

Model Technical Specifications

For

**Power Conditioning / Conversion
System (PCS)**

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Contents

1	General	3
2	Functionality	3
3	Construction	4
4	Technical Parameters	5
5	Monitoring, Protection & Control	6
6	Integration with Energy Management System	7
7	Earthing	7
8	Isolation & Interconnection with Grid	7
9	Testing requirement of Power Conditioning System	8
9.1	Type Test	8
9.2	Factory Acceptance Test (FAT)	9
9.3	Site Acceptance Test	9

Definitions, acronyms, and abbreviations

For the purposes of this document, the following terms and definitions apply

Definitions

electric power system (EPS): The power system network that acts as source/sink for the battery energy storage system

energy capacity: The energy available for transfer either from battery energy storage system to the grid or vice versa, usually expressed in kWh or MWh.

Energy management system: The software and hardware used for carrying out the targeted application of the BESS

islanding: A scenario when the main BESS along with the PCC is electrically isolated from the EPS

Module: A module consists of several cells generally connected in either series or parallel.

off grid: A working condition of BESS, which means the BESS disconnects from EPS. In this condition, the superior area EPS that BESS subordinated to is not connected to the EPS.

on grid: A working condition of BESS. In this condition, the superior area EPS that BESS subordinated to is connected to the EPS

power conditioning system (PCS): A system which acts as an energy interface between batteries and EPS, it regulates the voltage and current outputs of batteries.

power capacity: The power available for transfer either from the battery energy storage system to the grid or vice versa, usually expressed in kW or MW.

point of common coupling (PCC) (of BESS): The common connection point where the BESS is connected to the EPS.

P/Q mode: BESS performs as a controlled current source with the ability to adjust its active and reactive power.

PCC transformer: HV/EHV transformer connecting the EPS with the MV system of BESS

PCS transformer: MV transformer connecting AC side of PCS to the MV system of BESS

response time: the time required for the BESS to achieve the desired state of operation due to a control action.

state of charge (SOC): The degree to which a BESS is charged relative to the maximum possible amount of energy that can be stored by the system, typically expressed as a percentage.

string: An energy storage system consisting of two or more series connected cells up to the required system voltage

sub-systems of BESS: A complete subsystem of BESS includes a power conditioning system, battery management system, and batteries (or battery system). A BESS subsystem can operate independently with connection to monitoring, information exchange, and control (MIC). In general, a BESS consists of one or more BESS sub-systems.

Terms and definitions of terminologies related to BESS shall be as defined in IEC 62933 relevant latest version.

Acronyms and abbreviations

BESS	battery energy storage system
BMS	battery management system
DOD	depth of discharge
DR	distributed resources
EMS	energy management system
EPS	electric power system
MIC	monitoring, information exchange and control
PCC	point of common coupling
PCS	power conditioning system
PF	power factor
SCADA	supervisory control and data acquisition
SOC	state of charge
SOH	state of health
THD	total harmonics distortion

SECTION – Power Conditioning System

1 General

- a) The Power Conversion System (PCS) shall be bi-directional Inverter and shall act as an interface between the DC battery system & the AC grid.
- b) PCS shall be designed to charge & discharge the BESS battery in coordination with energy management system and battery management system.
- c) The PCS may consist of a single unit or multiple parallel units. Paralleling may be carried out at DC or AC terminals.
- d) The PCS shall be capable of delivering rated active and reactive power for the rated duration, without violating temperature rise limits, at the specified site ambient conditions.

2 Functionality

- i. The PCS shall:
 - a. Be a bi-directional inverter with four-quadrant operation
 - b. The PCS circuit topology shall be voltage source (that is, the PCS at its AC terminals shall appear to the grid as a voltage source rather than as a current source and, at its DC terminals, shall be capable of reversing current flow in the battery without reversing the polarity of the DC bus). Remain continuously synchronized with grid voltage, frequency, and phase
 - c. Use self-commutated power electronic devices (IGBT or equivalent), adequately rated
 - d. Continuous combined rating of all PCSs shall not be less than BESS Plant capacity with 0.95 p.f. at 50-degree temperature.
 - e. Capacity used in the plant may be chosen such that it can comply the 0.95 power factor capability as per the CEA regulation of the total BESS plant at Point of Interconnection (400 KV, 220 KV, 132 KV, 33 KV, as applicable) of Grid Substation switchyard.
- ii. The design shall comply with:
 - a. CEA Connectivity to the Grid Regulations, 2007, including latest amendments
 - b. IEEE 519 (Harmonics)
 - c. Other applicable Indian Grid Codes
 - d. shall remain valid and effective for the entire design life of the BESS.
 - e. Contractor shall provide the only central PCS
- iii. Same size and same make of PCS is recommended for the whole plant.
- iv. Automatic 'sleep' mode shall be provided so that unnecessary losses are minimized.
- v. The PCS shall support following functions:
 - a. Black Start operation
 - i. The PCS shall be capable of starting and operating as black start i.e., without the presence of the utility voltage. Exercise of the black start capability shall be manual and interlocked and shall under no circumstance result in an accidental energizing of the Host Utility's bus.

- ii. PCS black start shall be possible from EMS without any setting modification at PCS panel locally.
 - iii. In case auxiliary supply of PCS is met internally, then it should have sufficient power backup to meet the LVRT requirement.
 - iv. Contractor to submit third-party verified OND files of the battery inverter during detail engineering.
- b. Ancillary Services (PRAS, SRAS, TRAS, etc.),
- c. Synthetic Inertia response as per grid requirements.
- d. Static Var Generation (SVG) and reactive power support as per grid requirement. PCS shall have Static Var Generation (SVG) function.
- vi. The PCS shall be capable of automatic, unattended operation, including:
 - a. Self-protection & Self-diagnostic to protect itself from damage in the event of component failure or the excursion of operating parameters beyond a safe or expected range. This includes excursions due to internal or external causes. The self-protective features shall prevent the PCS from being operated in a manner that may be unsafe or damaging.
 - b. Faults due to malfunctions within the PCS, including commutation failures, shall be cleared by the PCS over-current protection device(s).
 - c. Synchronization
 - d. Paralleling with grid
 - e. Safe disconnection

3 Construction

- i. The PCS shall consist of fast acting solid state electronic switches along with all associated control & protection, filtering, measuring instruments and data logging devices.
- ii. The PCS shall use only self-commutated device which shall be adequately rated.
- iii. Outdoor PCS enclosure must be suitable to withstand the harsh environmental conditions for complete life of plant. Suitable shed along with canopy shall be provided for outdoor installation.
- iv. For outdoor solution (Other than containerized), the electronic card compartment shall have IP 65 or better protection.
- v. Bidder to submit temperature endurance test report of complete assembly during detail engineering stage.
- vi. Containerized solution shall have projection of at least 60cm wherever an opening in the inverter door exposes the inverter component to outside environment. Structural steel and paints for shed shall be as per ISO 12944-5.
- vii. Outdoor inverter (including containerized solution) platform shall be raised Min 1250 mm from NGL. Cable bending radius and other relevant factors to be considered during platform design. This shall be reviewed and finalized during detailed engineering.

4 Technical Parameters

i.	Rating (kVA)	As per project requirement
ii.	Nominal output voltage frequency	50Hz
iii.	Continuous operating frequency range	47.5 Hz to 52. Hz
iv.	AC Voltage Range	± 10% of rated AC voltage
v.	Efficiency at rated power	Minimum 97% (as per IEC 61683)
vi.	Surge Protection Device (SPD)	<ul style="list-style-type: none"> • Type-I & II DC side • Type-II AC side
vii.	Euro efficiency	Minimum 97% (as per IEC 61683)
viii.	Operating power factor range	1.0 Lead to 1.0 Lag
ix.	IP rating	Min. IP-20 (Indoor) or Min. IP-55 (Outdoor)
x.	SVG /Four Quadrant Operation	Required.
xi.	Voltage/Current harmonics	As per CEA regulation requirement / IEEE 519
xii.	Current THD value	< 3% at nominal power
xiii.	DC Injection	<0.5 % at rated current
xiv.	Operating ambient temperature	As per section project
xv.	Humidity	95 % non-condensing
xvi.	Maximum Noise level	75 dBA (for indoor application)
xvii.	Flicker	As per CEA regulation requirement
xviii.	Remote start and stop facility from SCADA/EMS	Required.
xix.	Active power limit control, reactive power, and power factor control features.	Required. Possible both from PPC and/or EMS SCADA.
xx.	PCS designed DC fault current level	Maximum short circuit current of Battery system connected to PCS and duration continuous.
xxi.	PCS designed AC fault current level	Maximum short circuit current of LV side of Inverter Duty transformer and duration one sec.
xxii.	Cooling	Air / Liquid Cooling

		<p>Contractor may offer liquid cooling system subject to Employer's approval.</p> <p>In case Liquid cooled inverters are offered, the contractor ensures that coolant is used in closed cycle.</p> <p>Complete PCS along with cooling system shall be of proven design.</p>
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5 Monitoring, Protection & Control

The PCS shall include the following protections as minimum:

- a) AC & DC Overcurrent
 - b) AC & DC Over / Under Voltage
 - c) Over / Under Frequency
 - d) Synchronization Loss
 - e) Over-temperature
 - f) Cooling System Failure
 - g) LVRT / HVRT
 - h) Anti-Islanding
 - i) Grid Monitoring
 - j) Battery Ground Fault (if applicable)
 - k) Insulation Monitoring (if applicable)
- The PCS shall have built-in limiters and thermal derating logic to ensure safe operation under all conditions.
 - PCS shall provide real-time cabinet and switching device temperature to SCADA (soft analog).
 - Power vs Ambient Temperature derating curve along with DC & AC voltage shall be submitted during detailed engineering.
 - The PCS 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 PCS will not excite any resonant conditions in the system that may result in the islanded operation of BESS plant and loss of generation. In case there is excitation of any resonant condition in the system during BESS plant operation that may result in the islanding/tripping of the BESS plant and affect the power transfer, it shall be the responsibility of contractor to rectify the design and carry out required modification in the equipment of his supply.
 - In case of grid failure, the PCS shall be re-synchronized with the grid after revival of power supply. Bidder to furnish the time taken by PCS to be resynchronized after restoration of grid supply during detailed engineering.
 - PCS shall have necessary limiters in-built features in the controller so as to ensure safe operation of the PCS within the designed operational parameters.
 - PCS shall have thermal overloading protection to prevent failure of switching devices and other components of Inverter. PCS controllers shall automatically regulate/limit the power output to reduce the PCS cabinet and switching devices temperature.
 - PCS shall have emergency stop push button for tripping of inverter with complete DC & AC electric isolation.
 - Monitoring
 - a. Local Display unit for viewing important parameters, configuration and troubleshooting purpose shall be provided.

- b. PCS shall be able to provide inverter inside cabinet and switching devices temperature (in soft analog value) to SCADA system for remote monitoring, storing and report generation purpose.
- c. PCS shall have suitable communication cards for networking and SCADA/EMS integration and same shall support dual master communication.
- d. PCS shall include all important measured & internal calculated analog values and alarm & trip signals for remote monitoring, storing and report generation purpose in SCADA system. Details list of above such parameters shall be provided along with their Modbus address during detail engineering stage.
- e. PCS shall have AC and DC side monitoring capability and reporting to SCADA/EMS system (measured analog and digital value measured within PCS).
- f. Any special software if required for this purpose shall be provided for local and remote monitoring and report generation.
- g. String Monitoring facility:- PCS shall be provided with current monitoring transducer at incoming DC cables from each battery array. The current transducers used for this purpose shall have accuracy of 1.0 class or better.

6 Integration with Energy Management System

- All-important alarm and trip signals shall be configured in the PCS and their corresponding modbus address shall be provided for SCADA/EMS configuration. Signals such as LVRT in action and trip operated, HVRT trip, islanding protection operated, over current operated, Inverter cabinet temperature high alarm and all other important signals shall be necessarily included. Details signal list shall be finalized during detailed engineering stage.
- PCS shall communicate with EMS on IEC 60870-5-104 or IEC 61850

7 Earthing

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

8 Isolation & Interconnection with Grid

- Must have provision to be isolated from grid through Air Circuit Breaker/MCCB. The ACB/MCCB as required can be provided as a part of PCS/its Modules or separately based on standard design and configuration of PCS manufacturer.
- The ACB and MCCB shall be able to withstand the maximum fault current for minimum one sec duration. ACB/MCCB shall be able to isolate PCS from AC grid under all fault current condition. Any alternate provision other than ACB/MCCB which is recommended by OEM and meeting the requirement, shall be considered on a case-to-case basis during detailed engineering stage.
- PCS shall have suitable rated DC isolator/contactors for isolation of DC Battery system from inverter. Suitable rated fuse shall be provided (at inverter end) in incoming DC cable from battery system. One set spare terminal with fuse/link (as applicable) and holder shall be provided for future use.
- The PCS should be designed for parallel operation through galvanic isolation. Solid state electronic devices shall be protected to ensure smooth functioning as well as ensure long life of the inverter. Parallel operated PCS system are also accepted subjected to recommendation of PCS manufacturer. In such case, PCS design shall also ensure that no abnormal interaction shall take place among the PCS unit during any grid operating condition which may result in outages.

- In case of modular design of PCS is offered, the Contractor shall ensure that no abnormal interaction shall take place among the various PCS modules during any grid operating condition which may result in outages. The PCS controller offered by the Contractor shall be such as to ensure stability, reliability, and good dynamic performance. The Bidder shall indicate the control scheme adopted for modular PCS and its merits and the test which will check its performance.

9 Testing requirement of Power Conditioning System

9.1 Type Test

During detailed engineering, the contractor shall submit all the type test reports as per following codes & standard 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.

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

1.	IEC-61683 Ed.1	Photovoltaic systems - Power conditioners - Procedure for measuring efficiency requirements
2.	IEC 61000-6-2 Ed.2	Electromagnetic compatibility (EMC) - Part 6-2: Generic standards - Immunity standard for industrial environments.
3.	IEC 61000-6-2 Ed.2.1	Electromagnetic compatibility (EMC) - Part 6-4: Generic standards - Emission standard for industrial environments.
4.	IEEE 519-2022	Recommended practices and requirements for harmonic control in electrical power systems.
5.	IEC 60068-2-1:2007	Environmental testing - Part 2-1: Tests - Test A: Cold
6.	IEC 60068-2-2:2007	Environmental testing - Part 2-2: Tests - Test B: Dry heat
7.	IEC 60068-2-14:2009	Environmental testing - Part 2-14: Tests - Test N: Change of temperature
8.	IEC 60068-2-30:2005	Environmental testing - Part 2-30: Tests - Test Db: Damp heat, cyclic (12 h+ 12 h cycle)
9.	IEC 62116 Ed.2	Testing procedure—Islanding prevention measures for power conditioners used in grid- connected photovoltaic (PV) power generation Systems
10	IEC 62477-1	Safety Requirements for power electronic converter systems and equipment-Part-1: General

11	IEC 62477-2	Safety Requirements for power electronic converter systems and equipment-Part-2: Power electronic converters from 1000Vac or 1500V DC up to 36kV AC or 54kV DC
12	IEEE 1547/IEC 61727/ BDEW (as applicable)	Standard for interfacing solar PV plant with utility grid.
13	IEC 60529	Ingress protection test
14	CEA Grid Connectivity Standard	Relevant CEA regulations and Indian grid code as amended and revised from time to time.

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.

9.2 Factory Acceptance Test (FAT)

Factory Acceptance Test shall be performed at Manufacturer's premises and tests to be covered under FAT shall be as per guidance of Quality Acceptance Section.

9.3 Site Acceptance Test

Contractor shall submit a comprehensive plan for site acceptance test (SAT) to approving authority for approval. SAT plan shall include procedures to test correct system responses to system disturbances and operating scenarios described in the specification.

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