sockets, single/double compression cable glands. Cable glands shall have adequate earthing provision. Suitable lock type crimping lug shall be used for cable end terminations.

c)

T Cable termination kits and straight through joints shall be selected as per the cable specifications. Heat shrinkable type kits only shall be used for HT & LT Cables

4.4.3.4.9 Inter Plant Cabling: Interplant cabling for main routes shall be laid in Cable trenches/cable trays/buried/duct banks

4.4.3.4.10 Trenches: PCC flooring of built up trenches shall be sloped for effective drainage with sump pits and sump pumps

4.4.3.4.11 Cable Trays, Fittings & Accessories: Cable trays shall be ladder/perforated type as specified complete with matching fittings (like brackets, elbows, bends, reducers, tees, crosses, etc.) accessories (like side coupler plates, etc. and hardware (like bolts, nuts, washers, G.I. strap, hook etc.) as required .Cable trays shall have standard width of 150 mm, 300 mm & 600 mm and standard lengths of 2.5 metre

4.4.3.4.12 Terminations & Straight through Joints: Termination and jointing kits for **Inverter Output Voltage**/33Kv and 1.1/1.5kV grade XLPE insulated cables shall be of proven design and make which have already been extensively used and type tested. Termination kits and jointing kits shall be pre-moulded type, taped type or heat shrinkable type. **Inverter Output Voltage** Kv, 33 kV and 1.1/1.5kV grade grade joints and terminations shall be type tested as per IS:13573. 3.3kV grade joints and terminations shall be type tested as per VDE0278

4.4.3.4.13 Cable glands: Cable shall be terminated using double compression type cable glands. Cable glands shall conform to BS:6121. Cable glands shall be made of heavy duty brass machine finished and nickel chrome plated. Thickness of plating shall not be less than 10 micron .

4.4.3.4.14 Cable lugs/ferrules: Cable lugs/ferrules for power cables shall be tinned copper solderless crimping type suitable for aluminium compacted conductor cables. Cable lugs and ferrules for control cables shall be tinned copper type. The cable lugs for control cables shall be provided with insulating sleeve and shall suit the type of terminals provided on the equipment. Cable lugs and ferrule shall conform to relevant standard.

4.4.3.4.15 Installation Cable tray and Support System Installation

Cables shall run in cable trays mounted horizontally or vertically on cable tray support system which in turn shall be supported from floor, ceiling, overhead structures, trestles, pipe racks, trenches or other building structures.

The Contractor shall design, erect & install the complete plant cabling system including HT, LT Power & Control cabling, trenches, cable trays, fittings and accessories with proper support system for cable trays, junction boxes, arrangement of proper termination as per system requirements, cable glands, lugs/ferrules, trefoil clamps, cable clamps and straps, receptacles including galvanizing and welding as per the relevant IS/IEC standards, necessary for reliable and satisfactory operation of the plant.

The Contractor shall submit a Cable Schedule for complete plant- to the Employer.

Cables shall run in cable trays mounted horizontally or vertically on cable tray support system which in turn shall be supported from floor, ceiling, overhead structures, trestles, pipe racks, trenches or other building structures. The Contractor shall ensure for properly embedding conduit pipe sleeves wherever necessary for cabling work. All openings in

the floor/roof/wall cable tunnel/cable trenches made for conduit installation shall be sealed and made water proof by the Contractor.

Junction boxes with minimum IP 55 degree of protection shall be mounted at an adequate height above floor level or as specified in the drawings and shall be adequately supported/mounted on masonry wall by means of anchor fasteners/ expandable bolts or shall be mounted on an angle, plate or other structural supports fixed to floor, wall, ceiling or equipment foundations.

In each cable run some extra length shall be kept at suitable point to enable one LT/two HT straight through joints to made, should the cable develop fault at a later stage. Control cable termination inside equipment enclosure shall have sufficient lengths so that shifting of termination in terminal blocks can be done without requiring any splicing.

The termination and connection of cables shall be done strictly in accordance with cable termination kit manufacturer" instructions, drawings etc.

At least 300mm clearance shall be provided between

- T power & LT power cables,
- T power & LT control/instrumentation cables

4.4.3.4.16 Routine Testing & Inspection at Works

All the acceptance tests and Routine Tests, inspection at manufacturer's works as well as at site shall be carried out strictly as per specifications, relevant standards and in accordance with the Final Quality Assurance Plan and reports shall be submitted to Employer. The Employer or its authorized representative reserves the right to inspect the modules at the manufacturer's site prior to dispatch.

4.4.3.4.17 Type Test

The cables supplied must be of type tested design and certified by any of the accredited certifying agencies in accordance with relevant standards /codes and the type test reports shall be submitted for employer's review. If the type tests are not done previously, then they shall be conducted by the Contractor without any additional cost to the Employer and the type test report shall be submitted before supply of Cables.

SI No	TYPE TEST	REMARKS
Conductor		
1	Resistance test	
2	Tensile test	For circular non – compacted only
3	Wrapping test	For circular non – compacted only
For Armour wires/Formed wires		
4	Measurement of Dimensions	
5	Tensile test	
6	Elongation test	
7	Torsion test	For round wires only
8	Wrapping test	For aluminium wires/ Formed wires
9	Resistance test	

10(a)	Mass & uniformity of Zinc Coating tests	For GS formed wires/wires only
10(b)	Adhesion test	For GS formed wires/wires only
11	Adhesion test	For GS formed wires/wires only

For PVC /XLPE insulation & PVC sheath

12	Test for thickness	
13	Tensile strength and elongation test before aging	
14	Ageing in air oven	
15	Loss of mass test	For PVC insulation and sheath only
16	Hot deformation test	For PVC insulation and sheath only
17	Heat deformation test	For PVC insulation and sheath only
18	Shrinkage test	
19	Thermal stability test	For PVC insulation and sheath only
20	Hot set test	For XLPE insulation only
21	Water Absorption test	For XLPE insulation only
22	Oxygen index test	For outer sheath only
23	Smoke density test	For outer sheath only
24	Acid gas emission test	For outer sheath only

The reports for following type tests shall be furnished for each type (voltage grade) & size of the cable

Sl No	**Type Test for all cables**
1	Insulation Resistance test(Volume Resistivity method)
2	High voltage test

For cables of 11 kV and above Grade only

3	Sheath Test
4	DC High Voltage Test
5	Dielectric power factor test a) As a function of voltage b) As a function of temperature
6	Impulse withstand test

4.4.3.5 PROTECTION SYSTEM

4.4.3.5.1 The Contractor shall provide suitable protection systems for the complete Solar PV Plant and the associated Power Evacuation System covering Inverters, DC System, Power/Inverter transformers, Auxiliary Transformer, HT Switchgear, LT Switchgear, Switchyard & associated Power Evacuation System, Battery Bank & Charger and other equipment and systems as per system design as required for safe, efficient and trouble free operation of the Solar PV Plant.

4.4.3.5.2 The Solar PV Plant and the associated Power Evacuation System shall be protected as per applicable IS/ IEC standards. Over Current Protection, Reverse Power Protection, Differential protection, Earth Fault protection/REF, Under voltage Protection, Over flux Protection, Bus Bar Protection, Breaker Failure Protection, Buchholz, Winding Temperature, Oil Temperature, PRV and other protection for Transformers and other equipment/ systems installed in the Solar PV Plant shall essentially be provided whichever and wherever applicable as per manufacturer's recommendation, standard practice and system design considering the fault current under most severe fault conditions.

4.4.3.5.3 General Requirement

Protection system shall be complete in all respect. Protection shall be provided through relays, which shall be Numeric type protection relays with RS 485 port or any other compatible port for communication with PC/Laptop for configuration and data download as well as communication with Numeric protection for Power/Inverter transformer shall be provided with 100% redundancy of relays.

The Solar PV System and the associated Power Evacuation system interconnections should be protected as per IEC 61727 Ed-2 norms.

All relays shall be rated for control supply voltage and shall be capable of satisfactory continuous operation between 80-120 % of the rated voltage, making, carrying and breaking current ratings of their contacts shall be adequate for the circuits in which they are used.

All communications of protection system with the control system shall be based on universally accepted protocol as per IEC 60870-5-10.

The numerical relay shall have RS-232/RS-485/RJ-45/USB ports on front side for local communication with PC and on rear side for remote communication to SCADA system.

All circuit breaker feeders shall be provided with communicable numerical relays (IED, i.e. Intelligent Electronic Device, complying with IEC 61850, having protection, control, measurement and monitoring features.

All major numerical relays shall have in built disturbance recorder (DR) and event recorder with adequate number of Digital & Analog channels and storage Capacity for enabling smooth fault analysis. All relays, disturbance recorders, event recorders etc. shall be time synchronised through universal time synchronisation system as described in "Section -Control and Monitoring (SCADA) System".

The control/ relay compartments shall have degree of protection not less than IP 5X in accordance with IS/IEC 60947.

One minute power frequency withstand test voltage for all numerical relays shall at least be 2kV (rms) for 1 min or 2.5 kV for 1 sec.

The alarm/status of each individual protection function and trip operation shall be communicated to Switchgear SCADA.

The design of relay shall be immune to any kind of electromagnetic interference.

All CT terminals on the relays shall be fixed type suitable for connection of ring type lugs to avoid any hazard due to loose connection leading to open circuit.

Relay shall have self-diagnostic features with continuous self-check for power failure, program routines, memory and main CPU failures and a separate output contact for indication of failure.

The relays and associated hardware shall be suitable for continuous operation in harsh environmental conditions, high temperature, humidity, dust etc.

The protection scheme shall also be coordinated with the fire protection system for step-up transformers & other areas. The detailed scope of supply given in relevant clause is indicative only. However, all protection as per relevant IEC standards shall be provided.

All the relays shall be of reputed make with proven performance. . If the protection system mentioned in the awarded contract become obsolete at the time of supply, the contractor shall offer a latest model without any extra cost.

The Contractor shall submit to the Employer the protection scheme / diagram, relay setting details/ chart and other relevant information as per Engineering Information Schedule during detailed Engineering.

4.4.3.5.4 Protections

The Incomer, Bus Coupler & Tie feeder protection relay shall be suitable for providing the following protections:

a. Three Phase Over current and Earth Fault protection (50 & 50N) with instantaneous, definite time, and IDMT features.
b. The over current element should have the minimum setting adjustable between 250- 2000% of CT secondary rated current. The earth fault element should be suitable for residually connected CT input. The relay shall be suitable for detection of earth fault currents in the range of 5% to 10% of the CT rated current.
c. The following protections shall be covered:
   A. **Step up Transformer & Transformer bay Protection as applicable as per standards**

      Contractor shall have to provide the protections for the Transformers as per system design including but not limited to following:

      i. 87 Differential Protection
      ii. 49 Winding Temperature Alarm and trip protection
      iii. 26 Oil Temperature alarm and trip protection

iv. 71 Oil Level alarm and trip protection
v. Bucholz Protection and alarm
vi. PRV Protection
vii. 50/51N Instantaneous and time delay over current and earth fault protection On HV as well as LV Side
viii. 64 R Restricted earth fault protection
ix. 59 F Over fluxing protection
x. 50 Z Local Breaker Failure protection
xi. 27 Under Voltage Protection

B. **Auxiliary Transformer Protection**

Contractor shall have to provide the protections for the Transformers as per system design including but not limited to following:

i. Transformer winding temperature alarm and trip protection
ii. 50/51N Instantaneous and time delay over current and earth fault protection On HV as well as LV Side
iii. 64 R Restricted earth fault protection
iv. 26 Oil Temperature alarm and trip protection
v. 71 Oil level alarm and trip protection

C. **Bus BAR Protection for complete system**

Contractor shall have to provide the following protections but not limited to following

i. 87 Differential Protection of all Buses
ii. 95 BB CT Wire supervision relay

D. **Other provisions**

i. Protection of Solar Inverters, Solar Power/Inverter Transformers
ii. Protection of 415 V Switchgear
iii. Protection of all Cables
iv. Necessary ICTs, Relay panels, marshalling boxes, isolating and shorting links etc.
v. Protection of **all** Line bay. Further, the contractor shall also have to co-ordinate in order to integrate the protection of Switchyard protection systems with State Authority Transmission Authority & Other systems so as to complete the protection of the entire system.
vi. Provision of necessary contacts and /or ports for integration with plant SCADA System for Alarm, tripping and status signal as per requirements.
vii. Trip circuit supervision shall be provided for all feeders to monitor the circuit breaker trip circuit.
viii. The numerical processor shall be capable of measuring and storing values of a wide range of quantities, all events, faults and disturbance recordings with a time stampings using the internal real time clock. Battery backup for real time clock in the event of power supply

failure shall also be provided. Sequence of events shall have at least 1 ms resolution at device level.

4.4.3.5.5 Routine Testing & Inspection at Works

All the acceptance tests and Routine Tests, inspection at manufacturer's works as well as at site shall be carried out strictly as per specifications, relevant standards and in accordance with the Final Quality Assurance Plan and reports shall be submitted to Employer. The Employer or its authorized representative reserves the right to inspect the modules at the manufacturer's site prior to dispatch.

4.4.3.6 SWITCHYARD

4.4.3.6.1 Switchyard/Switchgear Equipment

i. Inter connecting Power Transformer station shall be designed in accordance with the design of Inverter Transformers and then the output power from the Inverter Transformer is stepped up to **132 KV** by using the Power Transformer as per the UPNEDA/IMPLEMENTING AGENCY/STU/CTU requirements. The design shall strictly adhere to the requirements of UPNEDA/IMPLEMENTING AGENCY/STU/CTU.

ii. The Contractor shall provide suitable number of incoming bays and Outgoing bays as per system requirement comprising of circuit breakers, current transformers, isolators, Earth Switches, Surge Arresters, Wave trap and voltage transformers and other equipment necessary for satisfactory operation of switchyard

iii. The switchyard/**Switchgear** must have all the main equipment and auxiliaries and contractor is responsible for supply of all these items i.e. Conductor, galvanized gantry structures and supporting structures, insulators, hardware fittings, fasteners, lightning masts, earthing risers for equipment and gantry structures, earth wire, Marshalling Kiosks, secondary wiring, terminal blocks, labelling and nameplates, sockets etc. for reliable and satisfactory operation of the Solar PV Plant.

iv. All sundry equipment, fittings, unit assemblies, accessories, hardware items, foundation bolts, termination lugs for electrical connections, and all other items which are useful and necessary for efficient assembly and installation of equipment and components of the work shall be deemed to have been included in the scope of contractor irrespective of the fact whether such items are specifically mentioned in the specifications or not.

4.4.3.6.2 Rating and Functional Characteristics

The ratings of the Switchyard Equipment shall be based on Voltage level, which shall be updated based on project specific information. The contractor shall be provided the following details:

System Parameter	Description
Installation	Outdoor
Type of bus bar arrangement	As per system requirement

System Parameter	Description
Total No. of bays	As per system requirement
Rated voltage, kV, r.m.s	As per system requirement
Highest System Voltage	As per system requirement and relevant IS/IEC Standards
Rated frequency, Hz	50
Rated continuous current, A, r.m.s	As per the system requirement
Rated short time withstand current (rms) for 1 sec.	As per system requirement and relevant IS/IEC
Rated Peak withstand current, k A	As per system requirement and relevant IS/IEC
Rated duration of short circuit	As per system requirement and relevant IS/IEC
Rated /minimum power frequency withstand voltage	As per system requirement and relevant IS/IEC
Rated lightning impulse with stand voltage (peak)	As per system requirement and relevant IS/IEC Standards
Minimum Creepage distance , mm	As per system requirement and relevant IS/IEC
Rated control voltage DC, V	As per system requirement and relevant IS/IEC
Auxiliary AC supply, 3 phase, V	As per system requirement and relevant IS/IEC
Partial discharge of switchgear assembly at highest voltage for equipment, pc	As per system requirement and relevant IS/IEC
Circuit Breaker	
Type	Vacuum/SF6 Type

System Parameter	Description
Number of poles	Three (03)
Rated short circuit breaking current & making current kA (r.m.s)	As per IEC/IS Standards As per IEC/IS Standards
Rated line charging breaking current capacity, A	As per IEC
Auto Reclosing	Three Phase high speed auto reclosing
Closing time	As per system requirement
Maximum Fault Level	As per system requirement
Rated operating duty cycle	O-0.3Sec-CO-3 min–CO
Auxiliary Contacts	4 NO and 4 NC contacts per pole as spare
Noise Level	As per system requirement
Seismic Acceleration	As per system requirement
IP Protection	IP 65
Isolators	
Type	3 Phase double Break
Operation	Motorized/ manual as per system requirement
Rated short time current of Isolator & Earth switch	As per system requirement & relevant IS/IEC Standards

System Parameter	Description
Rated dynamic short time withstand current of isolator and earth switch	As per system requirement & relevant IS/IEC Standards
Temperature Rise	As per table IV of IS:9921
Line Charging breaking capacity	As per system requirement & relevant IS/IEC Standards
Rated Mechanical Terminal Load	As per 62271-102
IP Protection	IP 65
Current Transformers	
Current ratio	As per system Requirement
Line bay	As per system requirement
Power Tr. Bay(incoming)	
Accuracy	
For protection	Class PS for Differential & REF and core balance CTs (CBCT); 5P20 for other protection CTs
For metering	0.2S
System Neutral Earthing	Effectively Earthed.
Rated dynamic current	As per system Requirement
Partial Discharge Level	As per system Requirement
Temperature Rise	As per system Requirement

System Parameter	Description
Insulation Level	As per system Requirement
Number of CTs.	As per the requirement of STU/CTU/UPNEDA/State Transmission Authority.
No. of Cores	As per the requirement of STU/CTU/UPNEDA/State Transmission Authority.
CT Secondary Current	As per system requirement
Rated Burden	As per system requirement
No. of terminals in Marshaling Box	As per system requirement
IP Protection	IP 65
Surge Arrestors	
Class	As per system requirement
Rated arrestor voltage	As per system requirement
Rated nominal discharge Current (8/20 micro second wave)	As per system requirement
Maximum Residual Voltage	As per design
Minimum discharge capability	As per system requirement
Maximum Continuous operating voltage (MCOV)	As per system requirement
Partial Discharge at highest voltage	As per design
Max residual voltage at (1 KA)	As per system requirement

System Parameter	Description
Max switching impulse residual voltage at -1000 A Peak	As per system requirement
Max steep current residual	As per system requirement
High current short duration test value current (4/10 micro sec wave	As per system requirement
Current for pressure relief test	As per system requirement
Radio interference voltage at156	As per system requirement
IP Protection	IP 65
Capacitive Voltage Transformers for HV Bus	
IP Protection	IP 65
Voltage ratio	As per system requirement
Accuracy class for Metering & Protection	As per system requirement
Number of cores in secondary side	As per system requirement
Partial Discharge at highest	Less than 10pc
Insulation Class	A
Rated Burden	As per system requirement
Number of cores in secondary	As per system requirement
System Neutral Earthing	Effectively Earthed.
System Fault Level	As per system requirement
Stray capacitance and stray conductance of LV Terminal over entire carrier frequency	As per IEC :358
Temperature rise over an ambient temperature of 50 deg C	As per IEC 60044.
Rated Voltage Factor	1.2 continuous and 1.5 for 30 sec.
Partial Discharge at highest	As per Standards (IS/IEC)
Insulation Class	A
Minimum Creepage distance	As per system requirement
Accuracy class for Metering & Protection	0.2 & 3P respectively respectively

4.4.3.6.3 General Requirements

Circuit Breaker:

The Circuit Breaker shall be of outdoor type, comprising three identical single pole units, complete in all respects with fittings, wirings etc and shall conform to IEC

62271-100 or equivalent Indian Standards. The circuit breakers shall have all the necessary operation equipment and provisions for reliable and satisfactory protection of the system. The circuit breakers shall be capable of rapid and smooth interruption of currents under all conditions completely suppressing all undesirable phenomena even under the most severe and persistent short circuit conditions or when interrupting small currents or leading or lagging reactive currents. The circuit breakers shall be 'Restrike-Free' under all operating conditions. The over voltage caused by circuit breaker while switching inductive or capacitive loads shall not exceed 2.5 times the highest phase to neutral voltage. The over voltage caused by circuit breaker while switching inductive or capacitive loads shall not exceed 2.5 times the highest phase to neutral voltage. The rated transient recovery voltage for terminal fault and short line faults shall be as per IEC: 62271-100. The circuit breaker shall be capable of breaking the steady & transient magnetizing current corresponding to transformers. It shall also be capable of breaking line charging currents as per IEC-62271-100. The 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 proof of the total break time of complete circuit breaker, the contractor 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 DC component of the circuit breaker, the contractor shall note that IEC 62271-100 requires that this value should correspond to the guaranteed minimum opening time under any condition of operation. The critical current, which gives the longest arc duration at the lock pressure of extinguishing medium and arc duration, shall be indicated.

i. Breaker shall be C2/Ml class under all duty conditions and shall be capable of performing their duties without opening resistor. The circuit breaker shall be capable for breaking the steady & transient magnetizing current. It shall also be capable of breaking line charging currents as per IEC- 62271-100 with a voltage factor of 1.4
ii. The rated transient recovery voltage for terminal fault and short line faults shall be as per IEC: 62271-100
iii. **Operating Mechanism of Circuit breakers**
    a) Circuit shall be vacuum type and equipped with electrically spring charged mechanism.
    b) The operating mechanism shall be anti-pumping and trip free (as per IEC definition) electrically under every method of closing.
    c) 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. The VCB coil DC supply through appropriately rated battery bank and charger to be supplied by the Contractor.
    d) There shall be "SERVICE", "TEST" and "FULLY WITHDRAWN" positions for the breakers.

e) Suitable mechanical indications shall be provided on all circuit breakers to show "OPEN", "CLOSE", "SERVICE ", "TEST" AND "SPRING CHARGED" positions.

f) During closing, main poles shall not rebound objectionably and mechanism shall not require adjustments. Necessary dampers shall be provided to withstand the impact at the end of opening stroke.

g) Mechanical indicators shall be provided on the breaker trucks to indicate OPEN / CLOSED conditions of the circuit breaker, and CHARGED / DISCHARGED conditions of the closing spring.

iv. Routine Tests

Contractor shall submit the routine test report of SF6 Circuit Breaker comprising of tests but not limited to following:

a) Circuit Breaker Timing Measurement,
b) Contact Resistance Measurement ,
c) IR Test,
d) HV Test etc.

Isolator-cum-Earthing Switches:

The isolator-cum-Earthing Switches shall have all the necessary operation equipment and provisions for reliable and satisfactory protection of the system. They shall comply with the requirements of IS -9921 and IEC-129 (latest edition) and shall conform in general to IEC 62271-102 (or equivalent Indian standard). The insulators shall comply with the requirements of IS-2544 and IEC-168-1988 (latest edition). Isolator shall be double break, outdoor, gang operated for main blades and earth switches. The operation of the three poles shall be well synchronized 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. The design shall be provided for positive control of blades in all positions with minimum mechanical stress on the Insulators. Fixed guides shall be so provided that proper setting of contacts shall be obtained, when a blade is out of alignment even by 25 mm in either direction. All movable parts, which may be in current path, shall be shunted by flexible copper conductor of adequate cross-section and capacity, which shall be furnished under bill of material. 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 clearance of 4000 mm from live parts to ground as per provision of I.E. Rules shall be considered while manufacturing of isolators & to decide location of operating mechanism box. Height of structure of isolator from ground is to be considered as 2900 mm including 150 mm for muffing.

Routine Tests of Isolators

Contractor shall submit the routine test report of Isolators comprising of tests but not limited to following:

a) IR Test,

b) HV Test
c) CRM(Contact Resistance Measurement)

Contacts:

The moving & fixed contacts shall be made of hard drawn electrolytic grade copper strips and shall be heavy duty self-aligning & high pressure type preferably which applies pressure to the contact surfaces after the blades are fully closed and release the pressure before they start to open. High-pressure type contacts shall wipe the contact surfaces, while opening and closing. The contacts shall be so designed that wiring, action shall not cause securing or abrasion on the contact surfaces. The wiping action shall be sufficient to remove oxide film, formed during operation of switches. The pressure shall be developed by rotation of the entire blade. The temperature-rise of contacts due to flow of rated short circuit current for a period of 3-seconds shall not cause any annealing or welding of contacts. The moving contacts, if provided, shall close first and open last so that no damage is caused due to arcing whatever to the main contacts. The Contractor shall give full details of such contacts with necessary drawings. The arcing contacts, if provided shall close first and open last so that no damage is caused due to arcing whatever to the main contacts. The tender shall give full details of such contacts with necessary drawings. The female contact and its tensioning by spring shall be such that there will, always, be a positive contact with adequate pressure to give enough contact surface for the passing of current. The springs provided should not go out of alignment or get entangled with the male contact during operation. The details of springs shall be furnished on the G.A. drawing.

Earthing Blades: The Isolators controlling the transmission line (underground transmission cables) shall be equipped with earthing blades. The Earthing blades shall be counter balanced to ensure easy operation. Line earth switch shall consist of three Earthing links per Isolator which will normally rest against the frames, when the connected Isolator is in closed position. The Earthing links of all three phases shall be suitable for fitting on either side of the Isolator. Short time current withstand capacity of earthing blades of Isolator Earthing Switch shall be same as that of the main blades of Isolator. The material of the earthing Isolator, Each earthing blade shall be provide with flexible copper connections of adequate length of not less than 60mm2 are for connection between the operating shall and the base frame. The rated making capacity of earthing switches specified in the applicable standard of isolators.

Instrument Transformers:

Instrument transformers shall be completely encapsulated cast resin type, suitable for continuous operation at the ambient temperature prevailing inside the switchgear enclosure, when the switchgear is operating at its rated load and the outside ambient temperature is 50°C. The instrument transformer i.e. current and voltage transformers shall have all the necessary operation equipment and provisions for reliable and satisfactory protection of the system. The instrument transformers shall be single phase transformer units and shall be supplied with a common marshalling box for a set of three single phase units. The tank as well as top metallics shall be hot dip galvanized or painted Grey colour. 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 shall have cantilever strength of appropriate capacity.

a)

urrent Transformer:

i.

urrent transformers may be either of the bushing type or wound type. The bushing types are normally accommodated within the transformer bushings and the wound types are invariably separately mounted. The location of the current transformer with respect to associated circuit breaker has an important bearing upon the protection scheme as well as layout of, substation. Current transformer class and ratio is determined by electrical protection, metering consideration. The insulation of the CT, lower part as well as upper part shall be properly secured to avoid any risk of damage due to transportation stresses. Current Ratings, design, temperature rise, etc should be in accordance with IS 2705(Part I to IV). The type tests and routine tests shall be carried out conforming to IS/IEC 60044-1:2003

ii. Routine Tests of Current Transformers

Contractor shall submit the routine test report of CT comprising of tests but not limited to following:

a) IR Test,
b) HV Test
c) Ratio Test(Primary injection)

b)

oltage Transformer:

i.

oltage transformers shall be single phase oil immersed self -cooled type suitable for outdoor. They shall be electro-magnetic (EMU) type and 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. 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 core should be of high grade non –ageing electrical silicon laminated steel of high permeability. The VTs should be hermetically sealed to eliminate breathing and prevent air and moisture entering the tank. The type tests and routine tests shall be carried out conforming to IS/IEC 60044-2:2003

ii.

outine Tests of Voltage Transformers

Contractor shall submit the routine test report of PT comprising of tests but not limited to following:

a) IR Test,

b) HV Test

c) Ratio Test(Primary injection)

c)

urge Arrestors:

i.

urge Arrestors shall have all the necessary operation equipment and provisions for reliable and satisfactory protection of the system. 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. The surge arrestors shall conform to IEC-60099-4. The Surge Arrestors shall be of heavy duty station class and gapless Metal Oxide type without any series or shunt gaps and shall be capable of discharging over voltages occurring during switching of unloaded transformers and long lines. The Surge Arrestors shall be complete with insulating base for mounting on structure. Suitably enclosed for outdoor use . The type tests and routine tests shall be carried out conforming to IS/IEC 60099-4 .

ii.

outine Tests of Surge Arrestors

Contractor shall submit the routine test report of LA comprising of tests but not limited to following:

a) IR Test,

b) HV Test

d)

nsulator:

Insulator shall have all the necessary operation equipment and provisions for reliable and satisfactory protection of the system. Bushings shall be manufactured and tested in accordance with IS: 2099 & IEC: 137. Hollow column insulators shall be manufactured and tested in accordance with IEC: 60233/IS: 5261. The support insulators shall be manufactured and tested as per IS: 2544 / IEC: 600168/IEC: 600273. The insulators shall also conform to IEC 815 as applicable. 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. Insulator shall also meet requirement of IEC – 60815.

Bus Bars:

The Bus Bars shall have all the necessary operation equipment and provisions for reliable and satisfactory protection of the system. The outdoor bus-bars and equipment connections shall be with ACSR conductor suitably sized as per design requirement. All bus bars shall be adequately supported by non-hygroscopic, non- combustible, track- resistant and high strength sheet moulded compound or equivalent type polyester fibre glass moulded insulator.

Entire bus bar system shall be insulated with PVC sleeves. Bus bar sleeves shall be compliant to UL224 (Extruded insulating tubing), CE/UL certified, having fire retardant properties and working temperature of 105 deg C.

The Contractor shall submit to the Employer the layout arrangement ,equipment Drawings, design calculations for short circuit withstand capability , load calculation for bus bar rating selection etc and other relevant information as per Engineering Information Schedule during detailed Engineering.

4.4.3.6.4 Standards & Codes

The system and equipment shall be designed, built, tested and installed to the latest revisions of the following applicable standards.

Standard	Description
IS-13118/1991	General Requirements for Circuit Breakers for voltage above 1000 V
IEC 60694	Common specifications for high-voltage switchgear and control gear standards
IEC-60186	Voltage transformers
IEC-60099-4	Metal-oxide surge arresters without gaps for AC systems
IEC-62271 Parts)	"High voltage switchgear and control gear",
IEC 60044-1	Instrument transformers - Part 1 : Current transformers
IEC 60044-2	Instrument transformers - Part 2 : Inductive voltage transformers
IEC 60044-6	Instrument transformers - Part 6 : Requirements for protective current transformers for transient performance
IEC 62271-100	High-voltage switchgear and control gear – Part 100: High-voltage alternating-current circuit breakers.
IEC 62271-200	High-voltage switchgear and control gear – Part 200: A.C. metal-enclosed switchgear and control gear for rated voltages above 1 kV and up to and including 52 kV
IS 802	Code for use of Structural Steel in Overhead Transmission Line Towers
IS 875	Code of Practice for Design Loads (other than Earthquake) For Buildings and Structures

4.4.3.6.5

Routine Testing & Inspection All the acceptance tests and Routine Tests, inspection at manufacturer's works as well as at site shall be carried out strictly as per specifications, relevant standards and in accordance with the Final Quality Assurance Plan and reports shall be submitted to Employer. The Employer or its authorized representative reserves the right to inspect the modules at the manufacturer's site prior to dispatch.

4.4.3.6.6 Type Test

Switchyard equipments supplied shall be of type tested design and certified by any of the accredited certifying agencies in accordance with relevant standards /codes and the

type test reports shall be submitted for employer's review. If the type tests are not done previously, then the Contractor shall conduct them without any additional cost to the Employer and the type test report shall be submitted before supply of Switchyard equipment

4.4.3.7 ENERGY METERING SYSTEM

4.4.3.7.1 Metering System

ABT Energy Meter shall be provided as approved by the State Transmission Authority to measure the delivered quantum of energy to the grid for the sale. The responsibility of arranging for the meter, its inspection/calibration/testing charges, maintenance, renewal, and repair of meter etc. rests with the Contractor. Energy metering system is to be approved by State Transmission Authority and comply with Implementing Agency, UPNEDA & IMPLEMENTING AGENCY requirements. Necessary MRI, Modem etc. scheme shall be provided by Contractor as per the requirement for all meter as applicable as per SLDC, State Transmission Authority, CTU, Implementing Agency, UPNEDA.

The Contractor shall supply ABT Meters (Main & Check as well as Stand-by meter (s)) at the plant take off point as well as at the substation as per system requirement and as per UPNEDA & Implementing Agency requirements with all necessary metering rated CTs and PTs at the plant take off point as well as at the substation. These Energy meters of 0.2s accuracy class suitable for ABT requirement conforming to respective RLDC/State power Utilities/CTU requirement, shall be provided at each of the export feeders as per the requirement of the project. These energy meters shall be provided in a separate outdoor metering cubicle with padlock arrangement. For measurement of Auxiliary power consumption, the Contractors shall provide MFM in ACDB incomer.

4.4.3.7.2 General Requirements

Meters shall be microprocessor-based conforming to IEC 60687/ IS-14697/IEC 62052-11/IEC 62053-22/IEC 62056/IS 15959 for category B.

Shall carry out measurement of active energy (both import and export) and reactive energy (both import and export) by 3-phase, 4 wire principle suitable for balanced/ unbalanced 3 phase load.

Shall have an accuracy of energy measurement of at least Class 0.2S for active energy and at least Class 0.5 for reactive energy according to IEC 60687. The active and reactive energy shall be directly computed in CT & VT primary ratings

The reactive energy shall be recorded for each metering interval in four different registers as MVARh (lag) when active export, MVARh (Lag) when active import, MVARh (lead) when active export, MVARh (Lead) when active import.

Interface metering shall conform to the Central Electricity Authority (Installation and Operation Meters) Regulation 2006 and amendment thereof.

Shall compute the net MWh and MVARh during each successive 15- minute block metering interval with a plus/minus sign and average frequency during the previous metering interval; peak MW demand since the last demand reset; accumulated total (instantaneous) MWh and MVARh with plus/minus sign, date and time; and instantaneous current and voltage on each phases.

All the registers shall be stored in a non-volatile memory. Meter registers for each metering interval, as well as accumulated totals, shall be downloadable through Optical Port /RS232/RS485 Port.

Meters shall have a built in clock and calendar. Date/time shall be displayed on demand. The clock shall be synchronized by GPS time synchronization equipment

All the hardware required for interconnection, synchronization, commissioning shall be in scope of Contractor. All type tests reports should comply with IEC 62052-11/62053-22 and must be compliant with State Transmission Authority

The meter shall be suitable to operate with power drawn from the VT supplies. The burden of the meters shall be as per relevant standard. The power supply to the meter shall be healthy even with a single- phase VT supply. Automatic back-up in the event of non-availability of Voltage in all the phases shall be provided by built in long life battery.

Even under the absence of VT input, energy meter display shall be available and it shall be possible to download data from the energy meters

At least the following data shall be stored before being over-written for the following parameters:

Parameters	**Details**	**Min. No. of days**
Net MWh	15 min. block	90 days in meter
Average Frequency	15 min. block	90 days in meter
Net MVARh for > 103%	15 min. block	90 days in meter
Cumulative net MWh	At every mid-night	30 days in meter /90 days in PC
Cumulative net MVARh for >103%	At every mid-night	30 days in meter /90 days in PC
Date & time blocks for VT failure on any phase		

4.4.3.7.3 Type Test

Meters supplied shall be of type tested design and certified by any of the accredited certifying agencies in accordance with relevant standards /codes and as per requirement of the STU/CTU/Implementing Agency/UPNEDA and the type test reports shall be

submitted for employer's review. If the type tests are not done previously, then they shall be conducted by the Contractor without any additional cost to the Employer and the type test report shall be submitted before supply of Meters.

4.4.3.8 EARTHING & LIGHTNING PROTECTION SYSTEM

4.4.3.8.1 AC Earthing System

Earthing system shall be in strict accordance with IS: 3043, IEE80-2000, Indian Electricity Rules/Acts, Codes of practice and regulations existing in the location where the system is being installed.. The Solar PV Modules, BOS and other components of power plant requires adequate earthing for protecting against any serious fault as guided by IEC 60364. Contractor shall obtain all necessary statutory approvals for the system. The permissible fault level at **(Inverter Output Voltage), 33 kV** & **(132 Kv)** shall be kept in consideration while designing the earthing system.

For outdoor switchyard, Earthing system network/earth mat shall be interconnected mesh of mild steel rods buried in ground. For other areas in the solar plant such as transformer yard, switchgear room the earthing system shall consist of minimum two parallel conductors interconnected together. All non-current carrying metal parts, metallic frame of all electrical equipment shall be earthed by two separate and distinct connections to earthing system in compliance to Rule 11 and 61 Indian Electricity Rule 1956 (as amended upto date), IS3043 and IEE80-2000 . All the other structures such as Crane rails, tracks, metal pipes conduits Steel RCC structures, etc shall also be effectively earthed. Separate electronic earthing shall be provided each for PCU, SCB and SCADA system.

Inverter transformer neutral shall be floating, not to be earthed. However, recommendation of inverter manufacturer shall also be taken into account.

Inverter transformer shield shall be earthed separately using minimum two no. of earth electrodes. Earthing conductor between shield bushing and earth electrodes shall be copper flat of suitable size not less than 25 x 6 mm.

Neutral and body of the auxiliary transformer shall be earthed.

The earth conductors shall be free from pitting, laminations, rust, scale and other electrical, mechanical defects.

The material of the earthing conductors shall be as follows Conductors above ground level and in built up trenches -Galvanized steel

Conductors buried in earth - Mild steel

Earth electrodes - Mild steel rod

Neutral connections and metallic conduits/pipes shall not be used for the equipment earthing. Lightning protection system down conductors shall not be connected to other earthing conductors above the ground level.

Earthing conductors buried in ground shall be laid minimum 600 mm below grade level unless otherwise indicated in the drawing. Back filling material to be placed over buried conductors shall be free from stones and harmful mixtures. Earthing

conductor shall be buried at least 2000 mm outside the fence of electrical installations.

Earth pit shall be constructed as per IS:3043. Earth pits shall be treated with salt and charcoal if required. However Based on the soil resistivity data of the site, in case, the earthing resistance requirements as per applicable standard is not met, Contractor may have to provide special earthing arrangement like chemical earthing etc. in order to meet the earthing resistance requirements.

On completion of installation, continuity of earth conductors and efficiency of all bonds and joints shall be checked. Earth resistance at earth terminations shall be measured and recorded.

4.4.3.8.2 Solar Array Earthing

Equipment and structure in Solar Array System shall be earthed in compliance to the IS: 3043 (Code of Practice for Earthing) and Indian Electricity Rules/Acts.

Each Module mounting structure (MMS), SPV Module frames, mounting arrangement for String Monitoring Boxes, Metallic Junction Boxes, Metal frames/Panel, Metallic Pipes of the solar array shall be effectively earthed. The array structures are to be connected to earth pits as per IS standards. Necessary provision shall be made for bolted isolating joints of each earthing pit for periodic checking of earth resistance. Equipment and structure in the solar PV Plant shall be earthed in compliance to the IS: 3043 (Code of Practice for Earthing) and Indian Electricity Rules/Acts.

Each PV Module frame shall be earthed in accordance with module manufacturer guidelines. In case module frame earthing is to be seperately provided, it shall be earthed with minimum2.5 SQMM flexible copper cable with lug at suitable location of module frame.

Earth pit shall be constructed as per IS:3043. Electrodes shall be embedded below permanent moisture level. Earth pits shall be treated with salt and charcoal if required.

4.4.3.8.3 Lightning Protection General

Lightning protection system shall be in strict accordance with IS:2309 .

Lightning conductor shall be of 25x6mm GS strip when used above ground level and shall be connected through test link with earth electrode/earthing system

Lightning system shall comprise of air terminations, down conductors, test links, earth electrode etc. as per approved drawings

Down conductors shall be as short and straight as practicable and shall follow a direct path to earth electrode.

4.4.3.8.4 Lightning Protection System For Solar Array

Complete Solar Array with associated structure shall be protected from Direct Lightning Stroke.

Lightning protection system for solar array:

i) **Codes & Standards IS/IEC 62305: Protection Against Lightning**

ii) NF C 17-102: Lightning Protection with early Streamer Air Termination Rod.

Necessary concrete foundation or any other arrangement for holding the lightning conductor in position is to be made after giving due consideration to shadow on PV array, maximum wind speed and maintenance requirement at site in future. The Contractor shall submit to the Employer the design calculations for the Earthing System and other relevant information as per Engineering Information Schedule during detailed Engineering.

4.4.3.8.5 The Contractor shall submit to the Employer the design calculations for the Earthing System and other relevant information including Earthing Resistance Test Values of each of the Pits on DC side & AC side as per Engineering Information Schedule during detailed Engineering.

4.4.3.9 BATTERY SYSTEM

4.4.3.9.1 Battery System

Adequate capacity DC battery Bank (s) shall be provided at suitable locations as per system requirements for emergency control supply of inverters, control & protection system, Fire Detection/ Alarm Panel, SCADA System, Operation of Equipment, emergency lighting, CCTV, and other requirements.

Adequate capacity battery charger(Float Cum Boast Charger-FCBC) with relevant IS/IEC standards & protection and automatic change over system shall be provided to charge the battery bank(s) along with relay circuit, fuses, annunciations.

DC power supply Distribution panel/board shall be supplied along with the Charger (FCBC) as per relevant IS standards. Control Room DC Battery Bank & DC supply system design, calculations and detailed explanations along with drawing shall be provided to the Employer for review.

4.4.3.9.2 General requirements

DC Batteries the batteries shall have the following specifications :-

i. Type: VRLA batteries.
ii. Rating: As per system Requirement.
iii. Standarad – IS: 1651-1979; performance as per IS8702
iv. Container: Plastic Resin, ABS or PP
v. Terminal Posts: Designed suitably to accommodate external bolted connections.

The battery room shall be provided with epoxy paint coated exhaust fan for removal of gasses released from the battery cells.

The battery system shall be designed by the contractor considering sufficient back up time as per system requirement and in accordance with the prevailing practice for reliable and satisfactory operation of the solar PV Plant.

The Contractor shall ensure an adequate battery storage room with all necessary battery equipment and accessories

4.4.3.9.3 Codes & Standards

The system and equipment shall be designed, built, tested and installed to the latest revisions of the following applicable standards.

Sl. No.	Standard	Description
1	IEEE Std 485	IEEE recommended practice for sizing VRLA batteries for stationary applications.
2	IEC 60146	Semiconductor converters.
3.	IEC 60439	Low Voltage Switchgear and control assemblies
4.	IEC 62040	Uninterruptible Power Systems (UPS)

4.4.3.10 PLANT ILLUMINATION SYSTEM

4.4.3.10.1 Plant Illumination System

1. comprehensive illumination system shall be provided in the entire Plant Area. Each building shall be provided with adequate light fittings, 6A/16A socket, fans, etc. Exhaust fans shall also be provided in toilets, battery room and Pantry etc.
2. his specification covers design of Array yard and sub-station, street light using min. 15 W LED luminaires, tubular poles (from main gate up to the control room/switchyard gate and periphery wall of the plant) distribution pillar boxes, PVC cables, conduit steel trays etc. which shall be supplied by the contractor for installation of luminaires, their control gear and wiring on them.
3. ormal indoor and outdoor lighting system for Main Control Room, Inverter Rooms, switchyard and Security Room(s) etc. in plant shall be through 415 V AC systems, comprising Lighting cabinets, All energy efficient LED type lighting system for indoor, including the light fittings, lighting facia/panels, warning/direction sign boards, Push-buttons or switches and other accessories.
4. utdoor lighting for plant array yard, approach roads, boundary wall / fencing of plant, street lights, S/yard etc. shall be through energy efficient LED type. All lighting fixtures and control gears including lighting panels shall be powder coated, weather proof and of IP 55 deg of protection.

4.4.3.10.2 Emergency lighting system

Emergency lighting system **s**hall be provided for indoor applications such as Main control room, Inverter Rooms, Security Room(s) etc.

4.4.3.10.3 General Requirement

1. ormal AC Lighting System of 415V, 3Phase, 4wire, will be fed from Lighting Distribution Boards (LDBs), which in turn will be fed from the 415V, Main AC Distribution Board.
2. ontrol rooms, offices, facilities, utilities, Inverter Rooms shall be equipped with

power outlet circuits with necessary breakers/switches, protective and indicating devices shall be provided for each socket/cubicle.

3. dequate no. of switchboards (with 3-pin sockets), potable socket cubicles, distribution boards, lighting accessories, lighting poles for street lights etc., shall be provided by the Contractor.

4. he illumination system shall be properly wired, earthed and connected with suitable grade cables, as applicable.

4.4.3.10.4 Lux levels and quality of direct glare limitation

LED Lamps with at least 15-20 W (at 240 V) shall be provided in control room, Battery Room, Inverter Room, Office space, SACDA Room etc as per requirement.

The nominal illumination level for lighting, measured at the height of a worktable (0.9 m) shall have an average lux value as mentioned below.

Sl. No.	Location	Average Lux Level
1	Main Control Room	300
2	Inverter Room(s)	100
3	Street lighting – roads, Array Yard	20
4	Switchyard , Security room(s)	50
5	Other areas including periphery wall	20

4.4.3.10.5 The Contractor shall submit to the Employer general arrangement and layout plan for illumination system, Cable and conduit routing diagram, Wiring and termination drawings and other information in accordance to the Engineering information Schedule.

4.4.3.11 SCADA AND COMMUNICATION CABLES

A. SCADA

I. General Requirements

i. The Contractor shall provide complete SCADA system with all accessories, auxiliaries and associated equipment and cables for the safe, efficient and reliable operation and monitoring of entire solar plant and its auxiliary systems.

ii. The Contractor shall provide all the components including, but not limited to, Hardware, Software, Panels, Power Supply, HMI, Laser Printer, Gateway, Networking equipment and associated Cables, firewall etc. needed for the completeness.

iii. SCADA System shall have the provision to perform the following features and/or functions:

a) Web enabled Operator Dashboards: Showing key information on Generation, Performance and Current Status of various equipment in Single Line Diagram (SLD) format with capability to monitor PV

array string level parameters.

b) Real time Data Logging with Integrated Analytics & Reporting: Logging of all parameters - AC, DC, Weather, System Run Hours, Equipment Status and Alarms as well as derived/ calculated/ integrated values. The SCADA User interface shall be customizable and enable Report Generation and Graphical Analysis.

c) Fault and System Diagnostics with time stamped event logging.

d) Support for O&M Activities: SCADA shall provide a Data Analysis and Decision Support for smooth and efficient Plant Operations.

e) Generate, store and retrieve user configurable Sequence of Event (SOE) Reports

f) Interface with different field equipment in the plant and work seamlessly with field equipment supplied by different companies

g) Transfer of plant data reliably, to Cloud on any kind of remote network including low bandwidth and wireless links such as 2G/3G/VSAT.

(Note: Telecom Lease line connection, if required for transferring data from Plant over internet shall be taken by Contractor in the name of Employer for O&M period)

h) The Control system shall be designed to operate in non-air-conditioned area. However, the Contractor shall provide a Package/ Split AC of suitable capacity decided by heat load requirement in SCADA room at Main Control Room.

i) **The plant SCADA should be Open Platform Communications (OPC) compliant with standard DNP3 and mod bus control interfaces over TCP/ IP having the provision to add protocol converters to implement custom and secure communications protocol standard for providing real time online data (including but not limited to irradiance, plant generation (instantaneous/ daily/ monthly/ yearly), Daily Peak Generation, temperature, wind speed etc.) to UPPCL/UPNEDA.**

j) **Fibre Optic Ethernet Ring network (Managed type Ethernet switches in each Control Room) should be provided between MCR & Inverter Control Rooms.**

k) **Web-based monitoring should be available, which should not be machine dependent. The web-based monitoring should provide the same screens as available in the plant. Also, it should be possible to download reports from a remote web-client in PDF or Excel format**

II. Architecture

i. The SCADA System shall be built over Industrial IoT architecture with integrated Analytics, secure web access, enterprise software and Database.

ii. Data acquisition shall be distributed across MCR and LCRs while plant level data aggregation shall be done in the server.

iii. Analog and Digital IO modules shall have integrated processor for distributed IO processing and control.

iv. Data communication system shall be built over fibre optic cables/ wireless network with high bandwidth TCP/IP communication (Fast Ethernet or 802.11a/b/g/n) across all Inverter and Control Rooms with Internet/Intranet access at Main Control Room. Firewall shall be provided for network security.

v. Plant SCADA Server shall have Industrial Grade Server Hardware running SCADA & Monitoring Software with data storage (complete plant data) space for 2 years.

vi. Plant data for monitoring and control operations should be accessible without dependence on external network.

vii. A virtual/cloud server running SCADA & Monitoring Software shall be configured in parallel with Plant Server to enable easy access to plant data from outside the plant without having to login to plant server. Effectively, the plant data shall be replicated to provide data redundancy for critical plant data.

viii. Operator Workstation/PC shall be of Industrial Grade for browser-based access to plant data from Plant. Plant control & SLDC/Utility related operations shall only be initiated through browser-based interface requiring no client software or database to be installed on the Workstation. All critical software shall be installed/stored on local server and Plant Data shall be installed/stored on local as well as cloud servers with user access control for protecting the software and data assets from accidental deletion or corruption.

ix. Internet/Intranet at Plant: Public or private network access shall be provided at the plant through any broadband/VSAT connectivity of 2Mbps or higher bandwidth. In case no broadband/VSAT connectivity can be provided at the plant, a 3G/4G data card from any Internet Service Provider (ISP) may be provided. SCADA system shall be capable of sending all plant data in real time to the Cloud Server.

x. GPS based Time Synchronization System: The SCADA system shall have a Master/Slave Clock system along with antenna, receiver, cabinet and internal interconnection cables. All SCADA controllers, servers, OWS and communicating equipment shall be synchronized to the GPS clock.

III. Industrial IoT Controllers & Data Acquisition

The Plant SCADA and Monitoring System may use one or more IIoT Controllers at each LCR and MCR for the purpose of data acquisition and data forwarding to the Local and Cloud Servers. SCADA Servers. The IIoT Controllers shall meet the following minimum requirements:

i. The IIoT Controllers shall be distributed in nature and work independently of other IIoT Controllers or any central controller in the system.

ii. Shall be capable of supporting wide range of field protocols to communicate with different field equipment (Modbus over RS485/Ethernet, etc.)

iii. Shall have local storage for a minimum of 2 weeks (in case of network failure).

iv. Provide web-based interface to configure the controller for various equipment in the field.

v. IO Functionality: Shall support status monitoring of VCBs & Trip relays on RMU/HT & Transformer panels through distributed DI/AI modules.

vi. Controls: Shall be capable of Controlling Breakers (ON/OFF). Both ON/OFF and Parameter control of inverters shall be supported.

vii. Data Communication with Servers: Shall send the data collected, from all the equipment at Inverter Control Room and/or Main Control Room, to the Monitoring & Control Server.

viii. Controllers shall be capable of sending data over Internet connections, USB data cards

ix. Shall not require a static public IP address, at the plant for the purpose of remote access.

IV. Functionalities

i. The SCADA system shall monitor instantaneous and cumulative electrical parameters from all DC & AC Equipment including inverters, string combiner boxes, weather station, MFM, Transformer and Switchgear (LT & HT Panels) at regular intervals not greater than one minute.

ii. The SCADA system shall monitor Instantaneous and cumulative environment parameters from weather sensors or data loggers at same interval as electrical parameters and provide PR, CUF on the fly.

iii. The SCADA system shall provide Alarms and Alerts on equipment faults and failure in less than 5 seconds. Alarms on status change of hardwired DI shall also be provided.

iv. The SCADA system shall provide configurable alerts on any parameter crossing settable thresholds.

v. The SCADA system shall have user-friendly browser-based User Interface for secure access from anywhere, for minimum ten concurrent connections from the Operator PC or other securely connected laptop/mobile, for plant monitoring, O&M, daily reporting, and analysis. A dashboard providing summary details of total plant generation, day's export, irradiance, Inverter Control Room level generation and performance indicators like PR and CUF

vi. Reporting: The SCADA system shall provide downloadable reports in Excel/PDF, configurable for equipment parameters across the plant.

vii. The system shall have Configurable Analysis page for self-configured as well as on demand Analytics charts.

viii. The SCADA system shall be extensible to include maintenance of O&M schedules and related activities for plant equipment as per the O&M Manual

ix. Mobile User Interface: summary of plant performance and issues should be accessible in a mobile Native UI or browser UI.

x. Data Communication to SLDC: SCADA system shall provide required interface to integrate with TRANSCO-SLDC, in compliance with grid code, to send any parameters specified by SLDC

Note: The methodology and specification of SLDC interface will be provided separately by SLDC/TRANSCO and it shall be the responsibility of the Contractor to determine the same.

xi. Power Plant Control: SCADA system shall provide required interface to the local SCADA operator to set various power control modes (active/reactive power/frequency/PF) through the inverters over industry standard communication

protocols like Modbus over TCP/IP.

xii. Forecasting and Scheduling: SCADA shall provide day ahead and week ahead forecasting and scheduling for power generation at the plant as per SLDC/Utility stipulations.

xiii. All programming functionalities shall be password protected to avoid unauthorized modification

xiv. The Contractor shall provide software locks and passwords to Employer for all operating & application software. Also, the Contractor shall provide sufficient documentation and program listing so that it is possible for the Employer to carry out modification at a later date.

V. Cable Specifications

RS485 & IO Cables shall meet the following minimum specifications:

- For RS485: 0.5sq.mm ATC multi-strand (class-5), insulated core, twisted pair, overall screened with ATC drainwire, GI wire Armored, PVC sheathed, DIN47100 colour standard, FRLS, 1.1 kV grade
- For IO cabling (between HT/RMU panels and SCADA panel) – 1.0 sq.mm multi- strand, 4/8/12 core screened, armored, FRLS cable, 1.1KV grade.
- For Optical Cabling: 6F, Armored, Single/Multi mode laid through HDPE conduits to minimize cable breaks.

VI. Earthing

i. Two isolated electronic earth pits near to SCADA panel at every Inverter and Control Room with < 1 Ohm resistance shall be provided. One earth pit shall be used for protective/body earth and the other to be used for Signal Earth

ii. Apart from providing separate earth pits, manufacturer specified earthing
recommendations shall be followed for all communicating equipment connected to SCADA. This includes but is not limited to SMBs, Inverters, WMS and Switchgear panels

VII. Communication Cable Laying

i. All RS485, IO and CAT6 cables shall be laid in separate conduits with a minimum separation of 1.5ft from AC/DC power cables all along.

ii. Power cables shall be laid deep in the trenches first. Data cables shall be laid in separate conduits after partially filling the trenches to ensure minimum 1.5 ft separation between power and communication cables all along the trench.

iii. IO Cables between switch gear panels and SCADA panel shall be laid on separate cable trays, with a minimum of 1.5ft separation from trays carrying AC Power cables

iv. RS485 & CAT6 cables between switch gear panels or Inverters and SCADA panel shall be laid on separate cable trays, with a minimum of 1.5ft separation from trays carrying AC Power cables

VIII. Control Cabinets / Panels

i. The cabinets shall be IP-22 protection class. The Contractor shall ensure that the temperature rise is well within the safe limits for system components even under the worst condition and specification requirements for remote I/O cabinets.

ii. 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.

IX. Software Licenses

The Contractor shall provide software license for all software being used in Contractor's System. The software licenses shall be provided for the project and shall not be hardware/ machine-specific.

X. Hardware at Main Control Room

i. The Hardware as specified shall be based on latest state of the art Workstations and Servers and technology suitable for industrial application & power plant environment.

ii. The Local Monitoring & Control Server and the Operating Work station, to be deployed in the Plant Control Room, shall have the following server hardware and operating system along with accessories:

Plant Server

Server Hardware	Hex/Octal Core Xeon, 32GB RAM (expandable to 64 GB RAM), 4 X 2TB SATA hard discs in RAID 5 configuration, 2TB external USB hard disc (for backup), dual power supplies, 2 LAN ports, LCD console, keyboard & mouse. The Server hardware shall be housed in a rugged fan-cooled, and rodent-proof Server Rack.
Operating System	Operating System and Database shall be of enterprise scale (RedHat Linux or equivalent Linux OS, Oracle/MySQL or equivalent DB), with required AMC for 5 years.
Accessories	1. Monitor: Min 22" LED Flat Monitor with non-interfaced refresh rate min. 75 Hz. 2. Keyboard: ASCII type 3 3. Pointing Device: Mouse 4. Intelligent UPS (on line): Minimum 2 hour battery backup.

Operator Workstation

Hardware	i7 CPU running at 3.0 GHz or faster with 8GB RAM, 500GB hard disk, 25" LED monitor, keyboard and mouse, 4 USB ports, LAN port
Operating System	Windows operating system with necessary tools, anti-virus software.
Accessories	1. Screen Display Unit: Min 50" LED Flat Monitor with wall mounted arrangement for the display of SCADA screen 2. A4 size monochrome laser printer. 3. UPS of required capacity with 2 hour battery backup.

iii. All network components of LAN and Workstations shall be compatible to the LAN, without degrading its performance.