

a. Bidder shall consider as per standard design of vendor for Ethernet networking.

- b. PCU shall have protection against over current, sync loss, over temperature, DC bus over voltage, cooling fan failure (if provided), short circuit, lightening, earth fault, surge voltage induced at output due to external source, power regulation in the event of thermal overloading,
- xxxi. It shall have bus communication via interface for integration, remote control via telephone model or mini web server, integrated protection in the DC and three phase system, insulation monitoring of PV array with sequential fault location. Alternatively, the same can be provided through SCADA.
- xxxii. Ground fault detector which is essential for large PV generators in view of appreciable discharge current with respect to ground.
- xxxiii. The power conditioner must be entirely self-managing and stable in operation. A self-diagnostic system check should occur on start up. Functions should include a test of key parameters on start up.
- xxxiv. Over voltage protection against atmospheric lightning discharge to the PV array is required.
- xxxv. The power conditioner must be entirely self-managing and stable in operation. A self-diagnostic system check should occur on start up. Functions should include a test of key parameters on start up.

xxxvi. Standards and Compliances:

The Bidder also has to confirm the PCU specifications in the Bid.

Table 5-2 Detailed Specifications of PCU

Sr.	Particulars	Details
1	PCU Mounting	As per the design
2	Nominal AC Output Power	≥ 1000 kW
3	Nominal AC Output Voltage	415 Volts +15%/-10% AC / 270 V / As per design
4	Maximum Input Voltage	1500 V DC
5	Wave Form	Pure Sine wave
6	DC voltage range, MPPT	450 to 1000 volts DC / As per

		design
7	Minimum Efficiency at 100% load The rated European efficiency (Euro Eta Efficiency) and peak efficiency	≥ 98%, measured as per IEC 61683 standard for measuring efficiency. * Inverter No Load / Full Load Loss Calculation must be submitted by the Bidder.
8	Output frequency	50 Hz +3% to - 5% Hz
9	Power Factor	0.85 lag- 0.85 lead
10	Max. THD at rated power	Less than 3 %
11	Ambient dry bulb temperature range	0 to 50° deg C
12	Humidity	15% to 95 % non- condensing
13	Enclosure	IP 20/ IP 65 (Indoor/ Outdoor rated) IEC-60068-2 (environmental)
14	Protection rating (as per IEC-60721-3-3)	Classification of chemically active substances: 3C2
15	Grid Specifications	IEC 61727, VDE 0126
16	Nominal Voltage & Frequency	415 Volts & 50 Hz
17	Voltage Tolerance	+ 10% and -10% or better than that

- a. PCU shall confirm to IEC 60068-2 standards for Environmental Testing.
- b. All inverters shall be IEC 61000 compliant for electromagnetic compatibility, harmonics, etc.
- c. All inverters shall be safety rated as per IEC 62109 (1 &2), EN 50178 or equivalent DIN or UL standard.
- d. Each PCU shall be compliant with IEEE standard 929 – 200 or equivalent. The Bidder should select the inverter (Central / String) as per its own system design so as to optimize the power output.

xxxvii Display

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- a. The PCU shall have local LCD (Liquid crystal display) and keypad for system control, monitoring instantaneous system data, event logs, data logs and changing set points. Control and read-out should be provided on an indicating panel integral to the Inverter. Display should be simple and self-explanatory. Display to show all the relevant parameter relating to PCU operational data and fault condition in form of front panel meters/ LEDs or two line LCD Display.
- b. PCU front panel shall be provided with display (LCD or equivalent) to monitor the following
 - Instantaneous DC power input
 - DC input voltage
 - DC Current
 - Instantaneous active AC power output
 - Instantaneous reactive AC power output
 - AC voltage (all the 3 phases and line)
 - AC current (all the 3 phases and line)
 - Power Factor
 - kWh Produced during entire day
 - Total kWh produced during its life time
 - Thermal loading (percentage)

PCU must be provided with display and also the same has to be made available at the SCADA monitoring & controlling desk installed in Main Control Room through Universal Open Protocol of Communication.

xxxviii Documentary Requirements & Inspection.

- a. The bill of materials associated with PCUs should be clearly indicated while delivering the equipment.
- b. The Contractor shall provide to GSECL data sheet containing detailed technical specifications of all the inverters and PCUs. Operation & Maintenance manual should be furnished by the Bidder before dispatch of PCUs.

Note:The Company or its authorized representative reserves the right to inspect the PCUs/ Inverters at the manufacturer’s site prior to dispatch.

(B) String Inverters

Technical specifications for string Inverter

(1) CODES AND STANDARDS

The PCU shall conform to all applicable IEC standards. Where an applicable IEC standard is not available, IS/ any applicable international standard shall be referred to as best practice.

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IEC-61683	Energy efficiency requirements
IEC 61000	Emission/ Immunity requirement
IEEE 519	Recommended Practices and Requirements for Harmonic Control in Electrical Power Systems.
IEC 60068-2-1, 2, 6, 14, 27 & 30	Environmental Testing
IEC 62116	Testing procedure—Islanding prevention measures for power conditioners used in grid-connected photovoltaic (PV) power generation systems
IEC 62109-1 & 2	Safety of power converters for use in photovoltaic power systems
EN 50530	Overall efficiency of grid connected photovoltaic inverters
BDEW 2008	Technical Guidelines for Generating plant connected to Medium voltage network
IEEE 1547	Standard for interconnecting distributed resources with electrical power systems.
IEC 60529	Ingress protection test
Grid Connectivity	Relevant CEA Regulations (including LVRT/HVRT compliance) and Grid Code as amended and revised from time to time.

(2) GENERAL REQUIREMENTS OF PCU

- The minimum euro efficiency of the PCU as per IEC 61683 shall be 97%. The bidder shall specify the conversion efficiency at following load conditions i.e. 25%, 50%, 75% and 100% during detail engineering, which shall be confirmed by type test reports.
- The PCU shall remain connected to the grid as per Central Electricity Authority Technical (standards for connectivity to the grid) regulation 2007 with all latest amendments and its components shall be designed accordingly.
- In case auxiliary supply of PCU is met internally, then it should have sufficient power backup to meet the LVRT requirement. Bidder needs to submit the detail auxiliary supply arrangement for PCU during detail engineering stage.
- The PCU shall be capable of operating in the frequency range of 47.5 Hz to 52 Hz and shall be able to deliver rated output in the frequency range of 49.5 Hz to 50.5 Hz.
- The monitoring/measurement of DC inputs and AC output shall be done using transducers/instruments having sensor accuracy of 0.5 class or better.
- Internal Surge Protection Device (SPD) shall be provided in the PCU on DC and AC side. It shall consist of Metal Oxide Variaster (MOV) type arrestors. The discharge capability of the SPD shall be at least 12.5kA at 8/20 micro second wave as per IEC 61643-12.
- The PCU shall be capable of supplying reactive power as per grid requirement (manual intervention through SCADA) during solar generation hours. However,

reactive power support, below 0.95 power factor, might be as the behest of active power.

- The PCU shall have protection against any sustained fault in the feeder line and against lightning discharge in the feeder line.
- The Contractor shall ensure by carrying out all necessary studies that the PCU will not excite any resonant conditions in the system that may result in the islanded operation of PV plant and loss of generation. In case there is excitation of any resonant condition in the system during PV plant operation that may result in the islanding/tripping of the PV plant and affect the power transfer, it shall be the responsibility of contractor to rectify the design and carryout required modification in the equipment of his supply.
- The PCU must be self-managing and stable in operation.
- In case of grid failure, the PCU shall be re-synchronized with grid after revival of power supply. Bidder to furnish the time taken by PCU to be re-synchronized after restoration of grid supply during detailed engineering.
- The PCU shall include appropriate self-protective and self-diagnostic feature to protect itself and the PV array from damage in the event of PCU component failure or from parameters beyond the PCU’s safe operating range due to internal or external causes. The self-protective features shall not allow signals from the PCU front panel to cause the PCU to be operated in a manner which may be unsafe or damaging. Faults due to malfunctioning within the PCU, including commutation failure, shall be cleared by the PCU protective devices.
- PCU shall have active power limit control, reactive power and power factor control feature. Plant operator shall be able to provide (manual intervention) Active power, reactive power and power factor control/limit set point through SCADA HMI and local control display unit (or Laptop computer). PCU shall be provided with remote start and stop facility from SCADA HMI. All required hardware and software required for this purpose shall be provided by Bidder.
- PCU shall have necessary limiters in build in the controller so as to ensure safe operation of the PCU within the designed operational parameters.
- PCU shall have thermal overloading protection to prevent failure of switching devices (i.e. IGBT) and other components of Inverter. PCU controller shall automatically regulate/limit the power output in order to reduce the PCU cabinet and switching devices temperature. Bidder to submit the PCU power vs ambient temperature curve during details engineering stage. PCU shall be able to provide inverter inside cabinet and IGBT's (switching device) temperature (in soft analog value) to SCADA system for remote monitoring, storing and report generation purpose.
- PCU shall have the following feature,
 - a) AC & DC overcurrent protection.
 - b) Synchronization loss protection.
 - c) Over temperature protection.
 - d) DC & AC under and over voltage protection.

- e) Under & over frequency protection.
 - f) Cooling system failure protection
 - g) PV array ground fault monitoring & detection
 - h) PV array insulation monitoring
 - i) LVRT
 - j) Anti-islanding protection
 - k) Grid monitoring
- One number of laptop PC shall be supplied for PCU configuration and troubleshooting purpose. Laptop shall be supplied with complete set of hardware & software accessories. Laptop detailed configuration must ensure suitability for the required applications. Supplied Laptop shall be protected with the latest anti-virus software and shall be provided 3 Years onsite warranty including its battery. At least two sets of communication cable for Laptop to PCU communication shall be provided.
 - PCU shall be provided with Mobile user interface facility for monitoring of inverter by plant O&M personal for better O&M and highest yield from PV plant. In case PCU does not have this facility, then bidder can provide the same facility through plant SCADA system.
 - PCU shall have AC and DC side monitoring capability and reporting to SCADA system (measured analog and digital value measured within PCU). Any special software if required for this purposes shall be provided for local and remote monitoring and report generation.
 - DC Overloading: Maximum PCU DC overloading shall be limited to its design PV Array power to PCU nominal AC power ratio. Bidder needs to submit all the relevant technical documents/test report from PCU manufacturer (OEM) during detailed engineering stage in support of declared PCU design DC overloading capacity.

(3) EARTHING OF INVERTERS:-

The PCU shall be earthed as per manufacturer recommendation. During detail engineering the Bidder needs to submit the details earthing arrangement of PCU and system earth pit requirement during detail engineering stage. The detail specification for panel earthing for safety has been mentioned elsewhere in this specification

(4) OPERATING MODES OF PCU

- a) Low Power Mode: - The PCU shall be able to wake-up automatically when PV array open circuit voltage value is equal/more than preset value in the PCU program. Once it starts generation the PCU shall automatically enter maximum power mode.
- b) Maximum Power Point Tracking (MPPT):- In order to maximized the energy collection from solar PV array, the PCU shall have inbuilt maximum power point tracker (MPPT) controller and MPPT shall be able operate the PV array at its maximum power point by adjusting output voltage of PV array system according to atmospheric condition. PCU MPPT controller shall ensure that it operates the PV array system at its global maximum power point and it shall

not trap into PV array local maximum power point during cloudy atmospheric condition. The PCU shall operate within its MPPT operating input DC voltage range (window). The PCU MPPT operating DC voltage range shall be large enough so that it shall be able to satisfactorily operate the PV modules exposed to the maximum ambient temperature of 50°C or any other condition. In case the solar PV array operating maximum power point voltage fall below (or above) the PCU MPPT operating voltage range, then the PCU controller shall automatically adjust the PCU input voltage so that PCU shall not enter into sleep mode. If the PV array output power fall below the PCU minimum preset power value then PCU shall automatically switched to sleep mode. In case, PV modules connected to Inverter are in Flickering shading zone of Wind turbines, Suitable MPPT algorithm shall be adopted for those Inverters to optimize Energy Yield.

- c) **Sleep Mode:** -PCU shall automatically go into sleep mode when the output voltage of PV array and/or output power of the inverter falls below a specified limit. During sleep mode the inverter shall disconnect from grid. Inverter shall continuously monitor the output of the PV array and automatically start when the DC voltage rises above a pre-defined level. During evening and night (non solar generation hours) the PCU shall be in sleep mode in order to minimize the internal power loss. Maximum loss in sleep mode shall be less than 0.05% of PCU rated power.
- d) **Standby Mode:** - In standby mode the PCU DC & AC contactor are open, inverter is powered on condition and waiting for start command.

(5)PCU shall meet the following technical parameter

Nominal output voltage frequency	50Hz
Continuous operating frequency range	47.5 Hz to 52 Hz
Continuous operating AC voltage range	± 10% rated AC voltage
Operating power factor range	Operating power factor (adjustable) shall be 0.9 Lead to 0.9 Lag.
Maximum input DC voltage	1000V or 1500V as per application
Current THD value	< 4% at nominal load
Operating ambient temperature	0 to 50 ° C
Humidity	95 % non-condensing
Maximum Noise level (at 1 meter distance)	75 dBA for indoor type PCU
DC Injection	<0.5 % at rated current
Flicker	As per IEC61000

(6) Inverter Details

- The string inverter enclosure protection class shall be IP 65 or better protection.

- The string inverter should be placed inside a canopy shed with atleast 15 cm in all direction, if installed in open. Alternatively, the Bidder can also install the inverter on the column post of the module mounting structure, below the modules. In such case, the canopy is not required and the column and foundation shall be designed accordingly.
- String inverter shall have suitable communication port (RS485/TCP-IP/PLC) for SCADA integration. All necessary hardware, software and accessories used for communication with SCADA (including Data logger if supplied) at both the ends shall be provided by the bidder.
- String inverter shall have string monitoring capability and reporting to SCADA system. Any special software if required for this purposes shall be provided for remote monitoring and report generation.
- Anti-PID device along with all hardware and communication cable/device shall be provided in case negative grounding of PV string provision is not available in string inverter. Data logger used in Anti-PID device shall be integrated with SCADA system.
- DC fuse requirement for PV string at string inverter end shall be as per string manufacturer/system requirement and same shall be finalized during detail engineering stage.
- Provision for AC electrical isolation device (such as MCB/MCCB/Isolator) inside string shall be as per string inverter manufacturer practice.
- Local Display unit for viewing important parameters, configuration and troubleshooting purpose shall be provided as per string inverter manufacture practice.

(7) TYPE TESTING

During detailed engineering, the contractor shall submit all the type test reports including temperature rise test and surge withstand test carried out within last ten years from the date of techno-commercial bid opening for Owner's approval. These reports should be for the test conducted on the equipment similar to those proposed to be supplied under this contract and the test(s) should have been either conducted at an independent laboratory or should have been witnessed by a client.

However if the contractor is not able to submit report of the type test(s) conducted within last ten years from the date of techno-commercial bid opening, or in the case of type test report(s) are not found to be meeting the specification requirements, the contractor shall conduct all such tests under this contract at no additional cost to the owner either at third party lab or in presence of client/owners representative and submit the reports for approval.

5.3.4 Cables and Wires

- i. All cables and connectors for use for installation of solar field must be of solar grade which can withstand harsh environment conditions for 25 years and voltages as per latest IEC standards.(Note: IEC standards for DC cables for PV systems is under development, the cables of 600- 1800 volts DC for outdoor installations should comply with the draft EN 50618 for service life expectancy of 25 years)
- ii. Wires with sufficient ampacity and parameters shall be designed and used so that average voltage-drop at full power from the PV modules to inverter should be 2% (including diode voltage drop). PV Modules should be connected with USE-2/RHW-2 cables array to junction box conductors and junction box to photovoltaic disconnecter with the THHN/THWN-2 sunlight resistant with 90°C wet rated insulation cable. Due consideration shall be made for the de-rating of the cables with respect to the laying pattern in buried trenches / on cable trays, while sizing the cables. The Contractor shall provide voltage drop calculations in excel sheet **during detail engineering. Bidder shall also allow following EN 50618, IEC 60228 and IS7098 (Part-2).**
- iii. All cables shall be supplied in the single largest length to restrict the straight-through joints to the minimum number. Only terminal cable joints shall be accepted. No cable joint to join two cable ends shall be accepted. All wires used on the LT side shall conform to IS and should be of appropriate voltage grade. Copper conductor wires of reputed make shall be used. Armoured Aluminium cable connecting SMB and Inverter and also for LT applications are allowed.
- iv. All wires used for connecting the modules and array should conform to the NEC standards. Modules should be connected with USE-2/RHW-2 cables array to junction box conductors and junction box to photovoltaic dis-connector with the THHN/THWN-2 sunlight resistant with 90°C wet rated insulation cable.
- v. All high voltage cables connecting the main junction box/string inverters to the transformers should be PVC insulated grade conforming to IS 1554 and cables shall also conform to IEC 60189 for test and measuring the methods.
- vi. Irrespective of utilization voltage and current rating all type of power cables shall be minimum of 1100 V grade PVC insulated conforming to IS 1554 / IS 694 for working voltage less than 150 V control cable shall be of minimum 500 V grade, the control and power cable shall have to be laid separately. All LT XLPE cables shall confirm to IS: 7098 Part I & II. All HT XLPE Cables (up to 33kV) Shall confirm IS: 7098 **PART-2** & IEC -60287, IEC-60332 and the Contractor to submit technical data sheet, Voltage drop calculation, Power Loss Calculation and type test report for the approval of client / consultants. LV cables with voltage grade less than or equal to 1.1KV shall be as per IS 7098 part - 1, MV cables with voltage grade ranging from 1.1KV to 33KV shall be as per IS 7098 part - 2, HV cables with voltage grade greater than 33KV shall be as per IS 7098 part – 3.

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- vii. The cables shall be adequately insulated for the voltage required and shall be suitably color coded for the required service. Bending radius for cables shall be as per manufacturer's recommendations and IS: 1255.
- viii. Bidder shall also allowed for cable testing and measurement as per IS 7098 (Pt-2) 2011, IS 8130 (2013) and IS 3975 (1999).

Table 5-3 Relevant Codes & Standards for Cable

Sr.	Item	Relevant IS	Relevant IEC
1	Conductors of Insulated Cables	IS: 8130 - 1984	IEC: 228
2	Impulse tests on cables and their accessories		IEC: 230
3	Extruded solid dielectric-insulated power cables for rated voltage from 1 KV upto 30 KV.	IEC: 502	
4	Test methods for insulations and sheaths of electric cables and chords.	IEC: 540	
5	Test on cable over a sheath which has special protective functions and are applied by extrusion.	IEC: 229	
6	Calculations of continuous current rating of cables (100% load factor).	IEC: 287	
7	Cross-linked polyethylene insulated PVC sheathed cable for voltage from 3.3 KV up to 33 KV.	IS: 7098 (Part II)	
8	PVC insulation & sheath of electrical cables.	IS: 5831 - 1984	
9	Mild steel wires, formed wires and tapes for armoring of cables.	IS: 3975	
10	Electrical test methods for electric cables partial discharge test.	IEC: 885(2) - 1987 (Part II)	
11	Methods of test for cables.	IS: 10810	
12	Common test methods for insulating		

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	and sheathing materials of electric cables.	
13	Impulse test on cables & other accessories	
14	Cable termination for gas insulated switchgear.	

5.3.5 Technical Specification for LT XLPE Cable

General Constructional Features

The medium voltage cables shall be supplied, laid, connected, tested and commissioned in accordance with the drawings, specifications, relevant Indian Standards specifications, manufacturer’s instructions. The cables shall be delivered at site in original drums with manufacturer’s name, size, and type, clearly written on the drums.

A. Material:

Medium voltage cable shall be XLPE insulated. PVC sheathed, aluminium or copper conductor, armoured conforming to IS: 7098 Part I.

B. Type:

The cables shall be circular, multi core, annealed copper or aluminium conductor, XLPE insulated and PVC sheathed, armoured.

C. Conductor:

Uncoated, annealed copper, of high conductivity upto 4 mm² size, the conductor shall be solid and above 4 mm², conductors shall be concentrically stranded as per IEC:228.

D. Insulation:

XLPE rated 70° c. extruded insulation.

E. Core Identification:

- Two core : Red and Black
- Three core : Red, Yellow and Blue
- Four core : Red, Yellow, Blue and Black

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Single core : Green cable with Yellow strips for earthing

Black shall always be used for neutral.

F. Assembly:

Two, three or four insulated conductors shall be laid up, filled with non-hygroscopic material and covered with an additional layer of thermoplastic material.

G. Armour:

Galvanised steel flat strip / round wires applied helically in single layers complete with covering the assembly of cores.

- For cable size upto 25 Sq. mm. : Armour of 1.4 mm dia G.I. round wire
- For cable size above 25 Sq. mm. Armour of 4 mm wide 0.8 mm thick G.I strip

H. Sheath:

The cable shall be rated extruded for XLPE 90 deg.C. Inner sheath shall be extruded type and shall be compatible with the insulation provided for the cables.

Outer sheath shall be of an extruded type layer of suitable PVC material compatible with the specified ambient temp 50 deg. C and operating temperature of cables. The sheath shall be resistant to water, ultraviolet radiation, fungus, termite and rodent attacks. The colour of outer sheath shall be black. Sequential length marking required at every 1.0 meter interval on outer sheath shall be available. The contractor has to furnish resistance / reactance / capacitances of the cable in the technical datasheet.

I. Rating:

Rating shall be as per IS 7098 (part-II).

5.3.6 Technical Specification for HT XLPE Cable

General Constructional Features

A. Conductors:

The conductor shall be of circular stranded Aluminium conforming to IS: 8130 & IEC: 228. It shall be clean, reasonably uniform in size & shape smooth & free from harmful defects. Any other form of conductor may also be accepted if in line with modern trends.

B. Semi-Conductor Barrier Tape/Tapes:

The semi-conducting barrier tape/tapes shall be provided over the conductors.

C. Conductor Screen:

The conductor screen shall consist of an extruded layer of thermosetting semi-conducting compound which shall be extruded simultaneously with the core insulation.

D. Insulation:

The insulation shall be super clean XLPE compound applied by extrusion and vulcanized to form a compact homogenous body.

E. Insulation Screen:

- a. Each insulation have an insulation screen in two parts consisting of:
- b. A water barrier tape/Non-metallic semi-conducting swellable tape part and a metallic screen part.
- c. The non-metallic part shall be directly applied upon the insulation of each core and may consist of an impregnated but nylon/PVC tape or a similar approved material or, an extruded semi-conducting material extruded simultaneously with the conductor screen and insulation (triple extrusion).
- d. The semi-conductor shall be readily strippable and must not be bonded in such a manner that it has to be shaved or scraped to remove.
- e. The metallic part shall consist of a copper tape helical applied with a 30% overlap over the water barrier tape/blocking tape. A binder tape of copper shall be applied over the copper wire metallic screen.

F. Laying Up:

- a. The cores shall be identified on the non-metallic part of the insulation screen by legible printing on the length of each conductor or, by the inclusion of a marker tape.
- b. The cores shall be laid up with a right hand direction of lay.
- c. Binder tape/Moisture barrier:

During layup, a suitable open spiral binder may be applied, at the manufacturer's discretion, before the application of an extruded inner covering.

G. Fillers:

Fillers shall be polypropylene.

H. Inner Covering/Sheath:

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The inner covering shall be extruded over the laid up cores to form compact and circular bedding for the metallic layer.

I. Metallic Layer:

The metallic layer shall be galvanised steel wire.

J. Outer Sheath:

The tough outer sheath, black coloured best resisting PVC polyethylene compound type ST-2 as per IS: 5831 for the operating temperature of the cable shall be provided over the armour as specified in relevant standards by extrusion process.

K. Cable Marking:

a. Embossing on outer sheath:

The following particulars shall be properly legible embossed on the cable sheath at the intervals of not exceeding one meter throughout the length of the cable. The cables with poor and illegible embossing shall be liable for rejection.

- GSECL SPVPP
 - Voltage grade
 - Year of manufacture
 - Manufactures name
 - Successive Length
 - Size of cable
 - ISI mark
- i. Packing and marking shall be as per clause No. 18 of IS 7098 (part I)/1988 amended up to date.
 - ii. Cables inside the control room and in the switchyard shall be laid in Galvanized Cable Trays mounted on mild steel supports duly painted, in constructed trenches with RCC raft and brick sidewalls and provided with removable RCC covers.
 - iii. Cable terminations shall be made with suitable cable lugs & sockets etc, crimped properly and passed through brass compression type cable glands at the entry & exit point of the cubicles.
 - iv. All cable/wires shall be provided with Punched Aluminium tags only. The marking on tags shall be done with good quality letter and number ferrules of proper sizes so that the cables can be identified easily.
 - v. The wiring for modules interconnection shall be in the GI pipe /HD Pipe of approved make.

- vi. Data sheets of individual cable sizes (HT & LT) shall be submitted for approval by the Company. Drum numbers and drum length details shall be submitted with each consignment.
- vii. Cable end terminations and joint kits shall comply with the latest version of the relevant IS standard.
- viii. The cable ends shall be terminated with adequate size copper lugs and sockets etc, single/double compression cable glands. Cable glands shall be of robust construction capable of clamping cable and cable armor (for armored cables) firmly without injury to insulation. The metallic glands shall be earthed at two locations. Suitable lock type crimping lugs shall be used for cable end terminations. Where cables are raising from ground, suitable PVC pipe guarding shall be provided for cable raising with sealing of the guarding PVC pipe including a suitable clamp.
- ix. HT cable termination kits and straight through joints shall be selected as per the cable specifications. Installation shall be as per the instructions given in the manufacturer’s manual. Heat shrinkable type kits only shall be used for HT and LT cables.
- x. Data sheets of the joints and kits shall be submitted for approval by GSECL.

5.3.7 Clamps and Connectors

- i. The bus-support clamps, spacers, T-connectors and various equipment connectors shall be supplied as per the enclosed drawings. The material to be used for these items shall be generally as per the Table 5-4.
- ii. The materials shall be of the best workmanship, and all the sharp edges and corners shall be rounded off. The thickness of tinning, wherever applicable, shall be not less than 10 microns. The minimum thickness of pads made of copper shall be 10 mm and those made out of Aluminium/Aluminium Alloy, shall be 12 mm, unless otherwise indicated in the specifications.
- iii. All the clamps and connectors shall be designed to carry a continuous current not less than 125% of the rated current of the conductor (twin/single as the case may be)/equipment terminal to which these are to be connected. Temperature rise of the connector under the above condition shall not be more than 50% of the temperature of the main conductor/equipment terminal.

Table 5-4 Clamps & Connectors

Sr.	Application	Material
1.	Bolted type connection	
2.	For connection to ACSR/AAAC/	Aluminum Alloy conforming to

Aluminum terminal	designate A6 as per IS 617
3. For connection to copper terminals, with crimping facility to connect ACSR/AAAC jumper	Electrolytic grade copper, forged and tinned
4. Crimping type connection	
5. For connection to ACSR/AAAC jumper	Electrolytic grade aluminum

- iv. All the fasteners (i.e. nut-bolts, washers, check-nuts, etc.) used in the clamps and connectors shall be of non-magnetic stainless steel. The straight bolts shall be fully threaded, and the U-bolts shall be threaded up to 30 mm from the ends. For connectors made out of Aluminium/Aluminium Alloy, the bolts shall be of 12 mm diameter, and for copper connectors the bolts shall be of 10 mm diameter.
- v. The clamps and connectors meant for ACSR and AAAC shall have the same crimping dimensions. It shall be possible to use the same clamp/connector for ACSR or AAAC, as would be required, without any modification/change at site.
- vi. The length of bolt shall be chosen such that after fully tightening the nut and check-nut, minimum 5 (five) threads of the bolt shall project outside the nut/check-nut.
- vii. As an alternative to the various types of clamps and connectors detailed under 2.0 above, the Contractors may offer connectors of Power Fired Wedge Pressure Technology (PFWPT). However, the same needs to be specified in the Bid.
- viii. Connectors of PFWPT type shall meet the general requirements for various connections/joints as indicated in the relevant drawings.
- ix. PFWPT type connectors shall comprise of:
 - a. Tapered 'C' - shaped spring member
 - b. Wedge for connecting solid/stranded conductor along with handle, suitable for connection between:
 - Aluminium & Aluminium
 - Copper & Copper
 - Aluminium & Copper
 - Aluminium & Al. Alloy
 - Copper & Al. Alloy
 - Al. Alloy & Al. Alloy
- i. Components of the PFWPT type connectors shall be made of Aluminium Alloy suitably heat-treated to ensure that the required Mechanical & Electrical parameters are in line with ANS 1 specification no. C 119.4-1991. The connectors shall have

`self-cleaning' capability during application. The connector shall ensure stable and low contact resistance under varying load conditions and the thermal cycling effects.

- ii. The special tools and tackles required for installation of the PFWPT type connectors shall be identified in the offer. One set of these bolts and tackles shall be included in the scope of supply.
- iii. The Contractor shall furnish the following information in their bill of material:
 - a. Availability of the PGWT connectors indigenously.
 - b. Unit rate of each item
 - c. Notwithstanding anything stated above, the final decision regarding acceptance of the type of clamps and connectors (conventional/PFWPT type) shall rest with GSECL

5.3.8 Structural Steel Work

- i. The structural steelwork required for termination incoming 66 KV line/ Cable, equipment supports, lighting masts and for shielding towers together with all foundation bolts shall be included by the Bidder in its scope of work. The steel work shall be fabricated from galvanized structural sections. The height of structures for incoming line shall be as per the design developed by the Bidder and drawings submitted.
- ii. The incoming line gantry shall be designed on the basis of ACSR conductor/Cable considered in the design and also considering that GETCO terminal tower will be located at a distance of not more than 100 meters from the incoming gantry at SPV power station switchyard. The Bidder shall take into account wind load, temperature variation etc. while designing the gantry structure. The column shall be provided with step bolts and anti-climbing devices.
- iii. The entire structural steel work shall conform to IS: 802. The Bidder shall furnish design calculations for approval by Owner before procuring the material.
- iv. The design of the switchyard towers, gantries and equipment structures shall also be designed in conformity with the standards followed by the Company. Approval from the Company also shall be obtained by the Bidder if required.

5.3.9 Hardware

- i. Metal fittings of specified material for string hardware meant for power conductor and earth wire shall have excellent mechanical properties such as strength, toughness and high corrosion resistance. The suspension and tension clamps shall be made from aluminum alloy having high mechanical strength. Suspension and tension clamps offered shall be suitable for ACSR / AAAC conductor as per design.

- ii. All hooks, eyes, pins, bolts, suspension clamps and other fittings for attaching insulators to the tower or to the power conductor shall be so designed as to reduce (to a minimum) the damage to the conductor, insulator or the fitting arising from conductor vibration.
- iii. All drop-forged parts shall be free-from flaws, cracks, or other defects and shall be smooth, close-grained and of true forms and dimensions. all machined surfaces shall be true, smooth and well-finished. The thickness of all structural steel of Switchyard shall be minimum 80 microns measured at all points of the structure member when measured. No averaging is allowed. The gap between base plate of structural members and concrete top of foundation shall be filled with GP-2 grouting material of reputed make. The material of all J-bolts shall be of 8.8 Class.
- iv. All ferrous parts of hardware shall be galvanized in accordance with IS 2629. The galvanization shall withstand four dips of 1-minute duration each in copper-sulphate solution as per the test procedure laid down in the relevant ISS.
- v. The threads in nuts and tapped holes shall be cut after galvanizing, and shall be well-lubricated/greased. All other threads shall be cut before galvanizing.
- vi. Both the suspension and the tension hardware shall be of ball and socket type, and shall be with 'R' and 'W' type security clip of stainless steel or phosphor Bronze conforming to IS 2486. The tension clamps of both compression type and bolted type as shown in the relevant drawings shall be offered. Arcing horns shall be provided on the line side for both the suspension type and compression type hardware.
 - a. Danger Plates
- vii. Size of each Danger Notice plates shall be 200 mm x 150 mm made of mild steel sheet and at least 2 mm thick, and vitreous enameled white on both sides and with inscription in signal red colors on front side as required. The inscriptions shall be in Gujarati and English.
- viii. Fire Extinguishing System
 - ix. The installation shall meet all applicable statutory requirements, safety regulations in terms of fire protection
 - x. Liquefied CO2 fire extinguisher shall be upright type of capacity 10 kg having IS: 2171. 7 IS: 10658 marked. The fire extinguisher shall be suitable for fighting fire of Oils, Solvents, Gases, Paints, Varnishes, Electrical Wiring, Live Machinery Fires, and All Flammable Liquid & Gas. Bidder shall provide portable fire extinguisher as given below:

DCP Type(ABC type)(10 kg Cap)	CO₂ Type Hand 9 kg	Foam Type
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		Hand 9 kg
1	1	1

- xi. The minimum 1 no. of fire extinguishers shall be required for every installations / building.
- xii. Sand bucket should be wall mounted made from at least 24 SWG sheet with bracket fixing on wall conforming to IS 2546.

5.3.10 Lightning Protection for PV Array

- i. The source of over voltage can be lightning or other atmospheric disturbance. Main aim of over voltage protection is to reduce the over voltage to a tolerable level before it reaches the PV or other sub-system components as per IS: 2309 – 1989 (Reaffirmed – 2005), Edition 3.1 (2006-01).
- ii. Necessary foundation / anchoring for holding the lightning conductor in position to be made after giving due consideration to shadow on PV array, maximum wind speed and maintenance requirement at site in future.
- iii. The lightning conductor shall be earthed through flats and connected to the earth mats as per applicable Indian Standards with earth pits. Two earth pits shall be provided for each lightning arrester. Each lightning conductor shall be fitted with individual earth pit as per required Standards including accessories, and providing masonry enclosure with cast iron cover plate having locking arrangement, watering pipe using charcoal or coke and salt as required as per provisions of IS & Earth Resistance of Lightning System must be less than one (1) Ohm. Bidder may use maintenance free earth electrodes with compound as per standard.
 - a.If necessary more numbers of lightning conductors may be provided. The Contractor is also free to provide franklin rod / Early Streamer type of lightning arrestors on the MMS structure designed in such a way not to cast shadow on the next raw of solar PV modules. The Contractor to submit necessary calculations based upon rolling sphere method for the Lightning protection system.
- i. The Contractor shall submit the drawings and detailed specifications of the PV array lightning protection equipment to GSECL for approval before installation of system.

5.3.11 AC Network

AC converted by the inverter is transmitted through the appropriate cables from the Inverter to appropriately sized Inverter transformer and from transformer to adequate rating of 11/33KV VCB breakers.VCB breakers should be equipped with adequate protection relays, fuses, annunciations and remote operating and controlling facility from the Main Control Room.Relevant national & international codes to be follows:-

Table 5-5 Relevant National & International Code

Sr.	Item	Relevant IS	Relevant IEC
1	Power transformer	IS 2026	IEC 76
2	Fittings & Accessories	IS 3639	
3	Climate Proofing	IS 3202	IEC 354
4	Loading of Transformer	IS 6600	IEC 296
5	Oil	IS 335	IEC 137
6	Bushings	IS 20650	IEC 144
7	Degree of Protection	IS 2147	IEC 76
8	Testing, Tolerances on guaranteed Particulars	IS 2026	IEC 76
9	Buchholz Relay	IS 3637	
10	Electrical Insulation	IS 1271	IEC 85

- i. Radial scheme through VCB panel is acceptable. It shall have circuit breaker of suitable rating for connection and disconnection of PCU from grid. The bus bar shall connect the AC distribution board to the transformer. It shall have provision to measure bus voltage, current and power of the transformer. Outdoor inverter & RMU panel with IP65 or above are acceptable. In case of outdoor inverters, the inverter station should be properly provided with canopy structure and working platform.
- ii. Bus-bars shall be of high conductivity Aluminium alloy or Copper of adequate size. The bus-bars shall be adequately supported by non-hygroscopic, non-combustible track resistant and high strength type polyester fibre glass moulded insulators. Separate supports shall be provided for each phase and neutral bus bar. The bus-bars joints shall be provided with high tensile steel bolts, Belleville washers and nuts, so as to ensure good contacts at the joints. The bus-bars shall be colour coded as per IS 375.
- iii. The Bidder shall submit the detailed specifications of the AC bus and panel in the Bid.
- iv. The VCB panel with thermal over current and earth fault releases. The incomer shall be selected one size higher than the required rating as per Type 2 selection chart (**For LV switchgear**).

Bid for Design, Engineering, Supply, Procurement, Installation, Commissioning, Operation and Maintenance of 224 MW solar Photovoltaic grid connected power plant ranging from 10 MW to 55 MW at various substations of GETCO of Surendranagar, Morbi Kutchh, Jamnagar & Surat Districts in the State of Gujarat”.

- v. Removable gland plates with gaskets shall be provided in the cable alleys for glanding the power and control cables. The distance between the gland plate and the incomer terminals shall not be less than 450 mm.
- vi. The Contractor should submit theoretical design calculations and detailed explanations along with drawings shall be provided and approved by the Company.
- vii. Design short circuit levels shall be at least as per following table and has to be supported by calculation sheet:

Sr. No	Voltage	Fault level
1	220 KV	40 KA fo 3 sec
2	66 KV	25 KA for 3 sec
3	33 KV	25KA for 3 sec
4	11 Kv	25KA for 3 sec

11 or 33 kV SUBSTATION BLOCKS:

5.3.12 Step-Up Inverter Transformer

- i. The Contractor shall provide the complete turnkey design, supply, erection, testing and commissioning of transformers and transformer substation to first step-up the output of the inverter to 11 or 33 kV at the location of the inverter. Inverter Transformer must be protected with 11 or 33 kV VCB/**RMU** Panel of each inverter block. **Bidder to consider LCR capacity as per their own design.** Hence, total capacity of the solar plant with provision of rated 11/33kV Vacuum Circuit Breaker panel with single outgoing connected. 3 phase, Oil Filled, 11Kv or 33 kV, 50 Hz, Inverter Transformers of the selected inverter rating and associated Switchgear of approved make should be utilized as per IS 6600. 11/33 kV Inverter transformers can be off-load tap change type. The transformers shall be suitable for outdoor installation with 3 phase 50 Hz 11/33 kV system in which the neutral is effectively earthed, the Contractor may consider the guidelines of inverter manufacturer for transformer neutral earthing. Transformer can be with floated neutral.
- ii. **Bidder shall have to consider transformer MVA rating asper AC capacity with adequate design margin.**
- iii. Cumulative loss shall be as per IGBC / CBIP guidelines. All electrical equipment and installation shall confirm to the latest Indian Electricity Rules as regards safety, earthing and other essential provisions specified for installation and operation of electrical plants. The Contractor may consider the timeline of guideline of inverter manufacturer for Transformer neutral earthing. The transformer can be floated neutral.

- iv. Relevant national and international standards in this connection are mentioned in Table 5-6 General Standards for Transformers.
- v. All working parts, insofar as possible, are to be arranged for convenience of operation, inspection, lubrication and ease of replacement with minimum downtime. All parts of equipment or of duplicate equipment offered shall be interchangeable.
- vi. The quality of materials of construction and the workmanship of the finished products/ components shall be in accordance with the highest standard and practices adopted for the equipment covered by the specification.
- vii. All items of equipment and materials shall be thoroughly cleaned and painted in accordance with relevant Indian Standards. The finish paint shall be done with two coats of epoxy based final paint of colour Shade RAL 7032 of IS:5 for indoor equipment
- viii. Any fitting or accessories which may not have been specifically mentioned in the specification but which are usual or necessary in the equipment of similar plant or for efficient working of the plant shall be deemed to be included in the contract and shall be provided by the Contractor without extra charges. All plant and apparatus shall be complete in all details whether such details are mentioned in the specifications or not.
- ix. All equipment shall be designed for operation in tropical humid climate at the required capacity in an ambient air temperature of 50°C. Equipment shall be suitable for an ambient temperature of 50°C. Maximum relative humidity of 100% shall also be taken into consideration for design of equipment.
- x. The reference ambient temperatures for which the transformers are to be designed are as mentioned in Table 5-7.
- xi. The rating and electrical characteristics of the MV / 11 kV Outdoor type transformer (typical) shall be as mentioned in Table 5-8

Table 5-6 General Standards for Transformers

IS: 2026 (Part 1 to 4)	Specifications for Power Transformer
IS: 2099	Bushings for alternating voltage above 1000 V
IS: 3639	Fittings and accessories for power transformer
IEC: 60076 (Part 1 to 5)	Specifications for Power Transformer
IS: 9921 Part 1 to 5	Alternating currents dis-connectors (isolators) and earthing switches rating, design, construction, tests etc.