7.0	**Synchronization limit**	Between inverter & standby AC source shall be within 47 Hz to 53 Hz field adjustable. Inverter shall remain synchronized with the AC mains.
8.0	**Inverter protection**	Overload, short circuit and 100% loss of load.
9.0	**Load sharing**	At a time one incomer from UPS shall be in service. On failure of any UPS, its load shall automatically get transferred to the other healthy UPS without any degradation of the UPS power quality. Suitable auto changeover logic shall be provided. Power shall be transferred to the standby AC power without a break in synchronization if within limit in case of failure of both inverters. Asynchronous transfer to standby AC source in case inverters are being out of synchronism limit with AC mains.
10.0	**Static switch**	To transfer UPS loads automatically without any break from faulty inverter to standby AC source. Manual bypass switch shall be employed for isolating the UPS during maintenance.
11.0	**Enclosure**	Individual enclosure shall be ventilated switchboard type fabricated from not less than 1.6-mm thick sheet steel. Enclosures shall be furnished with concealed hinges. Front and rear doors shall be designed to permit easy access to all components for maintenance or replacement. The enclosures shall be reinforced with formed steel members as required to form a rigid self-supporting structure. Doors shall have three point latches. Adequate ventilating louvers and enclosure top panels shall be included. All vent openings shall be covered with corrosion resistant fine screen coverings. The cabinets shall be IP-42 protection class for indoor application and IP65 for outdoor application. The temperature rise inside all the cabinets/enclosures shall not exceed 10 deg.C above ambient temperature.
12.0	**Spare feeders**	25%
13.0	**Accessories**	Power distribution board, Voltage & current meters, power factor meter, KVA, frequency, panel alarms, switches etc. One set of tool shall be provided for maintenance and testing purposes.

4.0 APPROVAL

The Detailed Design Report submitted by the contractor to NTPC must contain but not limited to the following details of the data acquisition and monitoring system:

- Detailed scheme
- Details of panels, metering system
- Necessary drawings for the scheme etc.

Drawings and scheme shall be submitted by the bidder for approval of BHEL/NTPC.

E-1 WEATHER MONITORING STATION

As a part of weather monitoring station, Bidder shall provide following measuring instruments with all necessary software & hardware required to integrate with SCADA so as to enable availability of data from meteorological instrument in SCADA. Each instrument shall be supplied with necessary cables, transmitters and accessories (Trackers, Mounting and base stand etc.) Provided by OEM of the sensors only.

Aux. power required by instruments and data logger (If supplied) shall be from UPS only. Data logger shall have provision to receive reduntant power supply.

All the instruments to be supplied shall have valid calibration certificate

Single sensor for measuring combination of Wind Speed, Wind Direction, Relative humidity and Rainfall is also acceptable however offered sensor shall meet the specification as mentioned in following sections.

1.0 SOLAR RADIATION SENSORS

Contractor shall provide Solar Radiation Sensors as per specification given in following section. Contractor has the option to provide these sensors on separate base or on a single base (radiation monitoring station) with tracker, shadow ring and transmitter etc provided by the OEM. Calibration certificate with calibration traceability to World Radiation Reference (WRR) or World Radiation Centre (WRC) shall be furnished along with solar radiation sensors. Bidder shall provide Instrument manual in hard and soft form.

1.1 Pyranometer

Bidder shall provide minimum **03 (Three) numbers** of Secondary Standard Pyranometers as per ISO 9060 **for measuring incident solar radiation as for following**

- **Global Horizontal Irradiance (GHI)- 1 Nos.**
- **Global Inclined Irradiance (GII)-1 Nos**
- **Diffuse Horizontal Irradiance (DHI)- 1 Nos**

Sl.No	Details	Values
1.	Principle	Thermopile
2.	Spectral Response.	310 to 2800 nm
3.	Sensitivity	Min 7 micro-volt/w/m^2

4.	Time response (95%):	Max 15 s
5.	Non linearity:	±0.5%
6.	Temperature Response:	±2%
7.	Tilt error:	< ±0.5%.
8.	Zero offset thermal radiation:	±7 w/m^2
9.	Zero offset temperature change	±2 w/m^2
10.	Operating temperature range:	0 deg to +80 deg.
11.	Uncertainty (95% confidence Level):	Hourly- Max-3%, Daily- Max-2%
12.	Non stability:	Max ±0.8%
13.	Response Time(95% of final value)	<5 sec

Shadow ring/ball for measuring DHI shall require no regular adjustment for of tracker and shadow ring/ball. Pyranometer shall be shaded throughout the day and shall be exposed to diffuse solar radiation only to provide DHI value without any calculation.

Bidder shall provide 1 nos (one) Battery powered portable logger for pyranometer supplied by the OEM of the offered Pyranometer.

1.2 Pyrheliometer (Qty -1no.)

Sl.No	Details	Values
1.	Spectral Response (50 % Point)	200 to 4000 nm
2.	Sensitivity	Min. 7 micro-volt/w/m^2
3.	Time response (95%)	Max 10 s
4.	Non linearity	Max ±0.5%
5.	Temperature Dependence of sensitivity	±1%
6.	Full viewing angle	$5^o \pm 0.2^o$
7.	Zero offset thermal radiation	±7 w/m^2
8.	Zero offset due to temperature change	±2 w/m^2
9.	Operating temperature range	0 deg to +80 deg.
10.	Daily Uncertainty (95% confidence Level)	1%
11.	Non stability	Max ±0.8%
12.	Response Time(95% of final value)	<5 sec
13.	Temperature Sensor	PT 100/Thermistor
14.	Slope Angle	$1^o \pm 0.2^o$
15.	Sun tracker accuracy	Max 0.5^o

2.0 TEMPERATURE SENSORS

2.1 Ambient Air Temperature Sensor (Qty -1 no.)

Sl.No	Details	Values
1.	Principle	RTD (Platinum) Resistance proportional to temperature
2.	Range	0-50 ^{o}C
3.	Accuracy	$\pm$ 0.2 ^{o}C
4.	Operating Temperature	0 to 50 deg C
5.	Radiation Shield	Non-aspirated Radiation Shield

2.2 Indoor Air Temperature Sensor (Qty – 1 no. at each Inverter room)

Sl.No	Details	Values
1.	Principle	RTD (Platinum) Resistance proportional to temperature
2.	Range	0-70 ^{o}C
3.	Accuracy	$\pm$ 0.2 ^{o}C
4.	Operating Temperature and calibration	0 to 70 deg C

2.3 Module Temperature Sensor (Qty – 1 no. per 5 MW)

Sl.No	Details	Values
1.	Principle	RTD (Platinum) Resistance proportional to temperature
2.	Range	0-100 ^{o}C
3.	Accuracy	$\pm$ 0.2 ^{o}C
4.	Operating Temperature	0 to 100 deg C

Module temperature sensor shall be fixed on the back of module surface with adhesive or tape without using any mechanical fastener.

3.0 WIND SPEED SENSOR (Qty- 1no)

Sl.No	Details	Values
1.	Principle	Frequency proportional to wind speed/Ultrasonic Sensor
2.	Velocity range	0-60 m/ sec
3.	Threshold	0.3 m/s

4.	Operating Temperature	0 to 50 deg C

3.1 Wind Direction Sensor (Qty- 1no)

Sl.No	Details	Values
1.	Principle	Potentiometric type sensor (Resistance proportional to Wind direction) /Ultrasonic Sensor
2.	Range	0-360 deg
3.	Accuracy	±5°
4.	Operating Temperature	0 to 50 deg C

4.0 RAIN GUAGE (Qty- 1no)

Rain Gauge shall be of Self Recording Type and recording facility shall be provided in Electronics. The Gauge shall be rugged having material of construction resistant to atmospheric corrosion. The Instrument shall have automatic functions for computing rainfall for pre set time periods.

Sl.No	Details	Values
1.	Accuracy	5% or Below
2.	Sensitivity	1.0 mm
3.	Operating Temperature	0 to 50 deg C

5.0 RELATIVE HUMIDITY (Qty- 1no)

Sl.No	Details	Values
1.	Range	0-100 %
2.	Accuracy	±3%
3.	Resolution	1%
4.	Operating Temperature	0 to 50 deg C

6.0 METEOROLOGICAL MAST

One Meteorological Mast of telescopic type and of specified height to be placed on an existing structure (such as Buildings etc) so that height of the Meteorological Sensors from the Ground Level (GL) is 10 meters. The Mast is required for mounting the Meteorological Sensors. Necessary Hangers and Holders along with electrical Grounding Set shall be provided by the vendor for installation of the Sensors. Material of Construction of the Mast shall be metallic and robust and shall be

resistant to atmospheric corrosion. Fencing shall be provided for weather monitoring station.

7.0 CALIBRATION

All the instruments to be supplied shall have valid and traceable calibration certificate. Each Pyranometer shall be recalibrated at an interval not more than two years and all other instruments shall be recalibrated at an interval not more than four years.

8.0 DATA LOGGER

Weather Monitoring system shall be provided with standalone Data logger suitable for outdoor application with IP65 Protection and industrial grade hardware suitable for operating temperature up to 55 Deg C. Data logger shall be calibrated and proven in field for at least one year in outdoor environment. Data logger shall have following minimum features:

Processor	32 bits
Time synchronization	With Built in GPS Clock or with Solar SCADA GPC Clock
Wireless communication	GSM/GPRS Modem
Data storage	SD card, Min 2GB for storage of raw and processed data locally at resolution of 1 Second for retrieval whenever required. Data to be stored shall be in unencrypted CSV or equivalent format.
Display	LCD display for easy maintenance and debugging for site engineer
Scan resolution	1 Sec
Analog to Digital Converter (ADC)	16 Bit, Sampling -10 Hz (Min)
I/P Channel	As required with 20 % spare of each type of channel

It shall have facility for arithmetic processing (Time Integration, Simple Average, and Moving Average etc.) of incoming raw data. Data logger shall be interfaced with Solar SCADA on modbus preferably on TCP-IP.

Vendor shall submit Factory Acceptance Test (FAT) report and procedure before dispatch of material to site.

Data logger shall be provided with key-locked door access and all the cables (Power and Signal) to the data logger shall be protected with heavy duty HDPE pipes.

Project file (software, settings and sample reports) shall be handed over to site on permanent storage media (CD/DVD) in two copies after data integrity is verified by site and weather monitoring is commissioned

E-2 FIRE FIGHTING AND ALARM SYSTEM

The SPV plant shall be equipped with suitable fire protection & fire fighting systems for protection of entire equipment switchyard & control room as per CEIG requirements.

1.0 Bidder shall comply with recommendation of Tariff Advisory Committee to incurring minimal premium for insurance. The installation shall meet all applicable statutory requirements, safety regulations in terms of fire protection.

2.0 The fire fighting system for the proposed power plant for fire protection shall be consisting of:

a) Sand buckets
b) Portable fire extinguishers
c) Microprocessor based fire alarm panel.

2.1 Portable Fire Extinguishers and Sand Buckets

Bidder to provide following numbers of type tested portable fire extinguishers as per relevant code in the rooms mentioned below.

Rooms	DCP Type (ABC type) (10 Kg. Capacity)	CO_2 Type 9 kg capacity	Foam Type Hand 9 kg	Hand Portable pressurized water $C0_2$ 9 Litre	Sand Buckets
Control Room	2	2	1	1	1
Each Inverter Room	1	1			
ACDB Room (If applicable)	1	1			
Each Transformer Yard	1	1	1		1
Switchyard/ Metering Yard	2	2			1

2.2 Microprocessor based fire alarm panel

Bidder to provide intelligent microprocessor based main fire alarm panel of modular construction complete with central processing unit, input and output modules, power supply module, supervision control and isolator

modules with 10% spare provisions in each loop. Fire detection alarm system shall include) but not limited to the following items

a. Fire Alarm control Panel
b. Multi Sensor smoke detector
c. Heat Detectors
d. Hooter cum strobe
e. Manual call Point
f. Hooter
g. Fault isolation modules
h. Control Modules
i. Cables from Sensors to Fire panels.
j. Digital output from the fire detection system shall be integrated with SCADA
k. Network Control Module
l. Interfacing of Fire Alarm System with SCADA for display and storage of status and alarm in SCADA

Multi sensor type smoke detectors and heat detectors shall be provided for below false ceiling areas of control room and ACDB and/or inverter rooms. One (01) sensor shall be provided for each 20 sq. Meter of area. All the cable trench inside the control room and inverter room shall be provided with Multi Sensor smoke detector.

Fault Isolation module shall be provided in every room and for every 15 sensors at location proposed by Bidder to be approved by employer during detail engineering.

2.3 Fire Alarm Control Panel Indication

i. Alarm conditions shall be immediately displayed on the control panel and in SCADA. Alarm LED shall flash on the control panel until the alarm has been acknowledged. Once acknowledged the LED shall remain lit. A subsequent alarm received from another zone after acknowledgement shall illuminate the alarm LED and the panel display shall show the new alarm information.
ii. During an alarm condition, an alarm tone shall sound within the control panel until the alarm is acknowledged.
iii. If the audible alarm signals are silenced for any reason, they shall automatically resound if another zone is activated.
iv. All alarm signals shall be automatically “locked in” at the control panel until the operated device is returned to its normal condition and the control panel is manually reset

There shall be weather proof Hooter cum strobe outside and strobe inside each Inverter room and control room for indication fire alarm for respective zone/area at suitable location that is visible from all direction. All the hardware, relay and accessories required for completeness of fire alarm system is in Bidder scope. Fire alarm system shall have its own battery and charger and it shall be provided power from UPS DB. Each Inverter room and control room shall be also be provided with manual call point, Alarm acknowledge and reset facility for alarm for respective zone only.

Bidder shall submit document to employer for approval that will include fire alarm system configuration, layout, BoM, Datasheet and necessary test report.

Bidder shall consider 30 % design and aging margin for selection of nos. of sensors in each loop and length of each loop. Bidder shall submit the certificate from OEM indicating maximum nos. of sensors in single loop and maximum length of single loop allowed with offered panel and type of cable to be used. Each Fire Alarm Control panel shall have provision for minimum 10 (Ten) % rounded to next higher integer but not less than 2 (two) nos. spare loops for future use of employer.

Bidder shall submit Site Acceptance Test (SAT) for approval by employer. Complete fire alarm system shall be checked at site for verification of faithful performance and completeness of the system. Bidder shall carry out necessary modification and supply hardware/accessories if required.

C-9 EARTHING SYSTEM

1.0 GENERAL REQUIRMENTS

This specification is intended to outline the requirement of earthing (grounding) for Solar array (DC) side and AC Power block side of Solar PV Project. It is not the intent of the specification to specify all details of design and construction since the bidder has full responsibility for engineering and implementation of earthling system meeting the intent of the specification and functional requirement. Any additional equipment, material, services which are not specifically mentioned herein but are required for successful installation, testing and commissioning of earthling system for safe and satisfactory operation of the plant shall be included under scope of the bidder.

Earthing requirement for outdoor metering yard/Switchyard has been mentioned elsewhere in the specification and hence shall be excluded from scope of this chapter unless earthing requirement of metering yard/Switchyard is specifically mentioned in this chapter.

1.1 EARTHING DESIGN REQUIRMENT

The object of protective earthing system is to provide as nearly as possible a surface under and around a station which shall be at a uniform potential and as nearly zero or absolute earth potential as possible. The purpose of this is to ensure that, in general, all parts of apparatus other than live parts, shall be at earth potential, as well as to ensure that operators and attendants shall be at earth potential at all times. Also by providing such an earth surface of uniform potential under and surrounding the station, there can exist no difference of potential in a short distance big enough to shock or injure an attendant when short-circuits or other abnormal occurrences take place.

Care must be taken for equipment with functional earthing that its service is not disrupted due to undesired disturbances in protective earthing system.

1.2 CODES AND STANDARD

The equipment/product furnished for earthing system shall meet the requirements of all the applicable relevant National/International codes and standards or their latest amendment Codes and Standards. Product certification has to be CE/UL/BIS/TUV or equivalent. The relevant codes and standard for earthing system are tabulated below.

IS: 3043	Code of practice for Earthing.
IEEE: 80	IEEE guide for safety in AC substation grounding
IEEE: 837	Standard for qualifying permanent connections used in substation grounding
IS: 2309	Code of Practice for the protection of building and allied structures against lightning.
IS: 802	Code of practice for the use of Structural Steel in Overhead Transmission Line Towers.
IS: 2629	Recommended practice for hot dip galvanizing of iron & steel
IS: 2633	Method for testing uniformity of coating on zinc coated articles
IS: 513	Cold rolled low carbon steel sheets and strips
IS: 6745	Methods for determination of mass of zinc coating on zinc coated iron & steel articles.
IS 2062	HOT ROLLED MEDIUM AND HIGH TENSILE STRUCTURAL STEEL — SPECIFICATION
IS: 4736	Hot-dip Zinc coating for MS Tubes.
IS: 458	Precast Concrete Pipes (With and Without Reinforcement)
UL-467	Grounding and Bonding Equipment
IEC 62561-7	Requirements for earthing enhancing compounds
	CEA regulations for electrical safety-2010
	Indian Electricity Rules/ Indian Electricity Act.

All standards, specifications and codes of practice referred to herein shall be the latest editions including all applicable official amendments and revisions as on date of opening of bid. In case of conflict between this specification and those (codes and standards, etc.) referred to herein, the former shall prevail. All work shall be carried out as per the above standards/ codes as applicable.

The earthing system includes earth electrode, installation of earth electrode in suitable pit size, construction of earth pit with cover for the installation, connection of earth electrode with equipotential earth bus and connection of equipment to equipotential earth bus.

2.0 EARTH ELECTRODE

The earth electrode is in direct contact with the ground provides means for conducting earth current with ground. Earth Electrode material should have good electrical conductivity and mechanical strength and should not corrode in wide variety of soil conditions. For an effective earthing system, following type of vertical earth electrodes can be used.

I. MS Rods
Hot rolled, Medium or High Tensile Steel Rod as per IS 2062 of length not less than 3000 mm and diameter of 40 mm.

II. Copper Bonded Rods
High tensile-low carbon steel rod having diameter not less than 14/17 mm of Length 3000 mm to be selected based on earth fault current. The Rod shall comply with requirements of BS 4360 Grade 43A or EN10025:2-004 S275JR, molecularly bonded by 99.99% pure high conductivity copper on outer surface with copper coating thickness 250 micron or more in conformity to UL-467. Its surface shall be clean, free from mechanical defect and any visible oxide layer or foreign material.

2.1 **Earthing Enhancement Compound**

A low resistance earth electrode system is important to provide a low impedance path for the better dissipation of lightning/fault currents, and to protect personnel and equipment by minimizing and equalizing voltage potential differences. Earthing (ground) enhancement materials shall be used to improve the ground electrode resistance. Earth enhancement material shall be a superior conductive material which improves earthing effectiveness, especially in areas of poor conductivity (rocky ground, areas of moisture variation, sandy soils etc.). It shall be tested and should conform to the requirements of IEC 62561-7.It shall have the following characteristics:-

a) High conductivity, improves earth's absorbing power and humidity retention capability, non-corrosive in nature having low water solubility but highly hygroscopic.
b) Carbon based with min 95% of fixed carbon content premixed with corrosion resistant cement to have set properties. Cement shall not mix separately & shall not have Bentonite.
c) Resistivity of less than 0.2 ohms -meter.
d) It shall not depend on the continuous presence of water to maintain its conductivity and shall be permanent & maintenance free and in its "set form", maintains constant earth resistance with time.

e) It shall not dissolve, decompose or leach out with time and shall be environmental friendly, suitable for soils of different resistivity and any kind of earth electrode.

The Earth enhancement material shall be supplied in sealed, moisture proof bags, marked with Manufacturer's name or trade name, quantity etc. The minimum quantity of earth enhancement compound to be used with each earth-pit shall be 25 Kg.

2.2 **Earthing conductor**

Earthing conductor is the conductor for buried below the ground at the depth of 600 mm connecting earth pits to make interconnection of earth pit. To interconnect earth pits, following type of conductor can be used. Application of specific conductor and its size has been mentioned in relevant clause:

I. Galvanised Steel Flat (GS) Flat
GS/GI Flat (Strip) conductor shall comply to IS 2026 with Galvanization of 85 Micron as per IS. Material shall be clean and free form mechanical defects.

II. Copper Clad Steel (CCS) Earthing Conductor
The Copper Bonded Steel Grounding Conductor shall be made of steel with the coating of 99.99% pure copper complying to ASTM B 869-96 and ASTM B 452-93 standards. Each strand of CCS shall have continuous, uniform coating and the conductor surface shall be smooth and free from mechanical defects.

III. MS Rod
Hot rolled, Medium or High Tensile Steel Rod as per IS 2062 of length not less than 3000 mm and diameter of 40 mm.

2.3 **Earthing Technical and Installation Requirement**

Careful consideration should be given to installing an earthing system that meet or exceed statutory requirements. Contractor shall select certified product and ensure good workmanship for installation for satisfactory performance to fulfill the designed parameters all the times. Following care shall be taken while installation of earthing.

I. Metallic frame/ structure of all electrical equipment shall be earthed by two separate and distinct connections to earthing system, each of 100% capacity, Crane rails, tracks, metal pipes and conduits shall also be effectively earthed at two points. Steel RCC columns, metallic stairs, and rails etc. of the building housing electrical equipment shall be connected to the nearby earthing grid conductor

by one earthing ensured by bonding the different sections of hand rails and metallic stairs. Metallic sheaths/screens, and armour of multi-core cables shall be earthed at both ends. Metallic Sheaths and armour of single core cables shall be earthed as per requirement mentioned elsewhere in the specification. Every alternate post of the switchyard fence shall be connected to earthing grid by one GS flat and gates by flexible lead to the earthed post. Portable tools, appliances and welding equipment shall be earthed by flexible insulated cable. Metallic column for Inverter/Switchgear shelter/E-house shall be earthed with two distinct connections at minimum two column. All the wall cladding section shall be earthed at minimum two location with flexible copper cable of not less than 50 sq. mm.

II. Each continuous laid lengths of cable tray shall be earthed at minimum two places by G.S. flats to earthing system, the distance between earthing points shall not exceed 30 meter. Wherever earth mat is not available, necessary connections shall be done by driving an earth electrode in the ground.

III. 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.

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

V. 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.

VI. Suitable earth risers as approved shall be provided above finished floor/ground level, if the equipment is not available at the time of laying of main earth conductor.

VII. Connections between equipment earthing leads and between main earthing conductors shall be of welded type. For rust protection the 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. Resistance of the joint shall not be more than the resistance of the equivalent length of conductors.

VIII. 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. Back filling shall be placed in layers of 150 mm.

IX. Earthing conductors embedded in the concrete floor of the building shall have approximately 50 mm concrete cover.

X. A minimum earth coverage of 300 mm shall be provided between earth conductor and the bottom of trench/foundation/underground pipes at crossings. Earthing conductors crossings the road can be installed in pipes. Wherever earthing conductor crosses or runs at less than 300 mm distance along metallic structures such as gas, water, steam pipe lines, steel reinforcement in concrete, it shall be bonded to the same. Earthing conductors along their run on columns, walls, etc. shall be supported by suitable welding / cleating at interval of 1000mm and 750mm respectively.

XI. Earth pit shall be constructed as per IS:3043. Electrodes shall be embedded preferably below permanent moisture level. Minimum spacing between electrodes shall be 600mm.

XII. Earth pits shall be treated with earth enhancement compound if resistivity is more than 20 ohm meter.

XIII. 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.

XIV. Contractor shall obtain all necessary statutory approvals for the earthing system before charging of the plant and electrical equipments.

3.0 TECHNICAL DETAILS FOR AC EARTHING SYSTEM

This section outlines the requirements of protective and functional earthing system to discharge AC fault current to earth and provide equipotential bonding for Transformer, HT and LT Switchgear Panel and other similar electrical equipments, Transformer neutral and shield.

The Contractor shall furnish the detailed design and calculations as per IEEE 80/IS 3043 for Employer's approval for equipment earthing..

3.1

Earthing System requirement for AC Earthing:

1. Conductors above ground level and in built up trenches -Galvanized steel
2. Conductors buried in earth -Mild steel
3. Earth electrodes - Mild steel rod of diameter 40mm or Copper bonded steel rod of dia not less than 17 mm
4. Life Expectancy - 25 years
5. Fault Level - Mentioned Elsewhere
6. Min. Steel corrosion - As per IS 3043
7. Soil Restivity -Actual as per site condition

The sizes of earthing conductors for various electrical equipment shall be as below:

S No.	Equipment	Earth Conductor buried in Earth	Earth conductor above ground level and in built up trenches
1	33kV/11kV/6.6kV/3.3 kV/ switchgear equipment and 415V switchgear	--	65 x 8mm GS flat
2	415 V MCC/ Distribution boards / Transformers	--	50 x 6mm GS flat
3	LT Motors above 125 KW	--	50 x 6mm GS flat
4	LT Motors 25 KW to 125 KW	--	25 x 6mm GS flat
5	LT Motors 1 KW to 25 KW	--	25 x 3mm GS flat
6	Fractional House power motor	--	8 SWG GS wire
7	Control panel & control desk	--	25 x 3 mm GS flat
8	Push button	--	8 SWG GI wire

	station/Junction Box		
9	Columns, structures, cable trays and bus ducts enclosures	--	50 x 6mm GS flat
10	Crane, rails, rail tracks & Other non-current carrying metal parts	--	25 x 6mm GS flat

3.2 Contractor shall ensure there at least two earth pits each dedicated for earthing of each Transformer, HT/LT Switchgear panel, transformer neutral, Battery Charger/UPS/Control Panel etc. shall be provided. Earth electrode shall be located near to the equipment and all earth electrodes shall be interconnected with parallel conductor buried in earth surrounding the equipment.

3.3 Earthing system of different locations such as Inverter room/Pooling Switchgear/Sub pooling switchgear/Inverter shelter etc. shall be interconnected in single network with buried conductor of the size 65X8 GS Flat laid at 600 mm depth. Contractor shall submit the calculation based on the system of earth conductor and electrode connected in single network. Location and manner of interconnection shall be approved during detail engineering.

3.4 For functional earthing of electronic component such as SCADA, contractor shall provide 1 no. (Min) isolated earth electrode near to the equipment connected with 2 run of copper cable of size not less than 25 sqmm. Contractor shall comply to the recommendation of OEM (Original Equipment Manufacturer) for electronic earthing and electrode can be connected with other earth electrode as per recommendation of OEM.

3.5 Each inverter duty transformer having shield between HV and LV winding shall be provided with 2 nos. Isolated earth electrode connected with each other for functional earthing of transformer shield. Each electrode shall be connected with transformer shield with separate 25X6 Cu flat.

4.0 TECHNICAL DETAIL SOLAR ARRAY (DC) EARTHING (if applicable)

This section outlines the earthing requirement for discharging DC fault current to earth of Solar PV plant and provide equipotential bonding for Module Mounting Structure (MMS), SMB Mounting structure, Module Frames etc.

	System Requirement for the solar array DC earthing:
	Conductors buried in earth -GS Flat or CCS
	Conductors above ground level -GS Flat or CCS
	Earth Electrode -40 mm MS Rod or Copper bonded steel rod of dia. not less than 14 mm
	Life Expectancy -25 Years
	System fault level -5 KA for 3 Sec.
	Soil resistivity -Actual as per site conditions
	Min. Steel corrosion -As per IS 3043
4.1	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 by two separate and distinct connections to earthing system. Earthing system for solar array shall consist interconnected earth pits electrodes connected by 25X6 GS flat (Min.) or Copper Clad Steel (CCS) earthing Conductor of size not less than 120 SQMM laid at the depth of 600 MM below the ground. Minimum size of riser conductor to connect the structures to buried earthing conductor and structure to structure in the solar farm shall be 25X3 GS Flat or CCS of Min. 70 SQ MM size.
4.2	Periphery fencing wherever provided shall be earthed at every 100 meter interval with 25X3 GS flat connected with DC or AC side nearest buried earthing conductor.
4.3	Earthing conductor for connection to structure and equipment may be kept on the ground below MMS. However, these conductor shall be laid 300 mm below the ground along the pathway and/or crossing the pathway.
4.4	Equipment and structure in the solar farm shall be earthed in compliance to the IS: 3043 (Code of Practice for Earthing) and Indian Electricity Rules/Acts.
4.5	The Contractor shall furnish the detailed design and calculations for Owner's approval as per IS 3043 to determine the number of earth pit and size of earth conductor. However the no. of earth pit electrodes for the DC earthing shall be as per Clause. 2.0 of Chapter A-2
4.6	Buried earth conductor shall be laid all around periphery of solar array farm and at every 300 meter (Min.) across the rows of MMS. GS flat above the ground for structure earthing shall be connected to the nearest buried conductor or electrode. All the earth electrodes shall be interconnected in single network/mesh and no electrode or group of electrodes shall be isolated/islanded. These electrodes shall be uniformly

	distributed in the solar farm at maximum practical extent and location of earth electrode shall be approved during detail engineering. A continuous earth path is to be maintained throughout the PV array.
4.7	Connection of DC earthing system and AC earthing system with location and manner of connection shall be approved during detail engineering. Contractor shall submit the design calculation of earthing system of AC and DC side as standalone (no interconnection) system.
4.8	Connection of riser to the structures shall be bolted or welded type. Portion of galvanized structure which undergoes welding at site shall be coated with two coats of cold galvanizing and anti-corrosion paint afterwards.
4.9	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.
4.10	Each PV Module frame shall be earthed in accordance with module manufacturer guidelines. In case module frame earthing is to be separately provided, it shall be earthed with minimum 2.5 SQMM flexible copper cable with lug at suitable location of module frame. The Number of PV modules in single loop of earthing connection to module frame shall be as per Module manufacturer recommendation. Both ends of the loop of copper cable for earthing shall be connected with nearest earthed structure or earth conductor.
4.11	Contractor shall seek owner's approval for connecting solar array earth mesh with any other earth mat/earth grid of the solar PV plant.
4.12	Size of earth conductor, nos. of earth pits given in this clause is applicable for solar array earthing only. Relevant method and practice of laying of earthing conductor, earth pits and riser not mentioned herewith but given elsewhere in this specification is applicable to solar array earthing also.
4.13	Inverter functional earthing (Negative earthing, Anti PID Earthing) shall be carried out as per guideline of OEM. Contractor shall submit complete detail of such earthing from OEM and implement the earthing accordingly.
5.0	**EARTHING REQUIREMENT FOR EQUIPMENT ON FLOATER**
5.1	Aforementioned requirement of the earthing are applicable earth surfaces. For Floater area, contractor shall lay 25X6 GI Flat all along the periphery of the floater area. This periphery GI Flat shall be connected at suitable location by laying minimum 2 Nos. of 25X6 GI flat equi-spaced (Location

	to be decided during detail engineering) along East-West and North-South direction making a grid 25X6 GI Flat on the floater.
5.2	All the equipment/devices, module metallic frame & structure on the floater shall be connected with 25X6 Flat.
5.3	The earthing system of Floater shall be connected with earthing system of ground at each location of Inverter transformer with 2 (two) nos. of 120Sqmm copper earthing cable.

C-10 PLANT ILLUMINATION SYSTEM

This chapter covers supply and installation of suitable illumination system along the approach roads to inverter room and inverter room(s), transformer yard and other facilities inside the plant.

1.0 DESIGN PHILOSOPHY

A comprehensive illumination system shall be provided in the entire project. Each building shall be provided with adequate light fittings,6A/16A socket, fans, etc. Exhaust fans shall also be provided in toilets, battery room, etc

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.

2.0 LIGHTING SYSTEM DESCRIPTION for CMCS and inverter room

Normal AC Lighting System: 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 MCC.

Emergency AC Lightning System: The emergency lighting system consisting of 20% of the lights shall be fed from UPS DB or DCDB as per scheme adopted by the EPC bidder. Load of the same has to be considered for UPS/ Battery and charger sizing. Bidder shall provide indoor and outdoor emergency lighting at each inverter room, CMCS, security room and main gate.

3.0 Lighting Fixture, Lamps & Accessories

a. All lighting fixtures and accessories shall be designed for continuous operation for its life under atmospheric conditions existing at site.
b. 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% DC lighting fixtures and accessories shall be suitable for operation on 220 V, with variation between 190 V & 240 V.
c. All lighting fixtures shall be complete with lamp(s), lamp holder(s), LED chip assembly, terminal blocks, clamps, locking arrangements, fixing brackets etc. Driver circuit/Control gears shall be provided as applicable / specified. The fixtures shall be fully wired upto terminal block. The internal wiring of the fixtures shall be done with suitable low

smoke halogen free thermo-plastic or silicon rubber insulated or fire retardant PTFE copper conductor wires of suitable size and type. Further fuse protection of suitable rating in input side shall also be provided specifically for LED luminaires. However, the normal cross section of conductor shall be not less than 0.5 Sq. mm and minimum thickness of insulation shall be 0.6 mm. The wiring shall be capable of withstanding the maximum temperature to which it will be subjected under specified service conditions without deterioration and affecting the safety of the luminaire when installed and connected to the supply. All fixing /locking screws, washers, nuts, brackets, studs etc, shall be zinc plated and passivated.

d. All lighting fixtures shall be provided with an external, brass/GI earthing terminal suitable for connecting 14 SWG, GI earthing wire. All metal or metal enclosed parts of the housing and accessories shall be bonded and connected to the earthing terminal as so to ensure satisfactory earthing continuity through out the fixture
e. The lighting fixtures shall be designed for minimum glare. The finish of the fixtures shall be such that no bright spots are produced either by direct light source or by reflection
f. The reflectors shall be manufactured from CRCA sheet steel or aluminium as specified. The aluminium reflectors shall be made of high purity aluminium sheet, polished electrochemically brightened and anodized or proven alternate arrangement of anodizing
g. Starters shall have bi-metal electrodes and high mechanical strength. Starters shall be replaceable without disturbing the reflector or lamps and without use of any tool. Starter shall have brass contacts and radio interference suppressing capacitor.
h. LED luminaires body shall such designed that heat sink/heat dissipating housing shall be mounted outside the overall luminaires fixture housing, and shall be suitably clearing the driver circuit. Further for outdoor type LED luminaires, the exposed heat sink shall be suitably designed to avoid dust/foreign particles accumulation on the same.
i. LED luminaires housing/body shall be pressure die cast aluminium or extruded Aluminium or CRCA as specified alongwith finished powder coating. Care shall be taken in the design that there is no water stagnation anywhere.

4.0 LED Luminaires:

4.1 **CODES AND STANDARDS**

All standards and codes of practice referred to herein shall be the latest edition including all applicable official amendments & revisions as on date of techno-commercial bid opening. In case of conflict between this

specification and those (IS codes, standards etc.) referred to herein, the former shall prevail. All work shall be carried out as per the following standards & codes.

16101:2012	General Lighting. LEDs and LED modules Terms and definitions
16102(Part 1):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.
15885(Part 2/Sec. 13) :2012	Lamp control gear Part 2 particular Requirements Section 13 d.c. or a.c. Supplied Electronic control gear for LED modules
16104:2012	d.c. or a.c. Supplied Electronic control gear for LED modules - Performance Requirements.
16105:2012	Method of Measurement of Lumen maintenance of Solid-state Light (LED) Sources.
16106:2012	Method of Electrical and photometric Measurements of Solid State Lighting (LED) Products
16107:2012	Luminarie Performance
16108:2012	Photobiological safety of Lamps and Lamp Systems
IS 513	Cold rolled low carbon steel sheets and strips
IS 12063	Classification of degree of protection provided by enclosures.

	IS 14700 (Part 3/Sec. 2)	Electro magnetic compatibility (EMC) – Limits for Harmonic emission – THD < 15% (equipment, input current < 16 Amps. per phase.
	IS 9000 (Part 6)	Environment testing: Test Z – AD: composite temperature/humidity cyclic test.
	IS 15885 (Part 2/Sec. 13) IS 16004 – 1 and 2)	Lamp control gear: particular requirements for DC or AC supplied electronic control gear for LED modules.
	IS 4905	Method for random sampling
	IEC 60598	Ingress protection, luminaire performance and safety
	IEC 61000-3-2	Total Harmonic Distortion
	IEC 61000-4-5	Surge Protection
	IES-LM 80 along with TM 21/ IS 16105	Lumen Depreciation and Rated life of LED chip
	IES-LM 79 / IS 16106	Luminaire optics and color parameter and electrical parameter

4.2 **LED LIGHTING SYSTEM**

LED Luminaires shall be used for the lighting of all the indoor & outdoor areas. However for DC lighting & hazardous areas conventional type luminaires shall be used. In false ceiling area LED luminaires shall be recessed mounting type & in non-false ceiling area the LED luminaires shall be surface mounting type.

The individual lamp wattage for LED shall be upto 3 watt for outdoor type luminaires. However for indoor type luminaires fractional wattage LEDs are also acceptable. The LED chip efficacy shall be min 120 Lm/W. The luminaire efficacy shall not be less than 80 Lm/W. Heat sink/heat dissipation arrangement shall be provided in the luminaires. The LED used in the luminaires shall have colour rendering index (CRI) of Min 70 and 80 for outdoor and indoor luminaires respectively.

Colour designation of LED shall be “cool day light” (min 5700K) type for indoor type LED luminaires. Further for outdoor type luminaires, the colour designation shall be 5000K, except for well glass type LED luminaires, where the colour designation shall be 4000K. The LED luminaires shall

have minimum life of 25,000 burning hours with 80% of lumen maintenance at the end of the life.
The beam angle for LED chip for indoor type luminaires shall be 120 degrees. However for highbay & flood light type outdoor luminaires the LED chip with suitable beam angle shall be used to deliver better lumen-output. The maximum junction temperature of bare LED without heat sink shall be limited to 85 deg C, further the lumen maintenance at this temperature shall be min 90%. The THD of tube light based LED Luminaires shall be less than 20%. For other type of luminaries, it shall be minimum 10%.

Further the EMC shall be as per IS 14700. The power factor of the luminaire shall not be less than 0.9. The marking on luminaire & safety requirements of luminaire shall be as per IS standards. Suitable heat sink/ heat dissipation arrangement, with proper thermal management shall be designed for the luminaires.

Driver Circuit: LED modules and drivers shall be compatible to each other. The LED module driver's ratings and makes shall be as recommended by corresponding LED manufacturer.
LED Drivers may have following control & protections:-

- Suitable precision current control of LED.
- Open Circuit Protection
- Short Circuit Protection
- Over Temperature Protection
- Overload Protection
- Surge Protection

Lighting panels shall be powder coated with color shade RAL9002. Lighting panels shall have IP55 degree of protection.
Wires of different phase shall normally run in separate conduit.
Power supply shall be fed from 415 / 240 V normal AC supply through suitable number of conveniently located lighting distribution boards (LDB) and at least one 6/16A, 240V AC universal socket outlet with switch shall be provided in offices, cabins, etc.
Suitable number of 63A, 3ph, 415V AC industrial receptacles shall be provided for welding purposes at one location.
Incandescent lamps may be used only with DC Lighting.
Electrification of all building shall be carried out as per IS 732-1989, IS 4648-1968 and other relevant standards.

Indoor Lighting fixtures shall generally be controlled from switch boxes of each area not directly from lighting panel. Each switch shall control a maximum of three fixtures.
All luminaries and their accessories and components shall be of type readily replaceable by available Indian makes.

Following test reports to be submitted for LED chip/LED luminaires:

a) LED parameters like Lumen per watt, CRI, Beam angle from manufacturer.

b) LM 80/IS: 16105 report.

c) LM 79/IS: 16106 report

5.0 JUNCTION BOXES, CONDUITS, FITTING & ACCESSORIES

Junction box for indoor lighting shall be made of fire retardant material. Material of JB shall be Thermoplastic or thermosetting or FRP type.
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.
All switches and receptacles upto 16A shall be modular type. These shall be provided with pre-galvanized/galvanized modular switchbox & plate.
Conduits, Pipes and Accessories:
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.
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.

6.0 LIGHTING WIRES

Lighting wires shall be 1100 V grade, light duty PVC insulated unsheathed, stranded copper/aluminium wire for fixed wiring installation. colour of the PVC insulation of wires shall be Red, Yellow, Blue and Black for R,Y,B phases & neutral, respectively and white & grey for DC positive & DC negative circuits, respectively. Minimum size of wire shall not be less than 1.5.sq.mm. for copper

7.0 LIGHTING POLES

The Street Light system and peripheral lighting shall be designed generally in line with design guidelines. Height of the poles should be chosen so as not to affect working of Solar panels. The poles shall be hot-dip galvanized as per relevant IS2629/ IS2633/ IS4759. The average coating thickness of galvanizing shall be min. 70 micron. The System shall

be capable of withstanding the appropriate wind load etc as per IS 875 considering prevailing soil/ site condition considering all accessories mounting on pole.

The street light poles shall have loop in loop out arrangement for cable entry and light fixture / wiring protected with suitably rated MCB. The required illumination level shall be as per Cl. 9.0 taking consideration of existing lighting infrastructure.

Hot dipped Galvanized with 80 mm thickness hexagonal/Octagonal lighting pole with inbuilt JB shall also be acceptable

The luminaries used shall be minimum 32 W with minimum pole height of 2.5 m with 50 m for internal roads.

8.0 EARTHING

Lighting panels, etc. shall be earthed by two separate and distinct connections with earthing system. Switch boxes, junction boxes, lighting fixtures, fans, single phase receptacles etc. shall be earthed by means of separate earth continuity conductor. The earth continuity conductor 14 SWG GI wire shall be run along with each conduit run. Cable armours shall be connected to earthing system at both the ends.
Alternately Vendor may offer technically superior and proven product subject to approval of employer.

9.0 AVERAGE ILLUMINATION LEVEL

Location	Average Illumination Level (Lux)	Type of Fixture
Control Room	300	LED Luminaries
Store Room	200	LED Luminaries
Switchgear Room, HT Room	150	LED Luminaries
Inverter Room	150	LED Luminaries
Street lighting-Roads	10	LED Luminaries
Yard/ Substation	20(general) 50(on strategic equipment)	LED Luminaries

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Sl. No.	ITEM	QP / INS CAT.	QP No. -	ACCEPTABLE SUPPLIER AS PER DATABASE	PLACE	SC APPL STATUS	REMARKS
1.	SPV module	I	Q-001	BHEL	Bangalore	A	
				Warree	Surat	A	
				Emmvee	Bangalore	A	
				Vikram Solar	Parganas	A	
				Lanco Solar	Chattisgarh	A	
				Tata Power Solar	Bangalore	A	
				Alpex	Solan	A	
				Synergy	Durgapur	A	
				Photonix	Satara	A	
				HHV Solar	Bangalore	A	
2.	Power Conditioning Unit (PCU)	I	Q-002	Schneider	Bangalore	A	Conditions apply
				ABB	Bangalore	A	Conditions apply
				Bongfiglioli	Germany	A	Conditions apply
				Fecon	Germany	A	Conditions apply
				AEG	Bangalore	A	Conditions apply
				Hitachi-Hirel	Gandhinagar	A	Conditions apply
				Hitachi-Hirel	Sananad	A	Conditions apply
				Vacon	Bangalore	A	Conditions apply
3.	String Monitoring Box (SMB)	II	Q-003	Trinity Touch	Palwal	A	Conditions apply
				Hensel	Sriperumbudur	A	Conditions apply
				AEG	Bangalore	A	Conditions apply
				Statcon	Pilkhuwa	A	Conditions apply
				Weidmuller	Spain	A	Conditions apply

Sl. No.	ITEM	QP / INS CAT.	QP No. -	ACCEPTABLE SUPPLIER AS PER DATABASE	PLACE	SC APPL STATUS	REMARKS
4.	Weather station panel (comprising of Pyranometer, anemometer & thermometer etc.)	III		Any make-model with VDE/ CE/UL/ CSA marking or BIS approved with CML no. (Refer Note-6)			
5.	DC Cable Connector	III		Any make-model which is Type Tested as per EN 50521 or having marking of VDE/ CE/UL/ CSA/ "BIS with CML no." (Refer Note-1)			
6.	Floor mounted Draw out type indoor LT Switchgear Panel (MCC etc.) Refer Note-5	I	Q-004	L&T	Mumbai / Coimbatore/ Ahmednagar	A	BOIs preferably with VDE/CE/UL/CSA marked or BIS approved with valid CML no.
				GE	Bangalore	A	
				C&S Electric	Noida / Hardwar	A	
				Schneider	Nasik	A	ACB from Schneider, France
				Nitya Electrocontrols	Noida	A	
				Siemens	Kalwa	A	Conditions apply
				Tricolite	Sahibabad/ Manesar	A	Conditions apply
7.	LV Air Circuit Breaker	*		C&S Electric	Noida	A	*(part of Swgr MQP)
				L&T	Mumbai	A	
				GE	Bangalore	A	
				Siemens	Germany	A	