B-3 AC CABLES

1.0 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 (IS codes, standards, etc.) referred to herein, the former shall prevail. All the cables shall conform to the requirements of the following standards and codes:

IS:7098 (Part -I)	Cross linked polyethylene insulated PVC sheathed cables for working voltages upto and including 1100V.
IS:7098 (Part -II)	Cross linked polyethylene insulated PVC sheathed cable for (Part -II) working voltage from 3.3 KV upto & including 33 KV
IS :1554 - I	PVC insulated (heavy duty) electric cables for working voltages upto and including 1100V.
IS : 3961	Recommended current ratings for cables
IS : 3975	Low carbon galvanised steel wires, formed wires and tapes for armouring of cables.
IS : 5831	PVC insulation and sheath of electrical cables.
IS : 8130	Conductors for insulated electrical cables and flexible cords.
IS : 10810	Methods of tests for cables.
ASTM-D -2843	Standard test method for density of smoke from the burning or decomposition of plastics.
ASTM-D-2863	Standard method for measuring the minimum oxygen concentration to support candle like combustion of plastics.
IEC-754 (Part-I)	Tests on gases evolved during combustion of electric cables.
IEC-332 Part-3:	Tests on electric cables under fire conditions. Tests on bunched wires or cables (Category-B).
IEEE-383	Standard for type test of Class IE Electric Cables
IS : 4905	Methods for random sampling.
IS : 10418	Specification for drums for electric cables.

2.0 General Requirements (For both LT and HT Cables as applicable):

- The cables shall be suitable for laying on racks, in ducts, trenches, conduits and underground (buried) installation with chances of flooding by water and shall be flame retardant, low smoke (FRLS) type designed to withstand all mechanical, electrical and thermal stresses developed under steady state and transient operating conditions. However, cables shall be armored type if directly buried, laying shall be as per latest relevant IS code.
- XLPE insulation shall be suitable for a continuous conductor temperature of 90 deg. C and short circuit conductor temperature of 250 deg C. PVC insulation shall be suitable for continuous conductor temperature of 70 deg C and short circuit conductor temperature of 160 deg. C.

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

Calculated nominal dia.of cable under armour	Size and Type of armour
Upto 13 mm	1.4mm dia GS wire
Above 13 & upto 25mm	0.8 mm thick GS formed wire / 1.6 mm dia GS wire
Above 25 & upto 40 mm	0.8mm thick GS formed wire / 2.0mm dia GS wire
Above 40 & upto 55mm	1.4 mm thick GS formed wire /2.5mm dia GS wire
Above 55 & upto 70 mm	1.4mm thick GS formed wire / 3.15mm dia GS wire
Above 70mm	1.4mm thick GS formed wire / 4.0 mm dia GS wire

- Outer sheath shall be of PVC as per IS: 5831 & black in colour for power cables. In addition to meeting all the requirements of Indian standards referred to, outer sheath of all the cables shall have the following FRLS properties.
  - Oxygen index of min. 29 (as per IS 10810 Part-58).
  - Acid gas emission of max. 20% (as per IEC-754-I).
  - Smoke density rating shall not be more than 60 % (as per ASTMD-2843).

- Cores of the cables shall be identified by coloring of insulation. Following colour scheme shall be adopted:
  - 1 core - Red, Black, Yellow or Blue
  - 2 core - Red & Black
  - 3 core - Red, Yellow & Blue
  - 4 core - Red, Yellow, Blue and Black

  For reduced neutral conductors (in case of power cable), the core shall be black.

- In addition to manufacturer's identification on cables as per IS, following marking shall also be provided over outer sheath.

  - Cable size and voltage grade - To be embossed
  - Word 'FRLS' at every 5 metre - To be embossed
  - Screen Fault current _ _ _KA for _ _ _ Sec. (Value of current & time shall be indicated) (If applicable)
  - Sequential marking of length of the cable in metres at every one metre -To be embossed / printed

  The embossing shall be progressive, automatic, in line and marking shall be legible and indelible.

- For cable connecting central inverter and inverter transformer, no. of runs and interconnecting trench, bus bar terminations, lugs shall be provided in such a manner so that no overheating of contacts & terminals encountered. Sufficient space for cabling & termination shall be kept.

3.0 CONSTRUCTIONAL FEATURES FOR LT POWER CABLES

a) 1.1 KV grade XLPE power cables shall have compacted aluminium/ copper conductor, XLPE insulated, PVC inner-sheathed (as applicable), armoured/ unarmoured, PVC outer-sheathed conforming to IS:7098. (Part- I). Cables which are directly buried shall be armoured.

b) 1.1KV grade PVC power cables shall have aluminium/copper conductor (compacted type for sizes above 10 sq.mm), PVC Insulated, PVC inner sheathed (as applicable) armoured/ unarmoured, PVC outer-sheathed conforming to IS:1554 (Part-I).

3.1 CABLE SELECTION & SIZING

Cables shall be sized based on the following considerations:

- Rated current of the equipment
- The Maximum Overall Voltage Drop: from Module to Inverter Transformer shall be limited to 3% of rated voltage. For all other LT cables, Maximum Voltage drop shall be limited to 3% of rated voltage..
- Short circuit withstand capability
    - Fault current- As per system fault current.
    - Time- Actual fault clearing Time subject to minimum of 120msec.

For a fuse protected circuit, cable should be sized to withstand the let out energy of the fuse. For breaker controlled feeder, cable shall be capable of withstanding the system fault current level for total breaker tripping time inclusive of relay pickup time.

4.0 CONSTRUCTIONAL FEATURES FOR LT CONTROL CABLES

- 1.1 KV Grade Control Cables shall have stranded copper conductor and shall be multicore PVC or XLPE insulated, PVC inner sheathed, armoured / unarmoured, FRLS PVC outer sheathed conforming to IS: 1554. (Part-1)
- Conductor of control cables shall be made of stranded, plain annealed copper.
- Outer sheath shall be of PVC as per IS: 5831 & grey in colour for control cables.
- Cores of the cables shall be identified by colouring of insulation. Following colour scheme shall be adopted:

  1 core - Red, Black, Yellow or Blue
  2 core- Red & Black
  3 core-Red, Yellow & Blue
  4 core-Red, Yellow, Blue and Black
- For control cables having more than 5 cores, core identification shall be done by numbering the insulation of cores sequentially, starting by number 1 in the inner layer (e.g. say for 10 core cable, core numbering shall be from 1 to 10).

4.1 LT CONTROL CABLE SELECTION & SIZING:

Control cables shall be sized based on the following considerations:

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

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

No. of cores in cable	Min. No. of spare cores
2C, 3C	NIL
5C	1
7C-12C	2
14C & above	3

5.0 CONSTRUCTIONAL FEATURES FOR HT POWER CABLES

- For single-core armoured cables, the armouring may constitute the metallic part of insulation screening
- In case of single core cables where there are both metallic screening and armouring, there shall be extruded inner sheath between them.
- Distinct extruded PVC inner sheath of black colour as per IS:5831 shall be provided for the cables as follows:
  a) For all multicore cables.
  b) For single core armoured cables, where armouring is not being used as metallic screen
- Cores of the cables of up to 3 cores shall be identified by coloring of insulation or by providing colored tapes helically over the cores with Red, Yellow & Blue colors.
- The cross-sectional area of the metallic screen strip/tape shall be considered in design calculations.
- The eccentricity shall be calculated as

Eccentricity	Ovality
tmax -tmin **---------- x 100** **t max**	**dmax -dmin** **---------- x 100** **d max**
Where t-max/t-min is the maximum/minimum thickness of insulation and d-max/d-min is the maximum / minimum diameter of the core	

The eccentricity of the core shall not exceed 10% and ovality not to exceed 2%

5.1 Cable selection & sizing

HT cables shall be sized based on the following considerations:

a) Rated current of the equipment

b) As per protection time grading requirement subject to minimum of 0.3 sec. For final power evacuation feeder, the time shall be min. 1.0 sec.

6.0 TESTS

All acceptance and routine tests as per the specification and relevant standards shall be carried out. Charges for these shall be deemed to be included in the equipment price. All cables to be supplied shall be of type tested design as per relevant standard.

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

B-4 Energy Management System and SCADA

1.0 GENERAL

Energy Management System (EMS) system shall be a computerized system for real time monitoring, operation, control, reliable & efficient operation and optimization of performance of the Solar and BESS Plant. SCADA system shall be part of EMS system. EMS shall be able to acquire real time data of various equipment of Solar and BESS system, have in built logic/programming to monitor, control, and optimize the performance of Solar and BESS according to IEC61724 standard and as per specification.

Bidder shall provide complete Energy management and SCADA system with all Hardware, Software, Panels, Power Supply, HMI, Laser Printer, Gateway, Networking equipment and associated Cable accessories, auxiliaries and associated equipments needed for the completeness even if the same are not specifically appearing in this specification for the safe, efficient and reliable operation of entire solar and BESS Plant and its auxiliary systems.

1.1 EMS System shall have the provision to perform the following functions:

a. Load and source prioritization.

b. Real-time acquisition and display of data, status, alarms and trends

c. Display of status of major equipments in Single Line/Mimic Diagram. Mimic Diagram colour shall comply with IS 11954: Guide for colour coding of electrical mimic diagrams.

d. Control of switchgears (as per requirement to meet objective of point a above) and Inverters (PCU and PCS)

e. Display and storage of measured values and important data , derived/calculated/integrated values, Alarm, Event and Trends

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

g. Generate, store and retrieve user configurable periodic reports. SCADA shall have facility to generate report in MS Excel file type.

h. Remote monitoring of essential parameters of plant on the web using popular web browser without requirement of additional software. Same shall be authorised with user id and password using standard modem. User ID and password for remote view can only be changed by SCADA/EMS Administrator.

i. System self-supervision

j. Operate the BESS as per application requirement.

k. Logic functions for control, protection and annunciation of the equipments and systems.

l. Security of Data from authorized access using Hardware Firewall and software access privileges/rights

1.2 EMS shall have provision to control (Switch On/Switch Off) all the MV Breakers and Inverters either in hard or soft signal and shall have facility to control Inverter active and reactive power as per requirement mentioned in respective chapter. EMS shall also be able to acquire real time Data, Status and Alarm from following equipment included but not limited to as required or offered under the scope of this specification:

i. All the MV Switchgear Equipment (Breakers/Earth switches)
ii. Main Incomer and Bus Coupler breaker of LT Panel
iii. UPS and Battery charger as approved in detail Engineering
iv. Weather Monitoring Equipment
v. Energy Meter/Multifunction meter
vi. Numerical Relay
vii. Fire Alarm Panel
viii. Energy Meter
ix. GPS Time Synchronisation unit
x. EMS Hardware, Accessories and Communication link
xi. Transformer
xii. PCU and PCS
xiii. Any other equipment required as per specification

Type of signal from equipment (Hard wired or Soft) shall be decided and approved during detail engineering.

1.3 The contractor shall provide at least one GPS clock, which shall be synchronized with the SCADA/EMS system. All devices having real-time clock (RTC) with time synchronization facility and are communicating with plant SCADA/EMS shall be synchronized with GPS Clock through SCADA/EMS or directly with GPS Clock. The technical details of GPS have been specified elsewhere in the specification

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

finalized during detailed engineering. System shall be designed such that there will be no upset when power is restored. These operation shall be demonstrated by vendor during Factory Accepted Test (FAT) in the presence of NTPC Representative.

1.5 Contractor shall provide a Package/Split AC of suitable capacity decided by load requirement in SCADA Main control/EMS room. All the power supply module, Ethernet switches and network accessories for non-air conditioned area shall be suitable for operating in ambient temperature of 50 Deg C minimum.

1.6 Power plant controller (PPC) shall be provided with two processors (main processing unit and memories), one for normal operation and one as hot standby. In case of failure of working PPC processor, there shall be an appropriate alarm and simultaneously the hot standby PPC processor shall take over the plant control function automatically. The transfer from main processor to standby processor shall be totally bump less and shall not cause any plant disturbance whatsoever. It shall be possible to keep any of the PPC processors as master and other as standby. The standby processor shall be updated in line with the changes made in working processor. The solar plant along with BESS SCADA and PPC networks shall be suitably designed, so that PPC shall directly and independently able to control the individual solar inverter/PCS. Detailed control logic in the PPC shall be finalized during detailed engineering stage.

2.0 SCADA CONTROLLER SYSTEM

The SCADA shall be of PLC based and shall have the following feature:

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

ii) It shall be provided with two processors (main processing unit and memories), one for normal operation and one as hot standby. In case of failure of working processor, there shall be an appropriate alarm and simultaneously the hot standby processor shall take over the complete plant operation automatically. The transfer from main processor to standby processor shall be totally bump less and shall not cause any plant disturbance whatsoever. In the event of both processors failing, the system shall revert to fail safe mode. It shall be possible to keep any of the processors as master and other as standby. The standby processor shall be updated in line with the changes made in working processor.

iii) The memory shall be field expandable. The memory capacity shall be sufficient for the complete system operation and have a capability for at least 20% expansion in future. Programmed operating sequences and criteria shall be stored in non-volatile semiconductor memories like EPROM. All dynamic memories shall be provided with buffer battery backup for at least 360 hours. The batteries shall be lithium or Ni-Cd type.

iv) Priority of different commands shall be as follows:

- Manual intervention shall be possible at stage of operation. Protection commands shall have the priority over manual commands and the manual commands shall prevail over automatic commands.
- A forcing facility shall be provided for changing the states of inputs and outputs, timers and flags to facilitate fault finding and other testing requirements. It shall be possible to display the signal flow during operation of the program.

2.1 HUMAN MACHINE INTERFACE SYSTEM (HMIS)

i) HMIS configured around latest state-of-the art servers/Workstations with open architecture supporting OPC /TCP/IP protocols, etc.

ii) Engineering workstation (EWS) shall work as a programming station both for controller and SCADA and shall perform control, monitoring and operation (as applicable). It shall be possible to use same EWS as programming station and the Human Machine Interface System.

iii) In addition to a desktop based EWS, vendor shall also provide dedicated portable (laptop) based EWS.

iv) All frequently called important functions including major displays shall be assigned to dedicated function keys on a soft keyboard for the convenience of the operator for quick access to displays & other operator functions.

v) The mimic shall be configured on the HMI and it shall be possible to control, monitor and operate the plant from the same.

2.2 PROGRAMMING FUNCTIONALITIES

i) Programming of the PLC Processor/controller as well as programming of HMIS shall be user friendly with graphical user interface and shall not require knowledge of any specialized language. For example, the programming of PLC shall use either of the following:

- Flow-chart or block logic representing the instructions graphically
- Ladder diagrams

ii) The programming of HMIS (like development and modification of data base, mimics, logs / reports, HSR functionalities etc.) shall also be possible through user-friendly menus etc.

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

2.3 SYSTEM SPARE CAPACITY

- Over and above the equipment and accessories required to meet the fully implemented system as per specification requirements, Control System shall have 10 % spare capacity and necessary hardware/ equipment/ accessories to meet following requirement for future expansion at site:

- Ten (10) percent spare relays of each type and rating mounted and wired in cabinets TB. All contacts of relays shall be terminated in terminal blocks of cabinets.

- The spare capacity as specified above shall be uniformly distributed throughout all cubicles. The system design shall ensure that above mentioned additions shall not require any additional controller/processor/ peripheral drivers in the system delivered at site. Further, these additions shall not deteriorate the system response time / duty cycle, etc. from those stipulated under this specification.

2.4 SCADA PANEL/CABINET/CONTROL DESK/FURNITURE

i) The SCADA cabinets shall be IP-22 protection class.

ii) The Contractor shall ensure that the packaging density of equipment in these cabinets is not excessive and abnormal temperature rise, above the cabinet temperature during normal operation or air-conditioning failure, is prevented by careful design. The Contractor shall ensure that the temperature rise is limited to 10 deg. C above ambient and is well within the safe limits for system components even under the worst condition and specification requirements for remote I/O cabinets. Ventilation blowers shall be furnished as required by the equipment design and shall be sound proof to the maximum feasible extent. If blowers are required for satisfactory system operation, dual blowers with blower failure alarm shall be provided in each cabinet with proper. Suitable louvers with wire mesh shall be provided on the cabinet.

iii) Contractor shall provide the two power supply feeders (DC supply or UPS AC) and one raw supply feeder of suitable rating to cater all the load requirements of SCADA panel/cabinet/control desk. System shall remain in service in case of single power supply failure/power supply module failure. Suitable alarm shall be generated in case of any power supply failure.

Sl No.	**Features**	**Industrial Grade Engineering Cum Operator Workstations/ Operator workstations/ Other workstations/ Documentation station (in case not part of prog. Stn.)**
1.	Processor	**Engineering Cum Operator Workstations:** 64 bit Server Grade (Xeon or Equivalent), Octacore minimum
2.	Memory	**Engineering Cum Operator Workstations:** 16 GB RAM upgradable to 24 GB minimum
3.	Hard Disk	**Engineering Cum Operator Workstations:** 1 TB RAID1 **For Historian:** 1 TB ultra wide RAID1
4.	Communication port	**Engineering Cum Operator Workstations:** 2 Serial bus. Expansion slot=2
5.	Monitor (color)	Min 22” TFT Flat Monitor with non-interfaced refresh rate min. 75 Hz, Graphic Memory = 16 MB
6.	Network Connectivity	**Engineering Cum Operator Workstations:** 4 Nos. Built-in Ethernet Network Port, Wifi
7.	Additional general purpose software (for using over network by servers/workstations/PCs)	Comprehensive disk maintenance utility for disk clean sweep/ crash guard/antivirus, etc.

8.	Software	MS. Windows latest, MS Office Editor (EXCEL,WORD, POWER POINT), Adobe Acrobat, Anti Virus, Network Security, Etc.

2.5 FACTORY ACCEPTANCE TEST (FAT)

Factory acceptance test of SCADA will be done as per the requirement for which FAT procedure shall be submitted by the bidder for NTPC approval and after approval of FAT procedure, FAT will be witnessed by NTPC Engineering. SCADA shall communicate with all third party devices which are part of Solar Plant and the same shall be demonstrated during the FAT.

3.0 TIME SYNCHRONISATION EQUIPMENT

Time Synchronization equipment complete in all respect shall be provided and shall be located in the Control Room. It shall receive Coordinated Universal Time (UTC) transmitted through Geo Positioning Satellite (GPS) for time synchronization of all components of Solar PV and BESS SCADA.

The system shall be fully tested to the relevant international standards such as IEC: 801 and IEC: 255.

All components of the SWYD SAS, including Substation Controllers, Workstations, Bay Control Units (BCU) and Bay Protection units (BPU) and all numeric protection relays as per requirement under this scope of technical specification or offered by bidder shall be synchronized with an accuracy of 1ms.

The GPS shall be synchronized with the SCADA system to be supplied under this contract. Necessary software and Hardware (including laying of communication cable) required for time synchronization with SCADA and all other devises shall be in scope of contractor.

B-5 INSTRUMENTATION AND COMMUNICATION CABLE

1.0 COMMUNICATION CABLE (Optic Fibre Cable)

Optic Fiber cable shall be 8/12 core, galvanized corrugated steel taped armored, fully water blocked with dielectric central member for outdoor /indoor application so as to prevent any physical damage. The cable shall have multiple single-mode or multimode fibers on as required basis so as to avoid the usage of any repeaters. The outer sheath shall have Flame Retardant, UV resistant properties and are to be identified with the manufacturer's name, year of manufacturing, progressive automatic sequential on-line marking of length in meters at every meter on outer sheath.

The cable core shall have suitable characteristics and strengthening for prevention of damage during pulling viz. Steel central number, Loose buffer tube design, 4 fibers per buffer tube (minimum), Interstices and buffer tubes duly filled with Thixotropic jelly etc. The cable shall be suitable for maximum tensile force of 2000 N during installation, and once installed, a tensile force of 1000 N minimum. The compressive strength of cable shall be 3000 N minimum & crush resistance 4000 N minimum. The operating temperature shall be -20 deg. C to 70 deg. C.

All testing of the optic fiber cable being supplied shall be as per the relevant IEC, EIA and other international standards.

Bidder to ensure that minimum 50% (but not less 4) cores are kept as spare in all types of optical fiber cables

Cables shall be suitable for laying in conduits, ducts, trenches, racks and underground buried installation.

Spliced/ Repaired cables are not acceptable.

Penetration of water resistance and impact resistance shall be as per IEC standard.

2.0 Communication Cable (Modbus)

Data (Modbus) Cable to be used shall be shielded type with stranded copper conductor based on VDE 0881 . Cable shall have minimum 2 pair each with conductor size of 0.5 SQMM and core identification shall comply with DIN 47100. Cable shall be flame retardant according to IEC 60332-1-2. or equivalent Standard Surge protection device to be provided shall be approved from UL/CSA or any national/international approved lab.

3.0 INSTRUMENTATION CABLES

3.1 Common Requirement

S No.	Property	Requirement
1.	Voltage grade	225 V (peak value)
2.	Codes and standard	All instrumentation cables shall comply with VDE 0815, VDE 0207, Part 4, Part 5, Part 6, VDE 0816,