision functions to ensure maximum availability. BCUs shall require no periodic routine maintenance and testing. An alarm contact shall be provided for hardware failures, failures of internal and external auxiliary supplies etc. Special algorithms shall be provided to check the microprocessor's memories. A watchdog function shall supervise the execution of program by the microprocessor.

e. Space for mounting Controlled Switching Device of circuit breaker shall be provided in respective BCU Panel.

f. The layout of equipment/panel in air-conditioning (AC) SWITCHYARD control Room shall be subject to Owner's approval.

6.12.2. Bay Control Units (BCU)

6.12.2.1. Control and Protection Features of BCUs

The Bay Control Units shall have following built-in functions:

a. Mimic control panel to display graphically the bay configuration, status of the plant, analogue measurands, alarms, and offer bay level control.

b. Switching of Switchyard Bay Equipment depending on conditions such as interlocking, synch-check, control mode, or external status condition. Adequate safety features like prevention of double operation, command supervision,

block/de-block, over-riding the interlocking etc. shall be provided. All such security features shall be finalized and approved by Owner during detailed engineering.

c. Status Supervision of switchyard equipment

d. Interlocking Function to prevent unsafe operation of switchyard equipment such as circuit breakers, isolators, earth switches etc. Interlocking shall be implemented on bay level, by user-friendly, menu-driven configuration software within the BCU, Interlocking shall operate independent from the Substation Controller. Signaling of statuses between bays shall be performed by inter-bay communication (peer-to-peer) i.e. Goose messaging. The auxiliary contacts of each of the equipment shall be wired to the BCU for this purpose. However for those equipment, which are required for interlock of other bay equipment, two sets of their contacts shall be wired to BCUs of two different bays. Such interlocks involving more than one bay equipment shall be realized through goose messaging. An over-riding / bypass function for bay-level interlocking shall be provided at appropriate security level for maintenance or during emergency conditions. Failure of any one BCU shall not affect the interlocking at any other bay, only the bay with failed BCU shall not be able to operate. This shall be achieved by providing a backup mechanism in case of failure of one BCU which affects the interlocking in another BCU (e.g. a backup mechanism for monitoring the status of the bus bar earths), to allow the remainder BCUs to function with full interlocking. The interlocking logic shall be defined during the details engineering phase to prevent illegal operation.

e. Analogue Measurements for bay voltage (per phase), current (per phase), frequency, MW and MVAR, tap position / gas parameters / winding temperature of Transformers. These measurements shall not require the use of any intermediate transducers. The accuracy of measurement shall be 0.5% for voltage, current and frequency, and 1.0% for MW and MVAR. The measured and computed values shall be displayed locally on BCU and on operator's workstation located in central control room.

f. Event and Alarm Handling: BCUs shall acquire all the bay level alarms and events from field inputs with a resolution and time tagging of 1 milli sec and shall transfer these to operator's workstation over substation LAN.

g. Synchronization Check Feature: Synchronization Check feature shall determine the difference between the amplitudes, phase angles and frequencies of two voltage vectors. Checks shall be provided to detect a dead line or bus bar. The voltage difference and phase angle difference settings shall be adjustable. A common hand held synchro- scope with a compatible synchronizing socket in each BCU shall also be provided.

6.12.3. Bay Protection Units General

6.12.3.1. General

a. Trip commands from Bay Protection Units shall be hard-wired directly to appropriate switchyard equipment. Also, critical interlocking data between Bay Protection Units and Bay Control Units, including the substation level interlocks such as bus bar protection trip etc shall also be hard-wired to ensure complete bay level functionality even in case of failure of substation LAN. The interlocking information to be hard-wired between Bay Protection Units and Bay Control Units shall be decided by Owner during detailed engineering stage.

b. The interface of Bay Protection Unit for HV and EHV lines with PLCC/communication panels shall be in contractor's scope.

c. Relay parameterization for SWYD relays shall be possible from the respective EWS.

6.12.3.2. General Requirements of Numerical Relays and Auxiliary Relays

a. All numerical relays, auxiliary relays and devices comprising the Bay Protection Units shall be of types, proven for the application, satisfying the requirements specified elsewhere and shall be subject to the Owner's approval.

b. The necessary auxiliary relays, trip relays, etc. required for complete scheme, interlocking, alarm, logging, etc. shall be provided. No control relay, which shall trip the circuit breaker when the relay is de- energized, shall be employed in the circuits.

c. Relays shall be provided with self-reset contacts except for the trip lockout, which shall have contacts with a manual reset feature. Manual resetting shall be possible from Control Level 2 as well as Control Level 1 with suitable authorization.

d. Transients present in CT & VT connections due to extraneous sources in the HV AND EHV system shall not cause damage to the numerical and other relays. CT saturation/ transients shall not cause mal-operation of numerical relays.

e. Only DC/DC converters shall be provided in the solid state devices / numerical relays wherever necessary to provide a stable auxiliary supply for relay operation. Except for event logging, alarm and annunciation type of non trip functions, protective relay contact multiplication shall be done through high speed trip relay only.

f. DC batteries inside protective relays necessary for relay operation shall not be acceptable. Equipment shall be protected against voltage spikes in the auxiliary DC supply.

g. Each numerical relay shall have a serial interface on the front for local communication to a Personal Computer and Printer. Additionally, facilities shall be provided to access each discrete protection function including modification in relay settings and monitoring of the relay from a HMI or a separate Protection / Disturbance Recorder Station provided and permanently wired to all the numerical relays comprising various Bay Protection Units. For numerical relays of switchyard,

the HMI shall be located in SWYD control room at the Substation Level. Dedicated engineering /DR work station has to be provided in switchyard control room. A print out of all settings, scheme logic, event records etc. shall be accessible through the HMI. The display of various measured parameters during normal as well as fault conditions on a segregated phase basis shall be provided. LEDs and a backlit LCD screen shall be provided for visual indication and display of messages related to major trips / alarms. Necessary multilevel password protection shall be provided.

h. The Bay Protection Units shall be arranged to provide two independent, high performance and reliable systems housed in different panels with separate DC supplies, separate CT/VT cores, separate cables and trip relays to obtain 100% redundancy. Associated trip relays of the two systems shall be separate, having a sufficient number of contacts for all the functions.

i. The numerical relays shall be provided with built-in disturbance recording functionality. The data from DR function shall be available in IEEE/COMTRADE format and shall be compatible with the dynamic relay test system being supplied under this contract.

j. The manufacturer of the numerical protection system offered shall carry out the complete engineering, testing and commissioning on site of the offered protection equipment including the associated relays and protection panels. The testing and commissioning protocols for the numerical protection systems offered shall be approved by the Owner before commissioning on site.

k. Pick up range of the Binary inputs shall be minimum 70V DC/AC.

l. All the numerical relays shall have adequate processor capability to carry out programmable scheme logics (PSL) required for implementing approved protection and control schemes over and above its inbuilt protection functions algorithm.

m. All numerical relays shall be supplied with all the protection function/features in disabled condition. Relevant features/protection function shall be enabled at the time of commissioning at site as per approved logic and relay settings.

n. BPU offered shall have adequate I/Os for function realization. Use of auxiliary relays (contact multiplication) shall be permitted only when the entire product range does not support any further hardware augmentation for additional I/Os.

o. Configuration/ scheme logics /relay settings shall be submitted by the Contractor for approval during detailed engineering.

6.12.3.3. Protection for HV AND EHV System

a. The total critical fault clearing time, including the circuit breaker operating time, from fault initiation in any part of the system under all conditions shall not be more than 80 ms for faults within zone-I reach (i.e. up to 80% of line length) and 100 ms for end zone faults including carrier transmission time of 20ms.

b. The SIR values to be considered for the operating time of relays for the SWYD feeders shall be between 4 and 15. The rated break time for the HV AND EHV circuit-breaker, as offered, shall be considered for the purpose of circuit-breaker operating time. The Contractor shall furnish the operating time curves at various SIR values for all types of faults.

6.12.4. Line Protection

6.12.4.1. Each 400kV or 220kV Line shall be provided with the following protection:

Main-I : Numerical Distance protection scheme suitable for carrier aided protection

Main-II : Numerical Distance protection scheme suitable for carrier aided protection and with a hardware platform different from that of the Main-I Protection

The Main-I and Main-II distance protection shall be of equal performance capability.

Each 132kV Line shall be provided with the following protection:

Main-I : Numerical Line Distance protection scheme suitable for carrier aided protection

Main-II : Back-up Directional Overcurrent Function: Shall be based on numerical technology with various characteristics such as Instantaneous, DMT/IDMT, very inverse etc.

The Main-I and Main-II relays shall be connected to two different protection groups (Main to Group-A and Main-II to Group-B) to meet the requirements of relevant clause above.

Other Protections to be implemented for all lines are mentioned below

a. Local Over voltage Function: The over voltage function shall have adjustable voltage and time settings. It shall monitor all phases and be tuned to power system frequency. The over voltage function shall have two independent voltage and time stages. It is also acceptable for the local over voltage function to be a built-in feature of the Main- I and Main-II Distance Protection relays.

b. Back-up IDMT Earth fault Function: A back-up IDMT Directional earth fault protection function shall be provided in each Main protection system. The function shall measure zero sequence current and have a current/timer setting range.

c. Open Jumper Protection: The open jumper protection function shall operate upon detecting negative sequence current and shall provide an alarm. The open jumper protection function, as a built-in feature of the Main-I protection is also acceptable.

d. The protective relays shall be suitable for use with capacitor voltage transformers (CVTs) having non-electronic damping and transient response as per IEC.

e. Back-up over-current Protection: Distance protection gets disabled, in case of its connected VT fuse, failure. Consequent to this, a back- up over-current function shall get activated in the respective distance relay.

6.12.4.2. Numerical Distance Protection Scheme

a. The numerical distance relays shall be the latest version meeting the in- service criteria specified elsewhere.

b. The distance protection schemes shall be such as to facilitate compatibility with the protection at the remote ends of the HV AND EHV transmission lines.

c. The reaches of relay for zones 1, 2 & 3 should be able to cover line lengths associated with this contract.

d. The distance protection shall be of the non-switched type with separate measurements for all phase-to-phase and phase-to-ground fault types.

e. The protection shall have two, independent, continuously variable, time settings each with a range of 0 to 5 s for zone-2 and zone-3.

f. The characteristics shall have adjustable characteristic angle setting ranges of 450 to 850.

g. Tripping characteristics shall be polygonal and / or mho circle with adjustable offset and with independently adjustable reactive and resistive reaches (for polygonal characteristics) separately settable for each zone. The type of tripping characteristics shall be user selectable.

h. The protection shall operate correctly for close-up three-phase faults and other adverse conditions. It shall operate instantaneously when the circuit- breaker is closed onto a zero-volt 3-phase fault.

i. The protection shall provide Phase segregated tripping i.e. single phase as well as three-phase tripping.

j. The protection shall have a maximum resetting time of 60 milliseconds.

k. Zone 3 shall have a reverse offset capability adjustable to 10 to 20% of zone- 3 setting, or alternatively, an independent reverse zone 4 shall be provided.

l. The earth fault measurements shall have zero sequence compensation variables from 0.5 to 5 (scalar Z0/Z1).

m. The setting / reach should not be affected by mutual coupling effects

n. It shall have a continuous current rating of 2 times rated current. The relay shall also be capable of carrying a high short time current of 100 times the rated current without damage for a period of 1.0 s. The voltage circuit shall be capable of continuously withstanding 1.2 times the rated voltage and 1.7 times for 3 s.

o. The protection shall include Power Swing Blocking protection. The power swing blocking feature shall:

   i. be of three pole type
   ii. Block/unblock tripping during power swing conditions, separately for each zone.
   iii. Have a continuously adjustable time delay on pick up of 0 to 5s.
   iv. Be in service during the dead time of a single pole Reclosing cycle.
   v. Have user configurable unblocking criteria in the case of fault detection during a power swing.

p. Shall include Fuse Failure Protection, which shall

   i. Monitor all the three fuses of the CVT and associated cabling against open circuit
   ii. Inhibit trip circuits on operation and initiate annunciation
   iii. Have an operating time of less than 7.0 ms
   iv. Remain inoperative for system earth faults

q. It shall have user configurable scheme logic such as permissive under- reach (PUTT), Permissive over-reach (POTT), Direct Transfer Trip, Blocking scheme etc. using communication channels. The scheme shall be complete so that the user can select any option on site without any modification. Non- carrier aided schemes such as Zone-1 extension, Loss of Load etc. shall be provided to ensure high-speed clearance during channel failure.

r. The protection shall be able to distinguish between short circuit and heavy load conditions.

s. It shall have supplementary over current and earth fault protection functions.

t. The dead line charging feature shall have adjustable minimum and maximum voltages.

u. The protection shall have a multiple settings group feature. It shall be possible to switch between the various available setting groups when the relay is in service without compromising the protection during the switch-over.

v. The protection shall include the following additional functions:

   i. Weak-in feed tripping
   ii. Echo function

iii. Current reversal guard
iv. Switch onto fault logic
v. It shall be suitable for series compensated lines.

6.12.4.3. Digital Fault Recording,

A Digital Fault Recorder shall be provided for each HV AND EHV line. The Digital Fault Recorder shall meet the following requirements:

a. Shall be used to record the graphic form of the instantaneous values of analog inputs such as voltages and currents in all the three phases, open delta voltage and neutral current in the primary circuits in the case of a short circuit (fault) and a disturbance in the Power System, as per the required technical parameters.
b. Shall be provided with a self-monitoring facility.
c. Fault / disturbance logs shall be clearly identified by Fault ID, Fault date and time (hour, minutes, seconds and ms). Time stampings on fault records shall be synchronized with a GPS clock.
d. The disturbance recorder shall comprise distributed individual acquisition units, one for each feeder and an evaluation unit which is common for the entire substation. The acquisition units shall acquire the disturbance data for the pre-fault, fault and post-fault periods and transfer them to the evaluation unit automatically for storage on a mass storage device. The acquisition unit shall be suitable for inputs from current transformers with 1 A rated secondary and capacitive voltage transformers with 63.5 V (phase-to-neutral voltage) rated secondary.
e. Shall have Scan rate of 1000 Hz or better for sampling each of the analog channels having a 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 with the DFR system shall not compromise this frequency response.
f. Shall be provided with sensors based on threshold values of voltage, current and frequency and rate of change of system frequency. External signals if required can also be used for triggering the DR. The starting sensors of the DFR, and pick-up, shall preserve the disturbance/fault data on the non-volatile solid state memory of the acquisition unit. The setting of the starting sensors shall be flexible, and shall have reasonable range/steps. The settings of the starting sensors shall be field programmable.
g. The fault data from the Digital Fault Recording feature shall be available in IEEE / COMTRADE format. The data format shall be compatible for dynamic protection relay testing with the relay test kit to be supplied by the Contractor. The necessary equipment for interfacing and transfer of data shall also be supplied by the Contractor.
h. All the fault records shall be transferred to the Protection / DR Station at the Substation Level automatically or on request for further detailed analysis. The software for analyzing the fault data shall be available at the Substation Level. The software shall be capable of the complete analysis of fault data, including the display of RMS/Peak envelop of any voltage / current, fundamental power frequency deviation, display of instantaneous values of Real Power (computed

value), Reactive Power (computed value), power factor angle etc. A facility to edit the fault data shall also be provided.

i. Following analog values shall be recorded –

Currents (R-phase, Y-phase, B-phase and Neutral), Voltages (VRY, VYB, VRB, Open Delta)

The pre-fault recording time shall be at least 200 ms and the post- fault recording time shall be at least 5.0secs.

8 Analogue channels (IR, IY, IB, IN, VRY, VYB, VBR AND OPEN DELTA) 16 Nos. Digital Channel

Amplitude Résolution of Analogue Channel (minimum): 16 bit Event Resolution of Digital Channel (minimum): 1 milli sec Aux. voltage: 110V/220VDC (+10%,-20%) DFR system offered shall also have a built-in Distance-to-Fault Locator Function. This function shall be an on-line function and shall be suitable for circuit-breaker operating times of 2 cycles. The computed distance-to-fault shall be available as a percentage of line length or kilometers without requiring any further calculations. It shall have a provision for mutual zero sequence compensation. It shall have an accuracy of 3% or better for all types of faults and fault levels. This accuracy shall not be impaired under following conditions:

i. Presence of remote end in-feed
ii. Predominant DC component in fault current
iii. High fault arc resistance
iv. Severe CVT transients
v. Mutual zero sequence coupling between adjacent lines

Digital Fault Recorder, having specified technical Parameters, as a built in feature in Main Numerical Distance Relay is also acceptable.

6.12.5. Auto-Reclose and Synchronizing Check

a. Auto-reclose (AR) and Synchronizing Check (SC) functionality shall be provided in a separate device i.e other than distance protection relay. The interfacing between BCUs and Bay Protection Units for achieving the AR function logic shall be achieved at Bay Level using communication LAN as well as standby hard-wired logic between BCU and Bay Protection Units. The intent of providing the hard- wired logic as a back-up to the software logic is to ensure that in the event of failure of Substation LAN, the bay level functionality is not hampered. The AR function shall meet the following criteria:
b. Be of single shot type
c. Have single-phase and/or three phase Reclosing facilities. It shall have a user-selectable option of single phase, three phase, single & three phase Reclosing or non-auto reclosure mode.
d. Incorporate a normal/delayed auto reclosure option with a time range of 1 to 60 s.
e. Have a continuously variable three-phase and single-phase dead time of 0.1 to 5 s.
f. Have a continuously variable reclaim time of 5 to 300 s.

g. Be properly configured for the breaker-and-a-half arrangement, permitting sequential closing of breakers.
h. Incorporate the necessary auxiliary relays and timers to provide a comprehensive reclosing and synchronizing scheme.
i. Have facilities for selecting check synchronizing or dead line charging features. The user shall have an option to change the required feature.

The built-in Synchronization Check feature shall determine the difference between the amplitudes, phase angles and frequencies of two voltage vectors. Checks shall be provided to detect a dead line or bus bar. The voltage difference, phase angle difference and slip frequency settings shall be adjustable.

6.12.6. Transformer Protection

a. The Bay Protection Unit offered for each transformer should be such that it provides a comprehensive protection for the transformer for all types of faults and abnormal operating conditions.
b. The numerical relays, comprising the Bay Protection Unit, for each transformer shall be configured into two protection groups operating on two separate DC supplies, such that one protection group shall always be available to detect and operate for any type of fault in the transformer, under condition of failure of other protection group or of associated DC supply of the other protection group.
c. Should the protection functions specified for a transformer be available as a single discrete numerical relay, two such relays shall be supplied to meet the requirements of relevant clause above. Differential, REF and Back-up protection of any transformer shall be realized in separate numerical relays with Differential , Back-up E/F in one channel and REF, Back-up O/C in another channel.

6.12.6.1. Transformer differential protection shall:

a. be of numerical type, suitable for three phase three winding transformer and shall have continuous self-monitoring and diagnostic features.
b. be three-pole type, with faulty phase identification/indication. The operating time of the relay shall not be greater than 30ms at 5 times the setting.
c. be stable for magnetizing inrush currents and shall be stable under normal over-fluxing conditions. Magnetizing inrush stability shall not be achieved through the use of an intentional time delay;
d. have an internal feature in the relay to take care of the angle and ratio correction;
e. have a disturbance recording feature to record the analogue form of instantaneous values of the current in all three windings (i.e. nine analog channels) during faults and disturbances for the pre-fault and post-fault periods. The disturbance recorder shall have the facility to record the following external digital channel signals in addition to the digital signals pertaining to the differential relay itself:
   - HV breaker (main and tie) status
   - LV breaker status
   - Buchholtz/On-load tap-changer Buchholtz alarm/trip

   •Winding temperature/Oil temperature/Pressure relief alarm/trip of transformer

f. The necessary hardware and software for downloading the data captured by the disturbance recording function to a personal computer available in the substation shall be included in the scope.
g. be acceptable with built-in features of definite time overload protection (alarm) relay provided the technical requirements of these relays specified under the relevant clauses are met.

6.12.6.2. Restricted Earth Fault Protection shall:
a. be single-pole type;
b. be of current/voltage operated high impedance type;
c. have a suitable non-linear resistor to limit the peak voltage
d. shall have setting range from 5-80%

6.12.6.3. Transformer over fluxing Protection shall
a. Operate on the principle of voltage to frequency ratio
b. Have inverse time characteristics compatible to transformer over fluxing withstand capability and also a separate high set feature.
c. Provide an independent alarm with continuously adjustable time delay.
d. Tripping time shall be governed by V/ F Vs time characteristic of the relay
e. Have a set of characteristics for various multiplier settings.
f. Have a resetting ratio of 98% or better.

6.12.6.4. Transformer Backup Over current Protection (51) shall
a. Be triple pole type
b. Be of definite time over current type
c. Have an adjustable setting range of 20-80% or 150-600% of rated current (as applicable) and 0.3 to 3.0 sec time delay.
d. Be provided with operation indicator

6.12.6.5. Transformer Backup Earth Fault Protection (51N) shall
a. Be single pole type
b. Be of definite time over current type
c. have an adjustable setting range of 10-80% of rated current as applicable and 0.3 to 3.0 sec. Time delay
d. Be provided with operation indicator

6.12.6.6. Directional Back up Over Current and E/F Protection (67/67N)
a. Shall have three over current and one earth fault element(s) which shall be either independent or composite unit(s) and shall have built- in timer with suitable range.
b. shall be of numerical type
c. the scheme shall include the necessary VT fuse failure relays for alarm purposes.
d. the over current function shall:
- have a low transient, overreach high-set instantaneous unit;
- include hand-reset indication. e. the earth fault function shall:
- have a low transient, over-reach high set instantaneous unit;
- include hand reset indication;
- Include the necessary separate interposing voltage transformers or have an internal feature in the relay for open delta voltage to the relay

The ranges mentioned above are only indicative only and the final ranges shall be finalized during detailed engineering

6.12.7. HV AND EHV Circuit-breaker Protection

Each circuit breaker in the HV AND EHV switchyard shall be provided with following protection functions:

1. Numerical Local Breaker Back up Protection Function: Duplicated LBB protection function shall be provided for each circuit breaker in the HV AND EHV switchyard. The LBB protection function for each circuit-breaker shall be interfaced with the Bus bar protection by hard-wired signals between the Bay Protection Unit and the Bus bar protection panels. The intent of providing the hard-wired logic as a back up to the software logic is to ensure that in the event of failure of Substation LAN, the bay level functionality is not hampered. The LBB function as a built-in function of Bay Protection Unit is acceptable provided it meets all the requirements specified for the LBB function. However, Tie LBB of incomplete dia shall not be realized not be realized as in built function of BB protection. In addition, the LBB protection function shall meet following criteria:
   a. Be three pole type having three single phase units
   b. Shall operate for stuck breaker conditions
   c. Have an operating/resetting time each of less than 15 ms.
   d. The LBB function shall be initiated by external trip contacts from the Bay Protection Units and after a set time delay shall energize the trip bus in the bus bar protection scheme on which the stuck breaker is connected for tripping of all breakers connected to the particular bus. For all CBs, a repeat trip command from LBB shall be given to the primary breaker through two separate self reset trip relay on different DC source.
   e. Have a setting range of 5 to 80% of rated current
   f. Have a continuous thermal withstand of 2 times rated current irrespective of the setting.
   g. Have time delay feature with a continuously adjustable setting range of 0.1 to 1 s.
   h. Shall be an individual phase comprehensive scheme.
   i. Shall not operate during the single-phase auto-reclosing period.
   j. Shall provide end-fault protection that initiates a direct transfer trip to the remote end.
2. Trip Coil Supervision: A Trip Coil supervision function shall be provided for each lockout trip relay and each of the circuit-breaker trip coils. It shall incorporate both the pre-close and post-close supervision of trip coils and associated trip circuits. An audible alarm shall be given in the event of operation of trip coil supervision function. It shall have a time delay on drop- off of not less than 200ms. Trip coil supervision function as a built-in feature of the BCUs / Bay Protection Units is also acceptable, provided it meets all other requirements specified here, including loss of DC supply.
3. High Speed Trip Relays supplied under this package shall be:
   a. With operating time of less than 10ms.
   b. With reset time of less than 20ms.
   c. Provided with operation indicator for each element/coil.

d. Have adequate contacts to meet the scheme requirements of trip, interlock, LBB, auto-reclose, DR, fault locator, etc.
e. Hand reset or self reset, depending on the application. Further, the trip relays shall be provided with a feature to receive manual reset command from engineering workstation located in remote

6.12.8. Bus bar (BB) Protection

Each HV AND EHV bus bar shall be covered with a duplicated decentralized high-speed busbar protection scheme connected to two different CT cores. Bus bar protection of each bus shall operate in a two-out-of-two mode so as to achieve better security. For 132kV system basbar protection scheme is not required.

Each bus bar protection scheme shall:

a. Be numerical having modular construction and three pole type.
b. Main I and Main II shall be connected to different DC source such that even under the failure of either Main I or Main II relays AND/OR failure of the associated DC, the bus bar protection will operate in one out of two mode.
c. Bay units shall be mounted in respective BPU Panels.
d. Have a maximum operating time for all types of faults of 20ms at five times the setting value.
e. Operate selectively for each bus bar.
f. Give 100% security up to a HV AND EHV bus bar fault level as per SLD. g.
g. Incorporate continuous supervision for the CT secondary against any possible open circuit and if it occurs, shall render the relevant zone of protection in-operative. The zone protection contact shall be bypassed automatically and the affected zone shall be protected by the appropriate healthy zone only.
h. Not give any false operation during normal load flow in bus bars.
i. Shall not mal-operate for an out-of-zone fault, particularly with current transformer saturation under maximum through fault current with maximum DC offset
j. Shall provide independent zones of protection and incorporate clear zone indication.
k. Include individual high speed tripping relays for each feeder, including future ones, as identified in single line diagram.
l. Be transient free in operation.
m. Incorporate protection "In-Out" switches for each zone.
n. Be a biased differential type, have operate and restraint characteristics and self monitoring facilities.
o. Shall be of phase segregated type with three-pole tripping
p. Shall include individual high speed hand reset tripping relays for each bay including Future bays as per Tender SLD
q. Shall include continuous DC supply supervision
r. Shall include modules for future bays as per Tender SLD.
The Bus bar protection relay shall be connected to the Inter bay communication bus. Use of external CT-switching relays and CT ratio correction relays is not

acceptable. The bus bar relay settings and analysis of bus bar fault data shall be possible from the Substation Level.

6.12.9. Time Synchronization Equipment

a. One dedicated time Synchronization equipment shall be provided for SAS system. It shall receive Coordinated Universal Time (UTC) transmitted through Geo Positioning Satellite (GPS) for time synchronization of all components of the SAS.
b. Shall be complete in all respects including antenna, all cables, processing equipment, etc.
c. All auxiliary systems and special cables required for synchronization of the equipment shall be supplied and commissioned by the Contractor.
d. Shall work from DC supplies only and the Contractor to clarify if any built-in battery backup is provided, in which case, same shall be of long life lithium batteries.
e. Shall be immune to hostile electrical environment. Suitable protections are to be provided against lightning surges and over-voltages in power supply systems and antenna feeders.
f. The system shall be fully tested to the relevant international standards such as IEC: 801 and IEC: 255. One copy of all the test reports shall be enclosed with the bid.
g. All components of the SWYD SAS, including Substation Controllers, Workstations, Bay Control Units (BCU) and Bay Protection units (BPU) and all numeric protection relays shall be synchronized with an accuracy of 1ms.
h. The system should be able to track more than 1 satellite at a time to ensure no interruptions of synchronization signals.
i. The system shall have provisions for combination of any of the following output signals:
   i. NTP (network time protocol) 100Mbits Ethernet port
   ii. IRIG-B00x (TTL, pulse width modulated signal)
   iii. 2 x Pulse per half-hour/ Pulse per minute/ Pulse per second outputs via potential free contacts
   iv. Any other output port as may be required for the offered system.
   v. Alarm status contact indicating healthy status of system
j. These output ports shall be compatible with the requirement of the equipment to be synchronized i.e. BCUs and BPUs. The master clock in control room shall also be synchronized with the time synchronization system. The aISTSal port requirements (no./type) in line with the system offered shall be finalized during detailed engineering.
k. The equipment should have a periodic time correction facility of one-sec. periodicity. The equipment shall also have real time display in hour, minute, second (24 hour mode) and have a separate time display unit to be mounted on top of the MIMIC panel, having display size of approx. 144mm height.

6.12.10. Relay Test Equipment

a. The required relay test equipment shall comprise the following:

i. One dynamic portable relay test system for allowing dynamic and steady state testing.
ii. Any other auxiliary items required for testing all the protection relays supplied under this contract.

b. It shall have the capability to replay the Disturbance / Fault records acquired by the numerical relays / stand-alone DR in IEEE / COMTRADE format or EMTP simulations, to facilitate dynamic testing of all the numerical relays supplied under this contract. The required software for steady state/dynamic testing of all the numerical protection relays, energy meters and transducers, along with a laptop PC, shall also be supplied.
c. All commissioning tests on protection relays, energy meters and transducers shall be carried out with this relay test equipment being supplied under this contract and test reports shall be maintained as per the agreed protocols.

6.12.11. Panels

a. All panels shall be free standing, floor mounting type and completely metal enclosed. Cable entries shall be from the bottom. Panels shall be of IP 31 class or better.
b. Panels shall have removable gland plates with glands made of brass and shall be suitable for armoured cables.
c. Thickness of panel sides shall be 2mm for Cold Rolled Sheet Steel, 2.5mm for Hot Rolled Sheet Steel.
d. Panels shall be painted. The colour of paint for exterior of the panel shall be as follows:
   i. Ends: Colour-, Shade-RAL7035
   ii. Front and Rear: Colour-, Shade-RAL7035
e. Panels shall have a lockable front toughened glass door and a swing frame/ fixed rack. Panels shall facilitate direct access to any component mounted inside and shall have at least 20% free space for future expansion.
f. Shall be supplied complete with interconnecting wiring between all devices mounted therein.
g. All equipment mounted on front and rear side of the panels shall have individual name plates with equipment designation engraved. Each panel shall also have circuit/feeder designation name plate.
h. Each panel shall be provided with a 240V AC fluorescent lighting fixture controlled by door switch as well as a 5A, 240V AC switch-socket unit.
i. Shall be provided with necessary arrangements for receiving, distributing, isolating and fusing of AC & DC supplies for various circuits for control, signaling, lighting, interlocking, etc. Selection of main and sub-circuit fuse rating shall ensure selective clearance of the sub-circuit faults.
j. Voltage circuits for protection and metering shall be protected by fuses. Suitable fuse failure relays shall be provided to give an alarm for voltage circuits of protection/metering. Voltage selection scheme based on relays shall be provided for meters wherever applicable.
k. The DC supplies at the individual relay and protection panels shall be monitored and failure of DC supplies shall be annunciated.

6.12.12. Earthing

a. The panels shall be equipped with an earth bus of at least 50x6mm2 galvanized steel flat bar or equivalent copper.
b. Earth buses of adjoining panels shall be connected for continuity. The continuous earth bus so formed shall be connected to the main earth grid at one end only.
c. All metallic cases of the mounted equipment shall be separately connected to the earth bus by 2.5mm2 copper wires. No loops in the earth wiring shall be permitted.
d. CT/VT neutral secondary shall only be earthed at the terminal block of the panel through links, such that the earthing of one group may be removed without disturbing others.
e. An independent Electronic Earth System shall be provided as per contractor's standard. The electronic earth shall be connected to the substation earth mat through a dedicated riser.

6.12.13. Wiring

a. Internal wiring to be connected to external equipment shall terminate on terminal blocks.
b. The terminal blocks for CTs and VTs shall be provided with test links and isolating facilities. The CT terminal blocks shall be provided with short circuiting and earthing facilities.
c. Shall have 20% terminals as spare terminals in each panel.
d. All equipment mounted on front and rear side of the panels shall have individual name-plates with equipment designation engraved. Each panel shall also have circuit/feeder designation name plate.
e. All wiring shall be with 660V grade, single core, PVC insulated stranded copper conductor. 660V grade Terminal Blocks shall be provided.
f. Wires shall be vermin proof. Minimum size of conductor shall be 1.5 mm2 in general, but for CT & VT circuits it shall be 2.5 mm2. Minimum number of strands shall be three.
g. Contractor shall be solely responsible for completeness and correctness of all the wiring, and for proper functioning of the connected equipment.

6.12.14. Control Cabling Philosophy in Switchyard

a. Each secondary core of all the phase CT/CVT shall be brought to the equipment marshalling box through independent cables.
b. Each three phase secondary core of each CT/CVT shall be brought to the associated control/relay panel from the equipment marshalling box through independent cables.
c. Duplicated cores with at least 2 x 2.5 sq.mm2 CU/equivalent core cross- sectional area per connection shall be used for connection of all CT/CVT circuits.
d. VT leads used for tariff metering shall have an equivalent core cross- sectional area of at least 10 mm2 CU/equivalent per phase/neutral connection.
e. Duplicate channels of protection shall have independent cables for

tripping, DC supply, etc. Duplicated cores shall be used for ALL closing/tripping commands and interlocking signals involving long (MORE THAN 500 m) cable lengths, such as interfacing between SWYD and SWGR.

f. For the following applications multiple cores with at least 2 x 2.5 mm2 CU / equivalent core cross - sectional area per connection shall be used:
   i. DC supply to Bay Marshalling box
   ii. DC supply to circuit-breaker cubicle
   iii. DC looping for closing and tripping circuits of circuit-breaker

g. All the interconnections (both AC/DC) within the switchyard and between switchyard and other systems required for the successful implementation of the control, interlocks and protection schemes under present shall be in the scope of the bidder. Such interconnections between switchyard and other system shall include but not limited to the following:
   i. CT connections 33kV switchgear / transformer MB to Control Room for transformer protections.
   ii. CT connections from SWYD to control room.
   iii. Necessary interconnections for the Inter tripping / closing interlocking between upstream and downstream systems for transformer.
   iv. Necessary interconnections from transformer MB to BCU for OLTC control & monitoring.
   v. Any screened cable required for connecting 4-20 mA analog signals.
   vi. Necessary cabling between Transformer MB and SWYD Control Room for various Transformer monitoring system and fire protection system.
   vii. Necessary interconnections for signal exchange between SWYD / SWYD CR to interfacing panels of RLDC etc whereever applicable.

h. Spare cores shall be provided as per following norms:

i.	Up to 3-core cable -	Nil
ii.	5 Core Cable-	Min 1 core
iii.	7 to 14 core cables -	Min 2 cores
iv.	Morethan14core -	Min 3 cores

6.12.15. Factory Acceptance Tests (FAT)

1. All equipment furnished under this specification shall be subject to test by authorized quality assurance personnel of the contractor and Owner's representatives during manufacturing, erection and on completion. The approval of the Owner or passing such inspections or tests will not, however, prejudice the right of the Owner to reject the equipment if it does not comply with the specifications when erected or fails to give complete satisfaction in service. The detailed requirement of operational and pre- FAT tests as well as FAT test (Integrated Test) is given in this Section.

2. The FAT shall be mutually agreed upon and approved by Owner during detailed engineering.

3. Operational and Pre-FAT Tests

a. The authorized quality assurance personnel of the contractor shall conduct all tests as per the requirements and fully satisfy themselves regarding completeness of hardware, software and full compliance with specification requirements by all equipment/sub-systems and the system as a whole before sending notification for FAT to the Owner.
Contractor shall maintain accurate records for all pre-FAT tests which shall be properly documented and duly certified documents shall be furnished to Owner at least two weeks prior to FAT tests, while giving inspection call.

b. Each individual item of equipment/ sub-system/ software package furnished by the Contractor as well as the complete system as per this specification shall be inspected and tested by the Contractor in his works for full compliance with specification requirements, completeness, proper assembly, proper operation, cleanliness and state of physical condition as applicable.

c. The Contractor shall conduct a point by point wiring continuity check
to every input and output and verify that the wiring connections agree with the documentation.

d. Contractor shall conduct all tests as per requirements (Factory Acceptance Tests) to fully satisfy himself regarding completeness of the system and full compliance with specification requirements for SAS as a whole as well as for individual components/ software module. This test will be done for 100% samples, even if the FAT requires tests for only some smaller percentages.

e. The pre-FAT report shall be in the format of FAT procedure as approved by the Owner. It shall be accompanied by a very detailed report, in a log form, of the performance of all pre-FAT Tests. These records shall list not only the successfully completed tests, but shall detail all system, test and component failures.

4. Notification for FAT

a. Contractor shall send notification regarding readiness for FAT and indicate the proposed date for commencement of FAT to enable the Owner to depute representatives for participating in these tests. The notification shall be sent to the Owner not less than one week prior to commencement of the FAT along with the copies of documents covering pre-FAT results.

b. The Contractor shall ensure that all hardware and software required for fully implementing the system as per requirements of this specification is available and the adequacy of hardware, software, system configuration, etc., is fully established during the pre-FAT Tests conducted by the Contractor. In case any deficiencies in hardware and/or software are noticed by the Contractor during the pre-FAT Tests, the Contractor shall make good all such deficiencies and re-conduct the required tests to fully satisfy him regarding completeness of the system and full compliance with specification requirements before sending notification to the Owner regarding FAT Tests.

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5. Factory Acceptance Tests (FAT)

a. Factory Acceptance Tests (FAT) shall include all tests required to fully demonstrate to Owner’s satisfaction that each equipment/sub- system/system as well as software

modules furnished as per this specification as well as SAS as a whole, fully meets the functional, parametric and other requirements of this specification and Owner's approved drawings/documents under all operating regimes. The testing shall be conducted with the all the SAS components fully interconnected as per the final system configuration, including BCU, BPU and other protection relays. The Owner shall witness all FAT tests.

b. The Factory Acceptance Tests (FAT) shall include all reasonable exercises which the combination of equipment and software can be expected to perform. These tests shall be divided into, as a minimum, but not limited to the following categories:
   i. Pre power on checks
   ii. Power on checks
   iii. Hardware tests
   iv. Functional tests
   v. Parametric tests
   vi. Specific tests on electronic hardware
   vii. Power failure auto-restart tests
   viii. Testing of interlocking

c. The Contractor shall submit a detailed FAT procedure for Owner's approval during detailed engineering stage based on the above guidelines. The FAT procedure to be submitted by the Contractor shall be detailed and exhaustive enough such that Owner is satisfied that all the SAS System specification requirements and features are being tested and the system meets these requirements. The test results obtained shall be properly documented by the Contractor and furnished in the Owner approved format as decided during detailed engineering and submitted in the requisite number of copies with all annexes irrespective of the fact that Owner's representative was present during the tests.

d. For integrated testing of the total SAS system, the Contractor shall provide an I/O generator/simulator, which will be connected, to the BCUs simulating the plant status and plant operation. This will help in generating desired rate and sequence of I/O to test various BCU and HMI functionality under worst case loading conditions. With the I/O generator/simulator, all possible interlocking conditions shall be simulated and controls tested.

e. Following the tests, if in the opinion of the Owner, the system has not been adequately manufactured, programmed, tested or debugged the Contractor shall make good all deficiencies including system parametric specifications of display response time, processor duty cycle, SOE resolution, etc., and re-run the test to fully satisfy the Owner regarding full compliance with specification requirements and requisite quality standards. The Contractor shall be responsible for all travel and accommodation costs of the Owner related to re- visits and/or re-testing required.

f. The system shall not be shipped without approval of Owner in writing. Upon successful completion of FAT, the Owner will provide the Contractor with a written authorization for shipment of the system equipment to the project site.

g. Contractor shall note that no payments towards dispatch of equipment and subsequent activities shall be due and payable to the Contractor till the Contractor is

able to successfully demonstrate to Owner's satisfaction that the SAS and parts thereof fully meet the FAT requirements.

h. The tests shall include the verification of all I/O functions at all Control Levels. The interface to the control center(s), interface to the HV AND EHV SAS shall be tested with the use of a protocol simulator.

i. Performance test: The duty cycle time shall be checked under the worst loading conditions.

6.12.16. Site / Commissioning Tests

1. Site tests shall include all tests to be carried out at site upon receipt of equipment. It shall include but not be limited to testing calibration, configurations and pre-commissioning trials start up tests, trial operation and performance and guarantee tests. The Contractor shall be responsible for all site / commissioning tests.

2. The Contractor shall maintain all tests, calibration records in Owner approved formats, and these shall be countersigned by authorized quality assurance personnel of the Contractor supervising these works.

3. The Contractor shall maintain master checklists to ensure that all tests and calibration for all equipment/devices furnished under these specifications are satisfactorily completed under the supervision of the authorized quality assurance personnel of the Contractor.

4. The site / commissioning tests shall be categorized under following categories:
   a. Start up tests
   b. Calibration and configuration checks
   c. Pre-commissioning tests
   d. Trial Operation
   e. Availability Tests

5. Point-to-point testing of all the I/O signals in the HV AND EHV network shall be done by the Contractor.

6. Point-to-point testing shall include:
   a. Verification of all status indications by operating the plant
   b. Verification of event / alarm indications by simulating alarm conditions
   c. Verification of all analogue indications by injection testing
   d. Verification of all controls by operating the plant

7. Availability Tests

   a. The Contractor shall guarantee 99.9 percent availability for a continuous period of 180 days. Availability guarantee test shall be conducted to assure this level of availability. If the accrued down time exceeds 0.1% of 180 days, during availability test run, a new 180 days test run shall start at the time when the system becomes available again. Loss of availability (unavailable system) shall be defined as the loss of the systems guaranteed accuracy and repeatability or of any system function,

except however, that the loss of a function for not more than five percent of the points shall not be considered loss of availability. Loss of function for not more than 5% of the points shall be treated as partial unavailability and the corresponding outage time shall be weighted with respect to the function and the percentage of the points for which the function is unavailable. Loss of each function shall have one weighing factor and unavailability of each equipment, peripherals device or process I/O card etc. shall have another weighing factor. The guaranteed accuracy and repeatability and system parametric requirements specified in clauses on system parametric requirements shall be maintained for the entire 180 days run without any manual re-calibration or any other changes made to the SAS.

b. Downtime shall start upon loss of a system function and shall end upon full restoration of the affected system function. A minimum of one hour's down time shall be charged for each loss of availability in determining system availability.
c. The Contractor shall submit the Availability Test Procedure for Owner's approval. The details regarding outage time, weighing factors for various systems functions equipment to calculate the down time shall be discussed and finalized during detailed engineering.
d. The availability test shall start at a date, which will occur, between the commissioning date and 5 months after commissioning.
e. The availability test shall be expressed as percentage, which shall be calculated as (100% x (test duration time – Accumulated test outage time/Test duration time).
f. System outage time will be accumulated over test duration and calculated as outage time x weighing factor. The contractor shall submit a list of weighing factors for all system components along with the bid and the same will be mutually finalized before contract award. Outage time shall be weighted by each function's weighing factor.

8. Conditions for Availability Tests

i. Down time shall start with the notification to contractor about any loss of function. Downtime shall be exclusive of travel time required by the Contractor, but not in excess of 8 hours.
ii. The contractor shall furnish in his bid recommended spare parts inventory, along with unit price, to be maintained at site during availability test run. If the spare parts required for maintenance as recommended by contractor are not available with Owner for fault repair the outage time necessary for obtaining spare will not be counted. If the required spare are not recommended by the Contractor and are required for repairs, then the time required to obtain the part by the Contractor shall be multiplied by weighting factor or 0.05 and counted as a accumulated outage time. The spare parts, which are used by the Contractor and not replaced by the contractor, shall accumulate outage time at the rate of time required to obtain the spare parts multiplied by the weighing factor of 0.05 if the part is required on a subsequent outage.
iii. The contractor shall be responsible for replacing any of the Owner's spare parts which are used in the availability run free of cost to the Owner.
iv. Failure of peripheral output devices shall be counted as outage time if failure of the device affects any for part of the system function.

v. Any degradation of function shall accrue outage time regardless of processor configuration.

vi. During a period of system outage, the Owner shall use operable functions of the system provided that such use does not interfere with maintenance of the inoperable functions or hardware as determined by the Contractor.

vii. Should the contractor determine that partial use of the system by the Owner will interfere with the contractor's maintenance procedures, system outage time shall accumulate with a weighing factor of 1.0 since no functions are available to the Owner. This shall include offline servicing.

viii. Outage time for each function shall stop at the time the contractor returns each of the functions in full service and relinquishes full use of the system to the Owner.

The contractor shall prepare a detailed site / commissioning tests procedure based on the guidelines given here and submit to Owner for approval during detailed engineering stage.

9. System Hand-over and Final Acceptance

a. The system will be handed-over to the Owner for commercial operation after the site / commissioning tests have been completed to the satisfaction of the Owner. A hand-over certificate will be issued by the Owner. The Contractor will still be responsible for the Availability Tests.

b. Final acceptance of the system by the Owner will take place after the Availability Tests have been done to the satisfaction of the Owner.

10. Type Test Requirements

Test reports for following type tests shall be submitted for all BCUs / BPUs / DR / Reports / Certificates of tests conducted in accredited Laboratories (accredited by the national accrediting body of the country where the lab is located) are also acceptable.

6.12.17. BCU/BPU

i. Insulation Tests

Description	Standard

Dielectric Withstand Tests	IEC 60255-5 ▪ 2kV rms for 1 minute between all case terminals connected together and the case earth. ▪ 2kV rms for 1 minute between all terminals of independent circuits with terminals on each independent circuit connected together. ANSI/ IEEE C37.90 ▪ 1kV rms for 1 minute across the open contacts of the watchdog relays. ▪ 1kV rms for 1 minute across open contacts of changeover output relays. ▪ 1.5kV rms for 1 minute across open contacts of normally open output relays.
High Voltage Impulse Test, class III	IEC 60255-5 ▪ 5 kV peak; 1.2/50 µsec; 0.5 J; 3 positive and 3 negative shots at intervals of 5 sec

ii. Electrical Environment Tests:

Description	**Standrad**
DC Supply Interruption	IEC 60255-11
AC Ripple on DC supply	IEC 60255-11
AC voltage dips and short Interruptions	IEC 61000-4-11
High Frequency Disturbance	IEC 60255–22–1, class III ▪ At 1MHz, for 2s with 200Ω source impedance: ▪ 2.5kVpeak;1MHz;T=15 µsec; 400 shots/sec; duration 2 sec between independent circuits and independent circuits and case earth. 1.0kV peak across terminals of the same circuit.
Fast Transient Disturbance	IEC 60255-22-4, class IV ▪ 4kV, 2.5kHz applied directly to auxiliary supply ▪ 4kV, 2.5kHz applied to all inputs.

Surge Withstand Capability	IEEE/ANSI C37.90.1 ▪ 4kV fast transient and 2.5kV oscillatory applied directly across each output contact, optically isolated input and power supply circuit.
Electrostatic Discharge	IEC 60255-22-2 Class 4 ▪ 15kV discharge in air to user interface, display and exposed metal work.
Surge Immunity	IEC 61000-4-5: 1995 Level 4 ▪ 4kV peak, 1.2/50ms between all groups and case earth. ▪ 2kV peak, 1.2/50ms between terminals of each group.

iii. EMC Tests:

Description	**Standrad**
Radiated Immunity	C37.90.2-2004 ▪ 25MHz to 1000MHz,
Radiated Electromagnetic Field Disturbance Test	IEC 60255-22-3 ▪ 80-1000 MHz, Amplitude Modulated
Disturbances Induced by Radio Frequency fields, Amplitude Modulated (Conducted Immunity)	IEC 60255-22-6 ▪ 150kHz – 80 MHz;
Power Frequency Magnetic Field	IEC 61000-4-8, class IV
Interference Voltage, Aux. Voltage (Conducted Emission)	EN 50081-2, 1994 or equivalent ▪ 150 kHz to 30 MHz
Interference Field Strength (Radiated Emission)	EN 50081-2, 1994 or equivalent ▪ 30 MHz to 1000 MHz

iv. Atmospheric Environment Tests:

Description	**Standrad**
Humidity	IEC 60068-2-3
Temperature	IEC 60255-1 IEC 60068-2-1 for Cold IEC 60068-2-2 for Dry heat

v. Mechanical Stress Tests:

Description	Standrad
Vibration (during Operation and Transportation)	IEC 255-21-1; IEC 68- 2-6
Shock (during Operation and Transportation)	IEC 255-21-2, IEC 68- 2-27
Seismic Vibration (during Operation)	IEC 60255-21-3

6.12.18. DISTURBANCE RECORDER

Type test reports for the following tests shall be submitted

a. High Voltage Impulse Test, class III as per IEC 60255-5
b. High Frequency Disturbance as per IEC 60255–22–1, class III viii. Fast Transient Disturbance as per IEC 60255-22-4, class IV

6.12.19. Functional Tests

All the numerical relays shall be tested for the functions specified in GIPCL technical specifications. In case of Numerical Distance Relays, test reports for dynamic tests clearly indicating the operating time under different system / fault conditions shall be submitted.

6.12.20. Settings

Fault levels will be provided to the Contractor by the Owner. The Contractor shall, based on this information, compile a complete and detailed report for the setting of the protection elements on all the protection equipment, to the approval of the Owner. Any additional information required to complete this exercise shall be timely requested by the Contractor.

The contractor shall provide the Owner with a philosophy document clearly setting out the philosophy the contractor will use in determining setting levels. Each setting will have a brief description of the specific function or element. The setting calculation and formula will also be shown on the document. All relevant system parameters, line data, transformer data additionally used for calculating the setting will appear in the setting document. The contractor will conduct system studies in determining fault levels on different locations. These study results will also form part of the setting document. Any additional information required to complete this exercise shall be timely requested by the Contractor.

The setting document will be presented and discussed with the Owner prior to final issue of the document. The final accepted setting document should be made available to the Owner in PDF format.

It is the Contractor's responsibility to configure each protection relay to provide the protection and control facilities required. A full set of relay configuration and setting files shall be included in the design and documentation submissions. The contractor will issue three sets of setting documents once accepted by the client and consultant.

6.12.21. Furniture

The furniture required for the officials/ operators & for locating the various items in the control/ relay room shall be supplied. The exact requirement/ details shall be finalized during detail engineering. However, a minimum requirement is specified below:

a)	Desk for Switchyard control room – Modular for workstations 2 and printers covered under this package	2
b)	Chairs	4
c)	Filing Cupboard	1

6.12.22. Engineering/Operator workstation

Minimum quantity requirement is specified below:

SL No	Description	Quantity
1	Engineering/DR workstation (PC with Min 22" LED Monitor)	01 Set
2	Operator work station (OWS) (PC with Min 22" LED Monitor)	02 Set
3	Portable (laptop) based EWS	01 No
4	50 Inch LED display (connect with both OWS)	01 No
5	Time Synchronization equipment	01 No
6	Control Desk	02 Set (min)
7	Chairs for Control Desk	04 Nos
8	Networked Color Laser Printer	01 No

Contractor shall provide the compatible Engineering, DR and Operator workstation and other components as per offered SAS system complying with following minimum specification requirement.

Operator Workstations

SI No	Features	Industrial Grade Operator Workstations
1	Processor	64 bit (i5 or Equivalent)
2	Memory	8 GB RAM upgradable to 16 GB
3	Hard Disk	500 GB ultra wide RAID1 for OWS/ 500 GB for Portable EWS 1 TB ultra wide RAID1 for Historian
4	Monitor (Color)	Min 22” TFT Flat Monitor with non- interfaced refresh rate min. 75 Hz. Communication port:- 2 Serial bus , one parallel Dual 10/100/1000 Mbps. Ethernet Graphic Memory = 16 MB Expansion slot=3
5	Removable bulk storage drive (DVD/DAT)	6 GB (minimum)
6	Network Connectivity	4 Nos. Built-in Ethernet Network Port
7	DVD R/W	16x or higher
8	Keyboard	ASCII
9	Pointing Device	Mouse
10	Additional general purpose software (for using over network by servers/workstations /PCs)	Comprehensive disk maintenance utility for disk clean sweep/ crash guard/antivirus, etc.
11	Software	MS. Windows latest, MS Office Editor (EXCEL, WORD, POWER POINT), Adobe Acrobat, Anti Virus, Network Security, Etc.

Engineering / DR Workstation

SI No	Features	Industrial Server Grade Engineering cu, Operator Workstations
1	Processor	64 bit Server Grade (Xeon or Equivalent), Octacore minimum
2	Memory	16 GB RAM upgradable to 24 GB
3	Hard Disk	1 TB RAID1
4	Monitor (Color)	Min 22” TFT Flat Monitor with non- interfaced refresh rate min. 75 Hz. Communication port:- 2 Serial bus , one parallel Dual 10/100/1000 Mbps. Ethernet Graphic Memory = 16 MB, Expansion slot=3
5	Network Connectivity	2 Nos. Built-in Ethernet Network Port
6	Removable bulk storage drive (DVD/DAT)	6 GB (minimum)
7	Portable Bulk Storage Media	2 TB (2 nos.)
8	DVD R/W	16x or higher
9	Keyboard	ASCII
10	Pointing Device	Mouse
11	Additional general purpose software (for using over network by servers/workstations /PCs)	Comprehensive disk maintenance utility for disk clean sweep/ crash guard/antivirus, etc.
13	Software	MS Windows latest, MS Office, Adobe PDF Reader, Anti Virus, Network Security Etc.

LED Display

1	LED Display	50 Inch LED Display, Display Resolution :

Printer

SI No	Features	Networked Color Laser Printer
1	Paper Size	A3
2	Printing Speed (min.)- in normal mode for A4 size paper	6 ppm (Color)
3	Type	24 ppm (B&W)
4	Resolution (black) (min.)	Heavy Duty, at least 50,000 pages per month
5	First page out time (with full graphic display)	600 dpi
6	Paper input capacity (min.)	=<1 min for color
		< 45 sec for BW
7	Additional features	Automatic Duplex Printing
8	Paper sheets (1 ream = 500 sheets) with printer (To be supplied with printer)	10 reams (A3)
		20 reams (A4)