

operating conditions.

Only terminal cable joints shall be accepted. No cable joint to join two cable ends shall be accepted. However, cable joints may be allowed if the route length is more than maximum available drum length subject to REIL / Customer's approval.

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

XLPE insulation shall be suitable for continuous conductor temperature of 90 deg. C and short circuit conductor temperature of 250 deg.C.

The cable cores shall be laid up with fillers between the cores wherever necessary. It shall not stick to insulation and inner sheath. All the cables, other than single core unarmoured cables, shall have distinct extruded PVC inner sheath of black colour as per IS 5831.

For single core armoured cables, armouring shall be of aluminium wires. The aluminium used for armouring shall be of H4 grade as per IS: 8130 with maximum resistivity of 0.028264 ohm- sq.mm/meter at 20 deg.C.

For multi core armoured cables armouring shall be of galvanized steel. The minimum area of coverage of armouring shall be 90%.

Cable shall conform to IS.7098-II .These cables shall have multi-stranded, compacted circular, aluminium conductors, XLPE insulated, metallic screened cable for carrying the system earth fault current, PVC outer sheathed. The conductor screen and insulation screen shall both be extruded semiconducting compound and shall be applied along with XLPE insulation in a single operation of triple extrusion process so as to obtain continuously smooth interfaces. Method of curing for cables shall be dry/gas curing.

In addition to manufacturer's identification on cables as per relevant standard, following marking shall also be provided over outersheath.

- (i) Cable size, Conductor material and voltage grade
- (ii) Word 'FRLS' at every meter
- (iii) Sequential marking of length of the cable in meters at every meter

Cables shall be sized based on the following considerations:

- (i) Rated current of the equipment
- (ii) Maximum voltage drop in LT cable (from inverter to inverter transformer) shall be limited to 2% of the rated voltage. For HT cables (from inverter transformer to interconnection point), maximum voltage drop shall be limited to 0.5 % of the rated voltage. Successful Bidder shall provide voltage drop calculations in excel sheet.
- (iii) Short circuit withstand capability as per design for 1 second.
- (iv) 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 and soil resistivity for buried cables.

d) Cable lengths shall be considered in such ways that straight through cable joints are avoided. Cables shall be armored type.

Warranty

All cables shall be warranted for minimum of 1 (one) year against all material/manufacturing defects and workmanship.

Approval

Documents/Drawings

- (i) Guaranteed Technical Particular (GTP) Datasheet
- (ii) Cable sizing calculation
- (iii) Quality Assurance Plan(QAP)

Test Certificates/Reports

Test certificates as per the standards mentioned above shall be submitted for approval.

Testing

Type, Routine test and acceptance tests requirements shall be as per relevant standards for all cable sizes.

Packing

Cables shall be supplied in returnable wooden or steel drums of heavy construction. The surface of the drum and the outer most cable layer shall be covered with water proof cover. Both the ends of the cables shall be properly sealed with heat shrinkable PVC/rubber caps secured by 'U' nails so as to eliminate ingress of water during transportation, storage and Erection. Wood preservative anti-termite treatment shall be applied to the entire drum. Wooden drums shall comply with IS 10418.

Each drum shall carry manufacturer's name, purchaser's name, address and contact number, item number and type, size and length of cable and net gross weight stenciled on both sides of the drum. A tag containing same information shall be attached to the leading end of the cable. An arrow and suitable accompanying wording shall be marked on one end of the reel indicating the direction in which it should be rolled.

Installation

Cable installation shall be as per IS1255.

LT cable (from inverter to Combiner Boxes to Transformer) shall be laid on cable trays with supports.

Cable terminations shall be made with properly crimped lugs and passed through cable glands at the entry & exit point of the cubicles. Bimetallic lugs shall be used for connecting Cu bus bar and Al cables or vice-versa.

All AC cables shall be provided with punched/embossed aluminium tags. The marking shall be done with good quality letter and numbers of proper size so that the cables can be identified easily.

8. CABLE TRAYS

The design, material, construction, manufacture, inspection, testing and performance of Cable Trays supplied shall comply with all currently applicable standards, regulations and safety codes in the locality where the material will be installed. Nothing in this specification shall be construed to relieve the BIDDER of his responsibility. Where no standards are available, the supply items shall be of good quality and workmanship and backed by test results. Any supply items which are bought out by the BIDDER shall be procured from MANUFACTURERS approved by the REIL / Customer.

Applicable Standards for Cable Trays & Accessories

Steel	IS:2062, IS:1079, IS:811, IS:513, IS:808, IS:1730, IS:8910, ASME
Welding	IS:813, IS:816
Bolts, Screws, Nuts, Washers, Fasteners	IS:1364, IS:1367, IS:1368, IS:2016
Hot dip galvanising	IS:2629, IS:2633, IS:4759, IS:4826,
Electrical Work	IS:5216, IER, IS:1646, NEC-318

Design and Manufacturing Requirements

CABLE TRAYS & ACCESSORIES

Cable trays and the associated accessories including tray covers shall be Pre-fabricated type Galvanized steel sheets.

The nominal width of cable trays selected is 50, 100, 150, 300, 450, and 600 mm. The cable trays shall be supplied in standard lengths of 2500mm.

Types of trays used are Perforated type, Ladder Type & Solid type.

The Flange height shall be considered for Ladder Type as 50 mm & for perforated & solid type trays as 100 mm.

The thickness for cable trays shall be considered 2 mm and the thickness for cable tray cover shall be considered 1.6mm.

The maximum spacing between the rungs of the ladder type cable tray shall be considered as 250 mm.

Cable tray covers shall be provided for Perforated & solid type trays as indicated in the project drawings.

Accessories: The cable tray accessories are Vertical Elbows, Horizontal Bends, Adjustable Bends, Crosses, Tees and Reducers, etc,. All accessories shall have minimum bending radius of 600 mm.

The scope covers all these trays and special accessories including covers, coupler plates, bolts, and hinges for all type of trays as listed in items.

Connecting piece or coupler plate is used to connect two trays & accessories.

All finished cable trays and accessories shall be free from sharp edges, corners, burrs and unevenness.

Galvanizing: All cable trays, tray accessories, tray covers & tray supports including washers, etc. shall be hot dip galvanized. Should the galvanizing of the samples be found

defective the entire batch of steel shall be regalvanised at BIDDER's cost.

Grounding conductors for Cable Trays 25 x 6 GS flat conductor shall run along the trays & interconnecting the trays at every 2.5 m intervals. 95 Sq.mm stranded copper conductor shall be used to grounding trays at minimum two points.

CABLE TRAY SUPPORT

The cable tray supporting structures shall be of steel and galvanized. This supporting structure shall comprise of two parts, which shall be Vertical support channels & Horizontal supporting arms. This Horizontal supporting arms shall be welded to the Vertical support channels to form the cable supporting structure and this structure shall be welded to the Embedded Plate (EP) on the wall in case of wall mounted cable trays, EP in the ceiling in case of ceiling mounted cable trays and EP on floor in case of floor mounted cable trays to mount the cable trays. In case of outdoor on the ground installation, proper PCC grouting should be done to the vertical supports.

GS SHEET ENCLOSURE FOR CABLE TRAYS FLOOR CROSSING

Vertical trays running exposed to corridor / rooms or the area having man movements shall be covered with GS sheets. The thickness of this GS sheet shall be considered 1.6 mm.

9. CABLE TRENCH

The Cables may be laid buried directly in ground at a depth of one meter in average, and terminate for outdoor connection to a power transformer or to overheadlines.

The Cables may also be laid within Prefabricated blocks/covered cable trenches in cable racks or open air ladder trays etc. for certain portions of lengths as per the suitable design according to site conditions and relevant standards.

APPLICABLE STANDARDS

	Indian Electricity Rules, 1956
	National Electrical Code (Indian standards Institution)
IS 1255	Code of practice for installation and maintenance of Power Cable up to and Including 33KV rating.
IS 1554	PVC Insulated Electrical Cables up to 11KV
IS 2274	Code of Practice for electrical wiring installation –system voltage exceeding 650V
IS 7098 Part II	Crosslinked Polyethylene Insulated PVC sheathed cables for working voltages from 3.3KV up to and including 33KV
IS 7098 Part III	Crosslinked Polyethylene Insulated PVC sheathed cables for working voltages from 66KV up to and including 220KV
IS 5820	Specification of precast concrete Cable cover

For prefabricated trenches consider Fiber/FRP Covers to cover thetrenches.

10. AUXILIARY SUPPLY SYSTEM

Scheme for Auxiliary supply system shall be submitted by contractor during detailed engineering for the approval by REIL / Customer.

It shall mainly comprise of AC distribution board(s) (ACDB), distribution cables and

metering & protective devices.

MCR (Main Control room) shall have its own auxiliary power supply system comprising of AC distribution board (ACDB). All ACDB's shall receive at least two incomers from different sources. All Auxiliary loads like illumination, SMU, cleaning system of modules etc. shall be fed from this ACDB. The auxiliary power supply for MCR and other emergency loads (SCADA, control and protection requirement of switchgears and emergency lighting etc. shall be made available by CUSTOMER from their sub-station(s) as detailed below :

220 V DC supply

CUSTOMER shall make available 1 nos 32 A spare feeder from their 220 V DC charger DCDB at their nearest Substation. Contractor shall make all necessary arrangements for tapping the DC supply from CUSTOMER Sub-station and shall installed their own DCDB for further distribution at their end. Bidder is required to maintain the Sizing of the cable by taking into account the permissible voltage variation limits.

110 V AC supply

CUSTOMER shall make available 1 no 32 A spare feeder from their 110 V AC UPS ACDB at their nearest Substation. Contractor shall make all necessary arrangements for tapping the AC supply from CUSTOMER Sub-station and shall installed their own ACDB for further distribution at their end.

Aux supply 415

CUSTOMER shall make available 415 V auxiliary supply from their nearest Substation. Contractor shall make all necessary arrangements for tapping the 415 V AC Auxiliary supply from CUSTOMER Sub-station and shall installed their own distribution panel at their end.

A separate kWh energy meter is to be provided by contractor for accounting of electricity consumed for auxiliary equipment's on ACDB.

11. METERING SYSTEM

Standards and Codes

Standard/Code	Description
IEC 62052-11:2003	Electricity metering equipment (AC) - General requirements, tests and test conditions - Part 11: Metering equipment
IEC 62053-22:2003	Electricity metering equipment (AC) - Particular Requirements - Part 22: Static meters for active energy (classes 0,2 S and 0,5 S)
IS 14967	AC Static Transformer Operated Watt-hour and Var-hour Meters, Class 0.2 S and 0.5.

The-metering facility of the system shall comply following minimum specifications.

- (i) **For Power evacuation at 33KV** -Incomers of solar PV Plant at MCR and CSS should be equipped with two ABT numbers (Main and check) meters.
- (ii) **For Power evacuation at 415V:-**Energy Meters of accuracy class 0.5 shall be installed at each location for metering of energy.
- (iii) The Contractor shall provide ABT compliant meters at the interface points (33KV). Interface metering shall conform to the CEA (Installation and Operation

Meters) Regulation in force and amendment thereof Commercial settlement of solar Photovoltaic Grid Interactive based power project.

- (iv) Meter shall be suitable for interfacing for synchronizing the built-in clock of the meter by GPS time synchronization equipment existing at the station either through a synchronization pulse received from the time synchronization equipment or through a remote PC synchronized to GPS clock shall also be in the scope of Contractor.
- (v) All charges for testing and passing of the meter with relevant government agency, if required shall be borne by Contractor, the REIL / Customer will assist Contractor for necessary document as and when required. Contractor has to intimate the required documents at least 7 days prior of such requirements.
- (vi) ABT compliant Energy Meters shall have technical specification as given below (not limited to specified requirement, Contractor can provide Meter with latest facilities).
 - a. Meters 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.
 - b. Meters shall have an accuracy of energy measurement of at least Class 0.2S and shall be connected to Class 0.2S CT cores and Class 0.5 VT windings or as per state grid regulations. The active and reactive energy shall be directly computed in CT & VT primary ratings.
 - c. Meters shall compute the net MWh and MVARh during each successive 15-minute block metering interval along with a plus/ minus sign, instantaneous net MWh, instantaneous net MVARh, average frequency of each 15 minutes, net active energy at midnight, net reactive energy for voltage low and high conditions at each midnight.
 - d. Each energy meter shall have a seven digit display unit. It shall display the net MWh and MVARh 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 a plus/minus sign, date and time; and instantaneous current and voltage on each phase.
 - e. 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. All the net active/reactive energy values displayed or stored shall be with a plus /minus sign for export/import.
 - f. The meter shall have a built in clock and calendar with an accuracy of less than 15 seconds per month drift without assistance of external time synchronizing pulse.
 - g. Date/time shall be displayed on demand. The clock shall be synchronized by GPS time synchronization equipment existing at the station provided by Contractor.
 - h. The meter shall be suitable to operate with power drawn from the VT supplies. The burden of the meters shall be less than maximum 2VA.
 - i. Meters shall have an optical port on the front of the meter for data collection from either a hand held meter reading instrument (MRI) having a display for energy readings or from a notebook computer with suitable software.
 - j. The meter shall have means to test MWh and MVARh accuracy and calibration at site in-situ and test terminal blocks shall be provided for the same.

- k. The REIL / Customer shall have the right to carry out surprise inspections of the Metering Systems from time to time to check their accuracy.
- l. The meter shall be installed in covered place as per approved design by Owner and as per direction of REIL / CUSTOMER.
- m. Meter must be provided with the necessary data cables.
- n. Solar system metering should work accurately for the complete range of energy, voltage, current, frequency and power factor envisaged for this installation (Cumulative kWh will be indicated continuously by default & other parameters through push-button).
- o. Software and Communication Compatibility: Shall be compatible to communicate and transfer all types of instantaneous and cumulative energy metering data with the SCADA system, all types of necessary software and hardware to connect the meter with SCADA system shall be in contractor's scope.
- p. Metering system shall be finalized during detailed design with the approval of Owner.
- q. In case of meter failure, SCADA reading of energy export shall be considered for generation calculation, temporarily till the meter is replaced /repaired. Standard losses ahead of the point where standard AC losses & transformer losses would be considered.
- r. In order to comply conditions mentioned above, all inverters of the project must communicate with SCADA to transmit data on real time basis.

12. **EARTHING**

Standards and Codes

Earthing system shall comply with latest revisions and amendments of the relevant OISD/ IEC standards and IS codes. In particular, earthing system shall comply with the following standards and codes.

Standard/Code	Description
IS 2309	Protection of Buildings and Allied Structures Against Lightning--Code of Practice (Second Revision)
IEC 62305	Protection against lightning
IS 4736	Hot-dip Zinc Coatings on Mild Steel Tubes.
IS 3043	Code of Practice for Earthing
IEEE 80	IEEE Guide for Safety in AC Substation Grounding
IEEE 142	IEEE Recommended Practice for Grounding of Industrial and Commercial Power Systems
Indian Electricity Rules	
Oil Industry Safety Directorate (OISD) Standards for classified Hazardous areas	

General Requirements

- (i) Earthing system shall be designed based on system fault current and soil resistivity value obtained from geo-technical investigation report. Earth grid shall be formed consisting of number of earth electrodes sufficient enough to dissipate

the system fault current interconnected by earthing conductors.

- (ii) The earth electrode shall be made of high tensile low carbon steel rod, molecularly bonded by high conductivity copper on outer surface with coating thickness not less than 250 micron as per relevant standards. Suitable earth enhancing material shall be filled around the electrode to lower the resistance to earth. Inspection chamber and lid shall be provided as per IS-3043.
- (iii) Earth conductors shall be made of copper bonded steel or galvanized steel of sufficient cross section to carry the fault current and withstand corrosion.
- (iv) Earth conductors buried in ground shall be laid minimum 600 mm below ground 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.
- (v) 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. Earth electrode shall be of minimum 3000 mm long, hot dip galvanized and metal coated for rust proof, OD of minimum 65 mm shall be supplied by vendor. 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. All equipment required for testing shall be furnished by contractor. Individual earth pit resistance shall be 5 Ohm or less and Total grid resistance shall be 1 ohm or less.
- (vi) Earth electrodes shall not be situated within 1.5m from any building whose installation system is being earthed. Minimum distance between earth electrodes shall be the twice the driven depth of the electrode.
- (vii) Every alternate post of the transformer yard fence shall be connected to the earth grid by one GS flat and gates by flexible lead to the earthed post.
- (viii) All connections shall be made by bolt method.

Earthing of PV array Area

- (i) All PV Modules, Module Mounting Structures (MMS) and String Monitoring Unit (SMU) structures in the PV array area shall be bonded to the earthing system by two distinct connections.
- (ii) Each PV Module frame shall be earthed using copper wire of sufficient cross section. The copper wire shall be connected to the earth hole provided in the module frame using suitable arrangement in line with the manufacturer recommendation. The earthing arrangement shall use stainless steel washers to prevent galvanic corrosion between aluminum frame and copper wire. In order to achieve effective earthing, serrated washers shall be employed to penetrate the iodization layer of the module frame.
- (iii) Continuous copper earthing wire/cable shall be run to connect a group of modules and both ends of the loop shall be bolted to the DC earth grid using bimetallic lugs and stainless-steel fasteners. The copper earthing wire shall be routed in such a way to avoid physical contact with the module aluminium frame.

- (iv) Earth electrodes of the DC earth grid shall be uniformly distributed throughout the PV array field so that optimum earth resistance is offered to leakage current flowing from any module frame or MMS.
- (v) SMU equipment earthing point shall be connected to the DC earth grid using flexible copper cable of sufficient cross section as recommended by the manufacturer. The connection with the DC earth grid shall be done using suitable bimetallic lugs and stainless-steel fasteners.

Each continuous laid lengths of cable tray shall be earthed at minimum two places to earthing system. The distance between earthing points shall not exceed 30 meter.

If the inverters, transformers or any equipment requires separate earthing as per OEM recommendations, the same needs to be provided.

Connections between earth leads and equipment shall normally be of bolted type. Contact surfaces shall be thoroughly cleaned before connections. Equipment bolted connections after being tested and checked shall be painted with anti-corrosive paint/compound. In case, the bolt type configuration is not able to ensure sufficient contact, the same shall be ensured through additional welding between the two. Portion of galvanized structure which undergoes welding at site shall be coated with two coats of cold galvanizing and anti-corrosion paint afterwards.

Connections between equipment earthing leads and between main earthing conductors shall be of welded type. For rust protection, welds should be treated with red lead compound and afterwards thickly coated with bitumen compound. All welded connections shall be made by electric arc welding. In case of Copper bonded rods, necessary bonding mechanism as prescribed by OEM to be ensured.

PCU Earthing

DC negative bus bar of the PCU shall be earthed to avoid Potential Induced Degradation (PID). DC negative bus bar and PCU equipment earth shall be bonded to the PCU earth bus and connected to earth electrodes through flexible copper cable of sufficient cross section as mentioned by the manufacturer. The interconnection of PCU earth electrodes with DC earth grid shall be as per PCU manufacturer recommendation.

Transformer Earthing

- (i) Transformer neutral shall be treated as per OEM,s recommendation. Transformer tank, cable box, marshalling box and all other body earth points shall be earthed.
- (ii) 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 6mm.

Inverter Room and Main Control Room Earthing

- (i) Metallic enclosure of all electrical equipment inside the inverter room and main control room shall be connected to the earth grid by two separate and distinct connections.
- (ii) Cable racks and trays shall be connected to the earth grid at minimum two places using galvanized steel flat.

- (iii) SCADA and other related electronic devices shall be earthed separately using minimum two no. of earth electrodes.

Transformer yard Earthing

The metallic framework of all transformer yard equipment and support structures shall be connected to the earth grid by means of two separate and distinct connections.

Specifications of GI flat:

All transformer neutrals are to be connected to earth electrode by GI Flat.

Supply of GI Flat or equivalent Single Core Cable:

- i. Size: Not less than 25 x 6 mm.
- ii. GI coating shall be not less than 80 micron.
- iii. Approved make of MS Flat: ESSAR, Jindal (JSW), Tata Steel, and SAIL.

Installation of GI Flat:

- i. Contractor shall install GI Flat/ equivalent Single core Cable from Solar Roof top plant equipment to earth pit as per requirement of site conditions.
- ii. All works such as cutting, bending, supporting, coating, drilling, brazing, clamping, bolting and connecting into structures, pipes, equipment frames terminals, rails or other devices shall be in the bidder's scope of work. The bidder shall also carry out the excavation and trenching work involved. The bidder shall also back-fill and reinstates the trenches after installation of earthing conductors.
- iii. GI Flat is to be connected at earth pit (patty clamp) by SS 304 Hardware (Set of nut bolts, plain washer, spring washers etc).

Approval

Documents/ drawings

- (i) Technical datasheet
- (ii) Earthing Design calculation

Tests

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. The earth plate shall be provided to facilitate its identification and for carrying out periodical inspection.

Measurement of Earth Resistance:

- i. Measure the earth resistance as per IS-3043-1987 code of practice. Earth resistance value shall be less than 1 ohm in non-rocky/non-sandy surface by single electrode

installation.

- ii. Valid calibration certificate from reputed government laboratory (ERDA, CPRI, NABL accredit labs) of earth tester shall be submitted before commencement of measurement.
- iii. Earth pit test report mentioning earth resistance measured value, reference IS, Serial no and make / model of earth tester, date, time; location, measured by, witness by and other required particulars shall be submitted for each earth pit.

13. **LIGHTNING PROTECTION SYSTEM**

BIDDER SHALL SUBMIT ALL CALCULATIONS AND DETAILED DRAWINGS FOR LIGHTNING PROTECTION OF SOLAR PV PLANTS.

General: The need for providing the lightning protection system shall be established by calculating risk index value for each building structure, etc., as per procedure given in IS-2309 and any building whose risk index is more than specified limit shall be provided with lightning protection.

Lightning protection system shall comprise the following:

- i. Vertical air termination rods whenever needed.
- ii. Horizontal roof conductor and down conductor.
- iii. Testing links.
- iv. Earth electrodes.
- v. Fasteners.
- vi. Earth Pits.

Conductor material for lightning protection air termination and down conductors for buildings shall be Galvanised Steel (GS Flat).

Lightning Protection System Layout: The lightning systems design and installation shall generally comply with IS: 2309 code of practice for the protection of building and allied structure against lightning.

Separate GS flat conductor shall be provided on the building roof in mesh formation and along the perimeter for lightning protection. Required number of GS flat down comers shall be brought down along the wall and connected to rod electrode which in turn shall be connected to the earth grid. Lightning protection conductor shall be run preferably on the highest point of building. Separate insert plates shall be provided for fixing these conductors.

Each down conductor shall be connected to separate earth pit through a rod electrode, through test links. Bitumen paint shall be applied at all joints.

Lightning protection shall also be provided for other buildings as required by the relevant codes and subject to Purchaser approval.

Lightning Protection System Installation: Conductors of lightning protection system shall not be connected with conductors of safety earthing system above ground level.

The down conductors shall be welded to steel structures at 1000 mm interval or cleated to wall at 750 mm interval. Wherever welded, the weld locations shall be treated to provide rust protection.

Each down conductor shall be provided with a test link at a height of about 1000 mm above ground level.

Specific Requirements for Lightning Protection: All buildings under System shall have suitable lightning protection. Air termination system comprising of horizontal roof conductors is recommended for the buildings.

The roof conductors will be laid out such that no part of the roof will be more than 9 m away from the nearest horizontal protective conductor as recommended in IS:2309.

Vertical down comers (at minimum interval of 10 meter) from the Air termination system for lightning protection shall be connected to underground in earth pits. For lightning protection all down comers shall be grounded through separate earth pits.

If air termination system is found ineffective from calculation for tall structures, then vertical air termination rods shall be used.

Lightning Protection System against direct and indirect lightning strokes shall be provided with Early Streamer Emission (ESE) Air Terminal as per IS/IEC 62305:2010/NFC 17-102:2011.

Protection Level for the entire plant shall be level -I.

The lightning conductor shall be earthed through flats and connected to the grounding mats as per applicable Indian Standards with earth pits. Three interconnected earth pits shall be provided for each lightning arrester.

Lightning Protection System shall consist of following accessories.

- (i) Early Streamer Emission (ESE) air terminal
- (ii) Highly insulated poly-plastic adaptor to fix the ESE air terminal with the FRP mast
- (iii) Fiberglass Reinforced Plastic (FRP) mast
- (iv) Coupler to connect FRP mast with GI mast
- (v) Galvanized Iron mast with base plate and guy wire kit
- (vi) Down-conductor: PVC insulated flexible copper cable of suitable size complying with EN 50164-2 or equivalent standard. It shall be routed along the mast with suitable fixings and connectors.
- (vii) Test joint with each down conductor
- (viii) Lightning event counter complying with EN 50164-6 or equivalent standard. It shall be fixed at suitable height in series with the downconductor.
- (ix) Earth termination system in accordance with NFC 17-102. Earth electrodes shall comply with the EN 50164-2 or equivalent standard. Earth enhancing compounds complying with EN 50164-7 or equivalent standard, may be used where soil resistivity is higher and making it impossible to achieve system resistance within specified limit.

Accessories listed above are indicative only and any other fittings or accessories, which are usual or necessary for satisfactory operation of the lightning protection, shall be provided by the Contractor without extracharges.

Necessary foundation/anchoring for holding the lightning mast in position to be made after giving due consideration to shadow on PV array, maximum wind speed and maintenance requirement at site in future.

Contractor needs to provide the lightning protection for each inverter, Switchyard building (if applicable) and MCR building in accordance to IS: 2309.

The product shall be warranted for minimum of 2 (two) years against all material/ manufacturing defects and workmanship.

Vendor shall submit general arrangement and detailed drawings with bill of materials / quantities of the overall lightning arrestor arrangement including foundation pedestal details to CUSTOMER for approval.

TESTS

Routine tests, Acceptance tests and Type test reports as per NFC 17-102:2011 shall be submitted during detailed engineering for approval.

14. COMMUNICATION CABLES

Optical Fiber Cables

- (i) Optic Fiber cable shall be 4/8/12 core, galvanized corrugated steel taped armoured, fully water blocked with dielectric central member for outdoor/ indoor application so as to prevent any physical damage.
- (ii) The cable shall have multiple single-mode or multimode fibers on as required basis so as to avoid the usage of any repeaters.
- (iii) The outer sheath shall have Flame Retardant, UV resistant properties and are to be identified with the manufacturer's name, year of manufacturing, progressive automatic sequential on-line marking of length in meters at every meter on outer sheath.
- (iv) The cable core shall have suitable characteristics and strengthening for prevention of damage during pulling.
- (v) The operating temperature shall be -20 deg. C to 70 deg.C.
- (vi) Suitable protection i.e. Hume pipe/ Casing of suitable grade is to be used for communication cable.
- (vii) All Hume pipe / Casing / conduit shall be properly sealed at both ends with suitable foam insulation.
- (viii) All testing of the optic fiber cable being supplied shall be as per the relevant IEC, EIA and other international standards.
- (ix) The Contractor shall ensure that minimum 100% cores are kept as spare in all types of optical fiber cables.
- (x) Cables shall be suitable for laying in conduits, ducts, trenches, racks and underground buried installation.
- (xi) Spliced/ Repaired cables are not acceptable. Penetration of water resistance and impact resistance shall be as per IEC standard.

Data Cable (Modbus)

- (i) Data (Modbus) Cable to be used shall be shielded type with stranded copper conductor. Cable shall have minimum 2 pair each with conductor size of 0.5 Sq.mm. Cable shall be flame retardant according to IEC60332-1-2.
- (ii) Cable shall be tested for Peak working voltage of not less than 300 V and shall be suitable for serial interfaces (RS 422 and RS485).
- (iii) Communication cable shall be laid through underground with suitable HDPE ducts.

15. **SCADA (For Set-1 and Set2)**

- **Contractor shall provide SCADA system to monitor complete 2.64 MWp SPV Power Plant at site. Also, contractor shall coordinate with Inverter Supplier for successful operation of SCADA system.**
- **Contractor shall provide required SIM cards for data communication and shall also recharge the SIM during O&M period.**

General Requirements

SCADA system is planned to be installed in the Main Control room (MCR) where HT switchgear panel is also planned to be installed and shall be called as Main control room.

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

The SCADA system shall gather information from each location of solar PV installation and shall act as a single point monitoring station for 2.64MWp solar PV Plants.

Bidder shall include in his proposal all the Hardware, Software, Panels etc. RTU (Remote Telemetry Unit) shall be provided by contractor so that the SCADA system of solar PV plant shall be interfaced with the existing SCADA system at COMPLEX. Minimum I/Os and SCADA Tags shall be submitted by contractor during detailed design for the approval of Owner.

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

SCADA System shall have the provision to perform the following functions.

- (i) 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.
- (ii) 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, Graphical Analysis, and display of data, status, alarms and trends.
- (iii) Remote monitoring of essential parameters on the web using standard modem (Internet connection for transferring data over web shall be taken by Contractor in the name of REIL / Customer for O&M period).And shall submit the connection after completion of O&M period.
- (iv) Fault and System Diagnostics with time stamped event logging. Generate, store and retrieve user configurable Sequence of Event (SOE) Reports.
- (v) Monitoring of essential Parameters.
- (vi) Separate indication for protection relay status for Over Current, Earth Fault.
- (vii) System self-supervision.
- (viii) Synchronisation of SCADA clock with inverter clock.
- (ix) Data sampling time to capture various parameters moment before fault /tripping/breakdown for analysis.
- (x) SCADA should have auto backup facility for data backup at every six months on CD-ROM/tapes.

- (xi) Datasheet for all the devices to be integrated in SCADA.
- (xii) Interface with different field equipment in the plant and work seamlessly with field equipment supplied by different companies.
- (xiii) Auto push of generated reports through email.

It shall be possible to remove/ replace redundant controller or various modules (like any I/O module, interface module, etc.) from its slot for maintenance purpose without switching off power supply to the corresponding rack without releasing any spurious signal to controller and causing disturbance or loss of controller functions for other controller.

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.

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 system shall be distributed across solar PV installation sites while plant level data aggregation shall be done in 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 locations with Internet/Intranet access at Main Control Room. Industrial 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 remote monitoring station shall also be provided at the SS#1 having the same specifications as the plant station, in parallel with Plant Server to enable easy access to plant data from remote. Effectively, the plant data shall be replicated in both places i.e. between systems at the Plant Server and Remote monitoring station at SS#1 to provide redundancy for critical plant data.
- viii. Operator Workstation/PC shall be of Industrial Grade.
- ix. All critical software and Plant Data shall be installed/stored on local server only with user access control for protecting the software and data assets from accidental deletion or corruption.
- x. Internet/Intranet at Plant: Public or private network access shall be provided at the plant through any broad-band/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 Remote monitoring station.
 - xi. 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.

Industrial IoT Controllers & Data Acquisition

The Plant SCADA and Monitoring System may use one or more IIoT Controllers at each Inverter location and MCR for the purpose of data acquisition and data forwarding to the SCADA Server. 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. Shall be capable of supporting wide range of field protocols to communicate with different field equipment (Modbus over RS485/Ethernet, etc.)
- ii. Shall have local storage for a minimum of 2 weeks (in case of network failure).
- iii. Provide web-based interface to configure the controller for various equipment in the field.
- iv. IO Functionality: Shall support status monitoring of VCBs & Trip relays on RMU/HT & Transformer panels through distributed DI/AI modules.
- v. Controls: Shall be capable of controlling breakers (ON/OFF). Both ON/OFF and Parameter control of inverters shall be supported.
- vi. Data Communication with Servers: Shall send the data collected, from all the equipment at Main Control Room and/or CSS, to the Monitoring & Control Server.
- vii. Controllers shall be capable of sending data over Internet connections USB data cards.

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. The list of such parameters shall be finalized in consultation with the Owner.
- v. The SCADA system shall enable integration with other sub-systems at the plant for supporting O&M activities.
- vi. The SCADA system shall have user-friendly User Interface for secure access, for 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, plant level generation and performance indicators like PR and CUF. The following real time data can be monitored:

1. Grid summary

- i. AC output voltage
- ii. AC output current
- iii. Power factor
- iv. Apparent Power (VA)
- v. Reactive Power (VAR)
- vi. Exported active power (W)
- vii. Frequency

2. Inverter summary

- i. AC output voltage

- ii. KVA
- iii. Frequency
- iv. Power Factor
- v. Ac output Current
- vi. Exported power (kW)
- vii. Operating temperature

3. DC summary

- i. DC voltage
- ii. DC Current
- iii. DC power input

4. Site Summary (Field data) and other data

- i. Insolation Data
- ii. Module temperature and ambient temperature
- iii. Wind speed data
- iv. Captive Grid outage
- v. Auxiliary consumption separate for day and night hours

The above data can be logged and stored at pre-set intervals. However data logging and storing intervals shall be finalised during detailed design. These data can be displayed on local/remote P.C. A set of graphical display of these data can also be obtained. Summation logging and event logging shall be provided. SCADA shall have provision to control all the Breakers and Inverters.

- vii. Contractor shall provide the I/Os to be connected to each type of module at control room/Inverter room for followings (included but not limited to):
 - a. Analog Input Module
 - b. WTI, OTI of all the transformers
 - c. Ambient Temperature --- 01 Nos
 - d. Module Temperature ---- 01 Nos
 - e. Meteorological Parameters (GHI, wind speed etc)
 - f. Binary Input Module
 - g. All the breakers
 - h. Bucholz, WTI, OTI, Pressure Relief Valve, Magnetic Oil Gauge of all the Transformers
 - i. Binary Output Module:
- viii. Reporting: The SCADA system shall provide downloadable reports in Excel/PDF, configurable for equipment parameters across the plant.
- ix. The system shall have Configurable Analysis page for self-configured as well as on demand Analytics charts.
- x. 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.
- xi. All programming functionalities shall be password protected to avoid unauthorized modification.
- xii. The Contractor shall provide software locks and passwords to REIL / Customer for all operating & application software. In addition, the Contractor shall provide sufficient documentation and program listing so that it is possible for the REIL / Customer to carry out modification at a later date.

- xiii. Adequate provision shall be made for interlocks to prevent unsafe operation of the plant while site personnel are working on them.
- xiv. The Contractor shall provide all softwares required by the system for meeting the intent and functional/parametric requirements of the specification.

Earthing

Two isolated electronic earth pits near to SCADA panel at Main 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.

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

Communication Cable Laying

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.

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.

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.

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.

Control Cabinets / Panels / Desks at Main Control Room

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.

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.

Software Licences

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.

Hardware at Main Control Room

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

Human Machine Interface System (HMIS) 3 Stations, one local operator station, one remote operating cum monitoring station and one engineering station may be considered.

The 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 (preferably RedHat Linux or equivalent Linux OS, Oracle/MySQL or equivalent DB), with required O&M / AMC
Accessories	1. Monitor: Min 22" LED Flat Monitor with non-interfaced refresh rate min. 75 Hz. 2. Keyboard: ASCII type 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 8GBRAM, 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.

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

Factory Acceptance Test (FAT)

FAT procedure shall be submitted by bidder for approval. SCADA shall communicate with all third devices which are part of solar plant and same shall be demonstrated during the FAT.

16. DATA ACQUISITION SYSTEM / PLANT MONITORING (For Set-3 and Set-4 Plants)

System shall have provision for plant monitoring, including recording of stamped data logs for analysis with Metering and Instrumentation, display of systems parameters and status indications.

The following parameters of string inverters of each location of installation shall be made accessible at SCADA in MCR

- AC Voltage.

- AC Output current.
 - Output Power
 - Power factor.
 - DC Input Voltage.
 - DC Input Current.
 - Time Active.
 - Time disabled.
 - Time Idle.
 - Power produced
 - Protective function limits (Viz-AC Over voltage, AC Under voltage, Over frequency, Under frequency ground fault, PV starting voltage, PV stopping voltage).
- i. Remote Monitoring and data acquisition through Remote Monitoring System software at the MCR with latest software/hardware configuration and service connectivity shall be supplied. Industrial Firewall shall be provided for network security.
 - ii. The bidders shall be obligated to push real-time plant monitoring data on a specified interval (say 15 minute) through open protocol at receiver location in compatible format.
 - iii. All the relevant parameters of Inverter should be available for remote monitoring over internet using GPRS based monitoring solution. The monthly charge of SIM card and server will be borne by bidder. The list of parameters should include:

PV Side	PV Voltage, PV Current, PV Power, total Generation etc.
Grid Side	• Inverter Voltage, Current, Frequency
	• Mains Voltage, Current, Frequency
	• Active Faults

17. **AUTOMATIC REPORT GENERATION**

- i. The server shall generate Automatic Report with performance data as per the user defined format. The configuration of the Automatic Report Generation - format, time interval, type of information required shall be set/ configured by the user.
- ii. The automatic report generation feature in the proposed server/system shall automatically generate the report based on the events or time duration and convert the same report in to PDF, word, excel, html and other formats and shall send to the specified e-mail ids as an attachment.
- iii. The row, column, content, user email-id, shall be specified during the configuration setting by the user.
- iv. The automatic report generation shall monitor the various user defined events continuously. When an event occurs, the system shall automatically retrieve the specified information from the server database and create in user viewable format (PDF, WORD, EXCEL, HTML, etc).
- v. For generating automatic reports and emailing process shall not require any human intervention.
- vi. The automatic report generation software shall be capable of integrating both the graphical and table information in one single report document along with the

required summary documents, header, footer, cover sheet, index page, etc.

18. **ILLUMINATION**

Plant Illumination System

a. Design Philosophy

A comprehensive illumination system shall be provided for the entire project. MCR (Main control room) building shall be provided with adequate light fittings, 6A/16A socket, fans, etc. Exhaust fans shall also be provided in toilets etc.

b. All outdoor lighting system shall be automatically controlled by synchronous timer or photocell. Provision to bypass the timer or photocell shall be provided in the panel.

Lighting System Description for MCR (Rain Control Room)

- i. AC lighting system 415V, 3Phase, 4wire, will be fed from lighting panels Control Board (LPs) which in turn will be fed from the lighting distribution boards (LDBs) of AC Switch board.
- ii. All lighting fixtures and accessories shall be designed for continuous operation for its life under atmospheric conditions existing at site.
- iii. AC lighting fixtures and accessories shall be suitable for operation on 240 V, AC, 50 Hz supply with supply voltage variation of +/-10%, frequency variation of +/- 5% and combined voltage and frequency variation (absolute sum) of 10%.

Codes and Standards

16101:2012	General Lighting. LEDs and LED modules Terms and definitions
16102(Part 1):2012	2012 Self Ballasted LED Lamps for General Lighting Services. Part-1 Safety Requirements
16102(Part 2):2012	Self-Ballasted LED Lamps for General lighting Services. Part-2 Performance Requirements.
16103(Part I):2012	LED modules for General lighting Safety Requirements.

Junction Boxes, Conduits, Fitting & Accessories

- i. Junction box for indoor lighting shall be made of fire retardant material. Material of JB shall be Thermoplastic or thermosetting or FRP type.
- ii. Junction boxes for street lighting poles and lighting mast if applicable, shall be deep drawn or fabricated type made of min. 1.6 mm thick CRCA Sheet. The box shall be hot dip galvanized. The degree of protection shall be IP55.
- iii. All switches and receptacles up to 16A shall be modular type. These shall be provided with pre-galvanized/galvanized modular switchbox.
- iv. Heavy duty PVC conduits conforming to IS: 9537 Part-III along with various accessories shall be used for indoor wiring in the buildings. These conduits shall be concealed in the wall/floor/roof. However, in PEB's, conduits can be fixed on surface.
- v. Pull out boxes shall be provided at suitable interval in a conduit run. Boxes shall be suitable for mounting on Walls, Columns, etc. Pull-out boxes shall have cover with screw. Pull out boxes used outdoor shall be weather proof type suitable for IP: 55 degree of protection and those used indoor shall be suitable for IP: 52 degree of protection.

Lighting Wires