

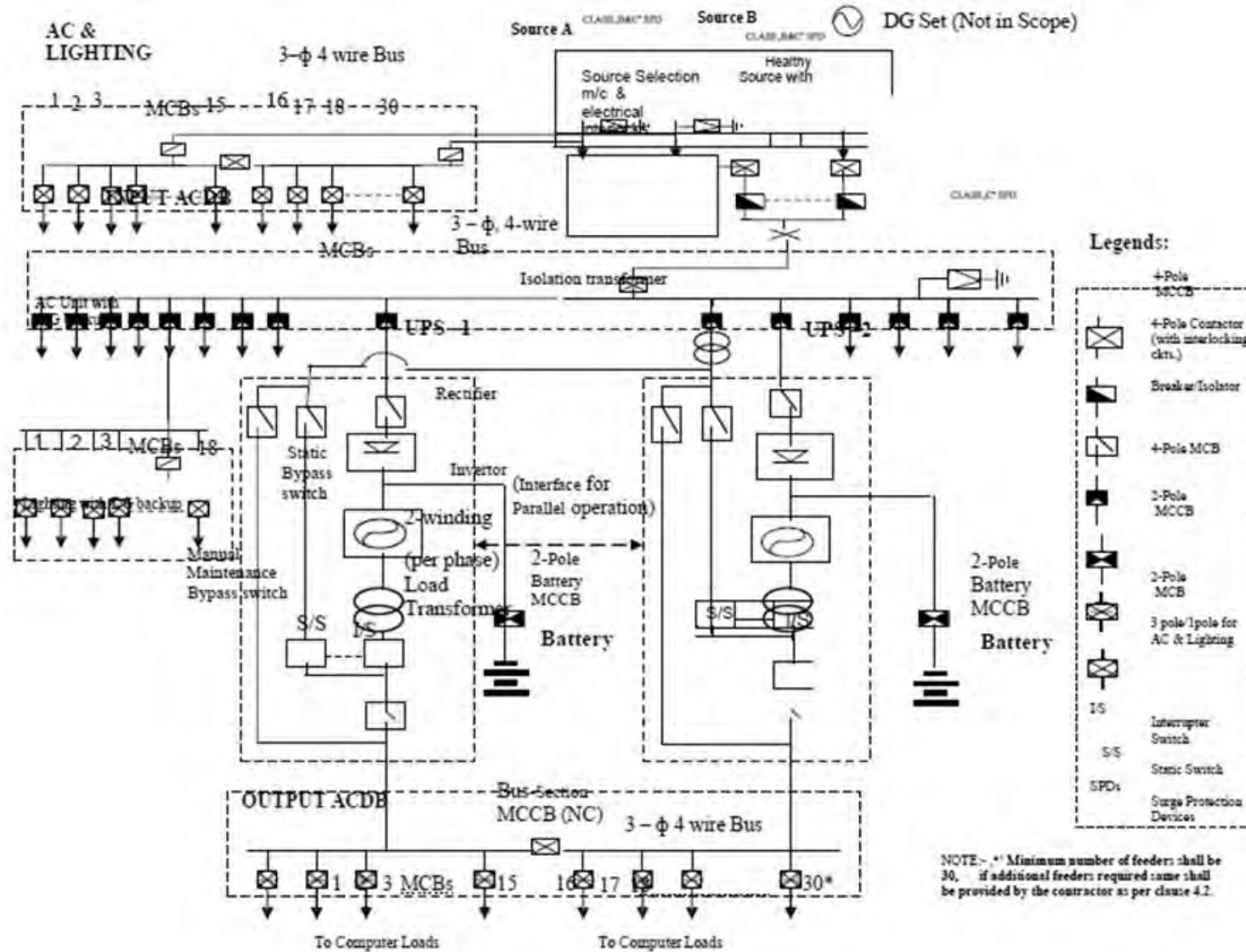
14.1.4 Rectifier/Charger Units

Each rectifier/charger unit output voltage shall be regulated to match the characteristics of the batteries and inverter. The rectifiers/chargers shall provide voltage regulated DC power to the invertors while also charging and maintaining the batteries at full capacity.

The rectifier/charger units shall have the following characteristics:

- Input Voltage and frequency characteristics as per clause 14.1.3 above.
- Input current limit of 125 percent of the nominal full load input current
- Maximum input current total harmonic distortion of 5 percent at nominal input voltage and under full load.
- The output shall be current limited to protect the rectifier/charger unit circuitry and to prevent the batteries from over-charging.
- Capacity to recharge the batteries to 90% of its capacity (from fully discharged state i.e. ECV of 1.75) within 8 hours while carrying full load.
- Automatic equalizing after partial discharge of the batteries.
- Temperature dependent battery charging with temperature sensing probes mounted on the battery banks.
- Automatic float cum boost charging feature.

FIG. 14-1: CONCEPTUAL AUXILIARY POWER SUPPLY SYSTEM CONFIGURATION



14.1.5 Invertors

The invertors shall normally operate in synchronism with the mains AC power source. Upon loss of the mains AC power source or its frequency deviating beyond a preset range, the invertors shall revert to their own internal frequency standard. When the mains AC source returns to normal, the invertors shall return to synchronized operation with the mains AC source. Such reversal of operation of invertors from synchronous to free running mode and vice-versa shall not introduce any distortion or interruption to the connected loads. A suitable dead band for frequency may be provided to avoid unnecessary frequent reversal of inverter operation between free running mode and synchronized mode under fluctuating frequency conditions.

The invertors shall have the following characteristics:

- (a) Inverter unit shall be based on Pulse Width modulation (PWM) technique.
- (b) The nominal output voltage shall be 415 Volt $\pm 1\%$, 3-phase, 4-wire AC up to rated load.
- (c) The transient voltage response shall not exceed $\pm 4\%$ for the first half-cycle recovering to $\pm 1\%$ within ten cycles for a 100 percent step load application or removal.
- (d) The free running frequency shall not deviate by more than $\pm 0.1\%$ for the rated frequency of 50 Hz.
- (e) The invertors shall be synchronized to the main AC source unless that source deviates from 50 Hz by more than 1% (adjustable to $\pm 1/2/3/4/5\%$).
- (f) The output voltage harmonic distortion shall not exceed 5% RMS and no single harmonic component shall exceed 3%.
- (g) The invertors shall be capable of resistive load operation & deliver at least 80% of the nominal capacity at the rated power factor and be capable of operation with loads ranging from the rated through unity power factor. Inverter shall also accept 100% load at crest factor of at least 3:1 for Switching Mode Power Supply (SMPS) load of computer system equipments without de-rating.
- (h) The invertors shall provide protection logic to automatically shut down and isolate itself from the load when the battery voltage drops below a preset voltage.
- (i) The invertors shall provide interrupter switch to isolate the unit from the load on failure of the unit. The interrupter switch shall be rated to carry full continuous load and to interrupt the inverter under full fault load.
- (j) The invertors shall be capable of supporting a start-up surge or overload of 150 percent of rated output for up to 60 seconds.

In case the inverter subsystem does not include an internal load transformer, an external load transformer of delta-wye configuration, 3-phase, 50Hz, 415 V AC, suitable for the inverter shall be provided.

14.1.6 Static Bypass Switches

Each UPS system shall include static bypass switch to facilitate automatic transfer of loads from the inverter sub-system output to bypass AC source through isolation transformer. Isolation transformer shall be rated for at least two times the rating of single UPS sub system. However, in case of parallel-redundant UPS systems, the transfer to Static bypass must occur only when the invertors of both the UPS systems have failed.

The transfer to Static Bypass from the inverter shall take place under the following fault conditions:

- (a) The inverter load capacity is exceeded
- (b) An over- or under-voltage condition exist on the inverter output
- (c) Inverter failure.

The static bypass switches shall be high-speed devices rated to transfer and carry full rated load. The static bypass switches shall provide protection to prevent out of phase transfers. The switching speed of the static bypass switches shall be less than 1 millisecond. During the changeover, the output voltage should not fall below 205V A.C, 50Hz $\pm 5\%$, in order to avoid any disruption to computer load supply. An automatic transfer back to the inverter subsystem shall occur if the transfer from the inverter subsystem was caused by a temporary overload and the load has returned to normal or by a temporary over/under voltage condition on inverter output and the voltage has returned to normal.

The transfer back to the inverter subsystem, both automatic and manual, shall be inhibited under the following conditions:

- a. The frequency of bypass AC source is outside the frequency band of $\pm 1\%$ of 50Hz (adjustable to $\square 1/2/3/4/5$ percent).
- b. The inverter output voltage and frequency are beyond the preset range.
- c. An overload exists.

14.1.7 Manual Maintenance Bypass Switches

Manual bypass switches are provided to facilitate maintenance of the UPS system and shall provide transfer of the connected load from one UPS output to the other UPS system. These switches shall be rated to transfer and carry continuous full rated load.

14.1.8 Batteries

UPS system shall have a set of storage batteries designed for continuous UPS application. The battery set shall have sufficient capacity to maintain output at full rated load for the specified backup duration after 8 hour charging. The backup duration of the battery shall be as specified in the BOQ. The battery set shall be maintenance free VRLA type Batteries. The detailed requirement of batteries is given under clause 14.4.

14.1.9 Battery Breaker for UPS system

A 2-pole MCCB of suitable rating shall be provided near the battery bank (at suitable location on the frame of the battery bank) to allow disconnection of the batteries from the rectifier/charger unit and inverter. This shall also provide over-current protection to the battery circuits.

14.1.10 UPS Control/Monitoring

The Contractor shall supply control panel to permit automatic & manual operation of UPS, display of associated alarms and indications pertaining to the UPS. In each UPS system, a local display of the following analog and status/alarm signals/indications as a minimum shall be included Analog signals for the following measurements:

AC input voltage (to display each phase)

- i. AC output voltage (to display each phase)

- ii. AC output current (to display each phase)
- iii. AC input mains Frequency
- iv. AC UPS Output Frequency
- v. DC voltage (battery subsystem)
- vi. DC current (battery subsystem) Status/Alarms signals for the following indications:
 - a) Parallel operation of inverters
 - b) Inverters running in synchronized / free running mode
 - c) Battery Low voltage alarm (battery subsystem)
 - d) Load on battery alarm
 - e) Battery Circuit Breaker Open alarm
 - f) Overload trip alarm
 - g) High-temperature alarm Equipment failure alarm

For remote monitoring a wall mounted type panel consisting of audio visible alarm or PC based monitoring system shall be provided in the control room. For PC based monitoring system required computer hardware and software shall be provided by the contractor. The monitor of PC shall be 15" TFT type.

14.1.11 Internal Wiring

All internal wires shall be of stranded copper conductor, sized according to the current requirements with minimum insulation rating of 1100 VAC. Extra-flexible wire shall be used for all circuits mounted on door or swing panels within the UPS.

14.1.12 Enclosures/Panels design

The UPS electronic equipment and associated circuitry & all devices shall be housed in a freestanding enclosures/panels. Modules and sub-assemblies shall be easily replaceable and maintainable. Cable entry shall be from the bottom/top of the enclosures (to be finalized during detailed engineering). The applicable degree of protection of enclosures shall be IP20 however, suitable protection shall be provided against vertical dripping of water drops. UPS shall be installed with the necessary base frame including anti-vibration pad. The thickness of the structural frames and load bearing members shall be minimum 2.0 mm and for front & rear, sides, bottom and top covers shall be minimum 1.6 mm. For other requirement of enclosure/panel, clause 14.2.3.4 may be referred.

14.1.13 Equipment / Panel Earthing

Each enclosure shall include suitable signal & safety earth networks within the enclosure. The signal-earthing network shall be separate & terminated at a separate stud connection, isolated from safety earth network. Each earth network shall be a copper bus bar, braid or cable. The contractor shall connect safety and signal earths of each enclosure to the earth grid/earth riser through suitable 50X6 sq. mm. GI strips. For other requirement of enclosure/panel earthing, clause 14.2.3.5 may be referred.

14.1.14 External Power Connections

All breakers/switches shall be suitably rated to match the requirement of external power

connections.

14.1.15 Testing of UPS

14.1.16 Type Test of UPS

The Contractor shall supply type tested UPS equipments. The Contractor shall submit the UPS type test reports of earlier conducted tests (including performance & EMC requirements) on the same make, model, type & rating as offered, as per IEC 62040 or equivalent EN/BS standards. For type testing requirements in addition to provisions of chapter 18 is also to be complied.

14.1.17 Factory Acceptance Test of UPS

A factory acceptance test shall be conducted on all the equipments and shall include, but not be limited to the following, appropriate to the equipment being tested:

- (a) Verification of all functional characteristics and requirements specified
- (b) Voltage drop and transients generated during switching operations
- (c) System efficiency tests
- (d) Verification of all features and characteristics included in all the delivered equipments and also as per specification requirements.
- (e) Inspection and verification of all construction, wiring, labeling

14.1.18 Documentation, and completeness of the hardware

Before the start of factory testing, the Contractor shall verify that all change orders applicable to the equipment have been installed. As a part of the factory tests, unstructured testing shall be performed to allow Employer representatives to verify proper operation of the equipment under conditions not specifically tested in the above structured performance test. A minimum of 8 hours of the factory test period shall be reserved for unstructured testing. The Contractor's test representative shall be present and the Contractor's technical staff members shall be available for consultation with Employer personnel during unstructured test periods. All special test facilities used during the structured performance test shall be made available for Employer's use during unstructured testing.

The respective factory acceptance tests for UPS are listed in Table 4.1

14.1.19 Environmental Conditions

UPS & all other hardware and components shall be capable of continuous operation at rated load without failures in the following environmental conditions:

Temperature/humidity - Ambient temperature of 0⁰ to 50⁰C and upto 95 percent humidity, non-condensing. However, air conditioned environment shall be provided for VRLA batteries.

Table 4.1: LIST OF FACTORY & SITE TESTS FOR UPS

Sl. No.	Test	Factory Acceptance Tests	Site Tests
1.	Interconnection Cable Check	√	√
2.	Light Load Test	√	
3.	UPS Auxiliary Devices Test	√	√
4.	A.C. input failure Test	√	√
5.	A.C. input return Test	√	√
6.	Simulation of parallel redundant UPS fault	√	
7.	Transfer Test	√	√
8.	Full Load Test	√	√
9.	UPS Efficiency test	√	
10.	Unbalanced Load test	√	
11.	Balanced Load test	√	
12.	Current division in parallel or parallel redundant	√	
13.	Rated stored energy time test (Battery test)		√
14.	Rated restored energy time test (Battery test)		√
15.	Battery ripple current test		√
16.	Overload capability test	√	
17.	Short circuit test	√	
18.	Short-circuit protection device test	√	
19.	Restart test	√	√
20.	Output Over voltage test	√	
21.	Periodic output voltage variation test	√	
22.	Frequency variation test	√	
23.	Harmonic Components test	√	
24.	Earth Fault test	√	
25.	On site ventilation test		√
26.	Audible noise test	√	
27.	Parameter/Configuration settings	√	√
28.	Phase Sequence Test	√	√
29.	Coordination and discrimination of Tripping of associated breakers (MCCB/MCBs) in upstream		√

14.2 AC Distribution Boards

AC distribution boards shall be provided for UPS input and output power distribution. The distribution boards shall distribute power and provide protection against failures on feeder circuits, to the equipment. The Contractor shall be responsible for design, engineering, manufacturing, supply, storage, installation, cabling, testing & commissioning of AC distribution boards required for distribution of power. The nominal input frequency is 50 Hz, which may vary from 47.5-52.5Hz. The phase to neutral input voltage shall be (Nominal 240V) varying from 190V to 265 V.

The Input ACDB will cater for the load requirements of DC power supply system, air-conditioning alarm system, fire protection alarm system, lighting loads and one spare of 20A minimum, in addition to UPS system load. The Output ACDB shall cater for only critical

loads in the control center. The number of feeders and their ratings in the output ACDB shall be decided during detail engineering. At least five spare feeders in the output panel shall be provided.

All MCCBs shall conform to IEC-60947-2 & IS 13947-2/IEC 947-2, IEC-60898 and IS8828 and shall be of Four (4) Pole type of requisite rating. MCBs used for load feeders in output ACDB shall be of minimum curve B characteristics. The load feeders shall be coordinated with requirement of loads of computers and other loads.

14.2.1 Enclosures/Panels

The equipments of ACDBs shall be physically mounted in freestanding enclosures/panels. MCCBs and sub-assemblies shall be easily replaceable and maintainable. Cable entry shall be from the bottom/top of the enclosures (to be finalized during detailed engineering). The Contractor shall state the type, size and weight of all enclosures and indicate the proposed manner of installation. The applicable degree of protection of enclosures shall be at least IP21. The thickness of the structural frames and load bearing members shall be minimum 2.0 mm and for front & rear, sides and top covers shall be minimum 1.6 mm. For wall mounted type of output ACDB the above requirements shall not be applicable.

14.2.2 Equipment/Panel Earthing & Surge Protection

Each enclosure shall include suitable safety earth networks as per clause 14.2.3.5. . Surge protection devices shall be installed in the input ACDB to provide adequate protection against current and voltage transients introduced on input AC due to load switching surges. These protection devices shall be in compliance with IEC- 61312, IEC- 61024 and VDE 0100-534 for following surges:

a) Low Voltage Surges (Class C)

Between	Requirement
R, Y, B & N	$I_n \geq 10 \text{ kA}, 8/20 \mu\text{S}$ for each phase
N & PE	$I_n \geq 20 \text{ kA}, 8/20 \mu\text{S}$

I_n = Value of Nominal Discharge Current.

14.2.3 Cabling Requirements

The contractor shall supply, install and commission all power cables, control cables, network interface cables and associated hardware (lugs, glands, cable termination boxes etc.) as required for all equipment. The contractor shall be responsible for cable laying and termination at both ends of the cable. The Contractor shall also be responsible for termination of owner supplied cables if any at contractor's equipment end including supply of suitable lugs, glands, terminal blocks & if necessary cable termination boxes etc. All cabling, wiring and interconnections shall be installed in accordance with the following requirements.

14.2.3.1 Power Cables

All external power cables shall be stranded aluminum/Copper conductor, armoured XLPE/PVC insulated and sheathed; 1100V grade as per IS 1554 Part-I. The conductor for the Neutral connection from UPS to Output ACDB shall be sized 1.8 times the size of the Phase conductors to take care of the non-linear loads. However, the cable between UPS & Battery bank shall be of copper conductor (armoured type).

14.2.3.2 Cable Identification

Each cable shall be identified at both ends, which indicates the cable number, and the near-end

and far-end destination. All power cables shall have appropriate color for identification of each phase/neutral/ground. Cable marking and labelling shall comply with the requirements of the applicable standards.

14.2.3.3 Cable and Hardware Installation

The Contractor shall be responsible for supplying, installing, and terminating all cables and associated hardware (lugs, glands, etc.), required to mechanically and electrically complete the installation of facilities for the project.

14.2.3.4 Enclosures/Panels design

Enclosures/panel shall be of freestanding type of design. Cable entry shall be from the bottom/top of the enclosures (to be finalized during detailed engineering). The enclosures shall not have doors that are wider than 80 cm and doors shall be hinged with locking as per standard design of the manufacturer. Keyed locking is required with identical keys for all enclosures. The enclosures shall not exceed 220 cm in height. The thickness of the structural frames and load bearing members shall be minimum 2.0 mm and for others shall be minimum 1.5 mm. The panels/boards shall be equipped with necessary cable gland plates. The Contractor shall state the type, size and weight of all enclosures and indicate the proposed manner of installation.

Wiring within panel shall be neatly arranged and securely fastened to the enclosure by non-conductive fasteners. Wiring between all stationary and moveable components, such as wiring across hinges or to components mounted on extension slides, shall allow for full movement of the component without binding or chafing of the wire. Conductors in multi-conductor cables shall be individually color coded, and numbered at both ends within enclosures.

The enclosures shall be painted inside and outside. The finish color of all enclosures shall be aesthetically pleasing and shall be approved by the owner. Further, finish color of external surfaces shall be preferably of same color for all enclosures/panels.

Maintenance access to the hardware and wiring shall be through full height lockable doors. Each panel shall be supplied with 240 VAC, 50Hz single-phase sockets with switch. Each ACDB and equipment within ACDB enclosures shall be clearly labelled to identify the enclosure/equipment. All labelling shall be consistent with Contractor-supplied drawings.

14.2.3.5 Enclosure/Panel Earthing

Each enclosure shall include suitable earth networks within the enclosure. Earth network shall be a copper bus bar, braid or cable inside enclosures.

The safety earth network shall terminate at two/more studs for connecting with the earthing grid. Safety earthing cables between equipment and enclosure grounding bus bars shall be of minimum size of 6 mm², stranded copper conductors, rated at 300 volts. All hinged doors shall be earthed through flexible earthing braid.

For all enclosures requiring AC input power, the green earthing wire from the AC input shall be wired to the safety-earthing stud. The Contractor shall provide all required cabling between enclosures for earthing. The contractor shall connect safety and signal earths (as applicable) of each enclosure to the nearest earth grid/earth riser through suitable 50X6 sq. mm. GI/25x3 Cu strips. The contractor may use the existing grid wherever available. In case the suitable earthing grid is not available the same shall be made by the contractor.

The signal earthing network shall terminate at a separate stud connection, isolated from safety ground. The stud connection shall be sized for an external earthing cable equipped with a suitable lug.

All earthing connections to equipment shall be made directly to each equipment chassis via earthing lug and star washer. Use of the enclosure frame, skins, or chassis mounting hardware for the earthing network is not acceptable.

14.3 DC Power Supply System

The DC Power Supply system shall be capable of meeting the load requirements for various Telecom equipments, RTUs and other associated equipment located at indoor, i.e. at the substations, the control centers and customer care system. The AC input to the ACDB shall be provided from the ACDB described under clause 14.2 at control center. At other locations the AC input to the DCPS system shall be single phase AC which will be provided from the existing system. At these locations the class B & C level of surge protection (between phase-neutral and neutral – protective earth) as specified under and conforming to IEC 61312, IEC 61024 and VDE 0100-534 shall be installed in the DCPS system.

Surge protection devices shall be installed in the DCPS panel to provide adequate protection against current and voltage transients introduced on input AC due to load switching and low energy lightning surges. These protection devices shall be in compliance with IEC- 61312, IEC- 61024 and VDE 0100-534 for following surges:

a) Lightning Electromagnetic impulse and other High Surges (Class B):

Between	Requirement
Ph & N	$I_{imp} \geq 50 \text{ kA}, 10/350 \mu\text{S}$ for each phase
N & PE	$I_{imp} \geq 100 \text{ kA}, 10/350 \mu\text{S}$

I_{imp} = Value of Lightning Impulse Current

b) Low Voltage Surges (Class C)

Between	Requirement
Ph & N	$I_n \geq 10 \text{ kA}, 8/20 \mu\text{S}$ for each phase
N & PE	$I_n \geq 20 \text{ kA}, 8/20 \mu\text{S}$

I_n = Value of Nominal Discharge Current.

14.3.1 General Technical Requirements for SMPS based DC power supply units

SMPS based DC power supply system is to be used in Auto Float-cum-Boost Charge mode as a regulated DC Power source. DCPS system is to be installed indoors and shall be provided with IP21 panels. The System shall consist of the following:

- (a) SMPS modules
- (b) Controller module to control and monitor all DCPS modules.

The number and rating of SMPS modules shall be provided as per the Employer's requirements stipulated in the BOQ. The Panel, Distribution/Switching arrangement shall be provided for the ultimate system capacity. Ultimate System capacity is defined as 150% of the present capacity specified. The ultimate capacity is over and above the requirement of redundancy wherever specified. All factory wiring for the panel shall be for the ultimate capacity so that only plugging-in of SMPS module shall enhance the DC power output. The size of fuses, MCBs, switch, bus etc. shall be suitable for the ultimate capacity.

The system shall be sufficiently flexible to serve any load depending on manufacturer's design, rating and number of SMPS modules used in panel and system configuration. To cater for higher load requirements, same type of SMPS modules mounted in the same rack or different racks shall be capable of working in parallel load sharing arrangement. The DCPS system shall be suitable for operation from single phase A.C. mains.

14.3.2 Operational/Component Requirements

The basic modules shall operate at specified ratings and conform to requirements stipulated in this specification. The DCPS system shall meet requirement of the latest TEC specification / IEC/BS for other parameters not specified in this specification. The component parts of the equipment shall be of professional grade of reputed manufacturer to ensure prompt and continuous service and delivery of spare parts. The component shall conform to relevant IEC/IS standards. The contractor shall obtain Employers approval of major component before procurement of the same. Conceptual diagram for DCPS is shown in figure 4-2.

The DCPS shall be suitable for operation at ambient temperature of 0-50 deg and relative humidity up to 95 %. Utility may specify requirements as per site conditions

14.3.3 Wiring

All insulated conductors except those within the confines of a printed circuit board assembly shall be of the rating enough to withstand the maximum current and voltage during fault and overload. All insulated conductors/cables used shall conform to IS 1554 or equivalent international standard.

All wiring shall be neatly secured in position and adequately supported. Where wires pass through any part of metal panel or cover, the hole through which they pass shall be suitably secured.

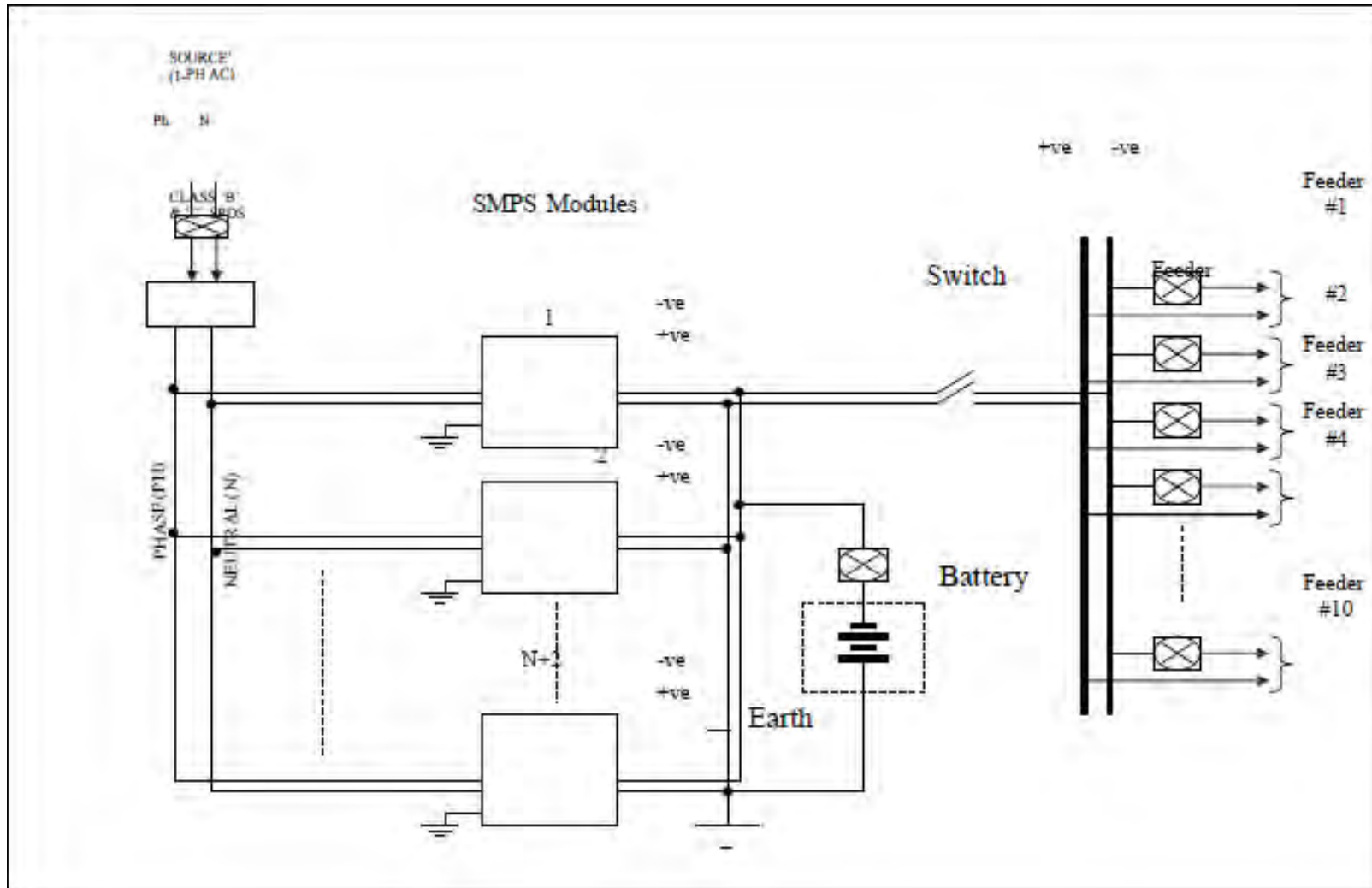
14.3.4 Bus Bars

High conductivity Cu bus bar shall be provided and shall be sized to take care of the current of ultimate DCPS system capacity for which it is designed. However, it shall not be less than 25mm X 5mm.

14.3.5 Earthing

Two earth terminals shall be provided in the frame of the system. The Contractor shall connect these earth terminals to the earth bus. All modules and devices shall be connected to these earth terminals. The hinged door shall be connected to the panel with braided Cu at two points at least.

FIG. 4-2 : CONCEPTUAL CONFIGURATION OF DC POWER SUPPLY (DCPS) SYSTEM



14.3.6 Finish and Painting

The finish of Steel/Aluminum alloy structure and panels shall conform to relevant IS specification (or equivalent international specifications). The color scheme for panel, Door and Modules shall be decided during detailed engineering.

14.3.7 Marking and Labelling of Cables

The Contractor shall propose a scheme for marking and labeling the inter panel cables and get it approved from the Employer. A cabling diagram, screen printed or any other better arrangement ensuring better life expectancy shall be placed in the inside of the front door or any other convenient place for ready reference of the maintenance staff.

14.3.8 Name Plate

A name plate etched, engraved, anodized or any other better arrangement ensuring better life expectancy shall be suitably fixed on each panel /module and contain at least the following information :

- (a) Type of the Unit / Model No
- (b) Manufacturer's Name and identification
- (c) Unit serial No
- (d) Year of manufacture
- (e) Input voltage and phase
- (f) Output Voltage and Current

14.3.9 System and Panel Configuration

The mechanical and electrical requirements of the Panel are described as below:

14.3.10 System Configuration

The SMPS modules shall be accommodated in panels. The system shall employ a modular configuration to provide flexibility, keeping in view the future load requirements of DC Power. The system shall be configured for ultimate capacity as brought out in clause 14.3.1 General Technical Requirements. The control, Monitoring, Alarm arrangement and DC & AC distribution shall be provided suitably in the panel.

The number of SMPS modules to be provided in the DCPS system shall be provided in $N+2$ configurations, where N is the number of SMPS modules to meet the battery charging current (10% of C10 AH Capacity) of the offered battery plus the load requirement stipulated in the BOQ. The current rating of each module shall be considered as output current of the SMPS module at nominal voltage (48V).

It shall be possible to easily mount/remove the modules from the front side of the panel. The SMPS modules/SMPS module sub-racks shall be designed to slide into the panels and fixed securely by a suitable mechanical arrangement.

14.3.11 Constructional Features of Panel

Panel (Enclosure) shall be freestanding type of design. Cable entry shall be from the bottom/top of the enclosures (to be finalized during detailed engineering). The enclosures shall not have doors that are wider than 80 cm and doors shall be hinged with locking as per standard design of the manufacturer. Keyed locking is required with identical keys for all enclosures. The enclosures shall not exceed 220 cm in height. The thickness of the structural frames and load bearing members shall be minimum 2.0 mm and for others shall be minimum 1.5 mm. The panels/boards shall be equipped with necessary cable gland plates. The Contractor shall state the type, size, and weight of all enclosures and indicate the proposed manner of installation.

Wiring within panel shall be neatly arranged and securely fastened to the enclosure by non-conductive fasteners. Wiring between all stationary and moveable components, such as wiring across hinges or to components mounted on extension slides, shall allow for full movement of the component without binding or chafing of the wire. Conductors in multi conductor cables shall be individually color coded, and numbered at both ends within enclosures.

The enclosures shall be painted inside and outside. The finish color of all enclosures shall be an aesthetically pleasing and shall be approved by the owner. Further, finish color of external surfaces shall be preferably of same color for all enclosures/panels.

Maintenance access to the hardware and wiring shall be through lockable, full height, from doors.

Each panel shall be supplied with 240 VAC, 50Hz single-phase sockets with switch and lighting lamp for panel illumination.

The manufacturer so as to ensure the uninterrupted use of the equipment shall do proper thermal engineering of hardware design. The Panel shall be designed to allow cooling preferably by natural convection. The Bidders shall submit detail design of proposed Panel/enclosure and heat dissipation calculations during detailed engineering. Forced cooling is permitted (DC Fans are permitted in the Panel or SMPS module) for equipment mounted indoors (buildings/rooms/shelters). If cooling is provided at Panel level it shall be provided with additional fan with facility for manual switch over. Proper filtering shall be provided to control dust ingress. There shall be an arrangement for automatic Switching-OFF of fans during AC input failure. The required individual modules may be separated by air baffle to provide effective convection. The manufacturer shall also ensure that the failure of fan does not cause any fire hazards. The failure of any of the fans shall draw immediate attention of the maintenance staff.

14.3.12 Electrical Requirements:

AC input supply: The nominal input frequency is 50 Hz, which may vary from 47.5-52.5Hz. The input voltage shall be single phase (Nominal 240V) varying from 190V to 265V.

There shall be an automatic arrangement for shutting off of the SMPS module whenever the input voltage is beyond the specified operating limits with suitable alarm indication. The SMPS module shall resume normal working automatically when the input is restored within the working limits. Hysteresis within specified working limits shall not cause shutting down of the SMPS. A tolerance of $\pm 5V$ may be acceptable for protection & alarm operation.

14.3.13 DC output Characteristics of Modules

The module shall be capable of operating in “Auto Float-cum-Boost Charge” mode depending on the condition of the battery sets being sensed by the Control unit.

- a) The float voltage shall be continuously adjustable & pre-settable at any value in the range of –48 to –56V either at the module or may be set from the common controller configuration. Further, the prescribed float voltage setting shall be based on recommendations of the VRLA battery supplier.
- b) In Boost charge mode SMPS shall supply battery & equipment current till terminal voltage reaches set value, which is normally 2.3V/cell (55.2V) or as recommended by the VRLA battery supplier & shall change over to constant voltage mode
- c) The DC output voltage variation shall not be more than 2% for load variation from 25% load to full load.

14.3.14 Current Limiting (Voltage Droop)

The current limiting (Voltage Droop) shall be provided in DCPS modules in float and boost charge modes of operation. The float/boost charge current limiting shall be continuously adjustable between 50 to 100% of rated output current for output voltage range of –44.4 volts to –56 Volts.

The float and boost charge current limit adjustment shall be provided in the DCPS system. The SMPS modules shall be fully protected against short circuit. It shall be ensured that short circuit does not lead to any fire hazard.

14.3.15 Soft/Slow Start Feature:

Soft/Slow start circuitry shall be employed such that SMPS module input current and output voltage shall reach their nominal value within 10 seconds.

The maximum instantaneous current during start up shall not exceed the peak value of the rectifier input current at full load at the lowest input voltage specified.

14.3.16 Voltage overshoot/Undershoot:

The requirements of (a) to (c) given below shall be achieved without a battery connected to the output of SMPS module.

- (a) The SMPS modules shall be designed to minimize DC output voltage Overshoot/Undershoot such that when they are switched on the DC output voltage shall be limited to $\pm 5\%$ of the set voltage & return to their steady state within 20 ms for load variation of 25% to 100%.
- (b) The DC output voltage overshoot for a step change in AC mains as specified in clause 14.3.12 Electrical Requirements shall not cause shut down of SMPS module and the voltage overshoot shall be limited to $\pm 5\%$ of its set voltage and return to steady state within 20ms.
- (c) The modules shall be designed such that a step load change of 25 to 100% and vice versa shall not result in DC output voltage Overshoot/Undershoot of not more than 5% and return to steady state value within 10 ms without resulting the unit to trip.

14.3.17 Electrical Noise:

The Rectifier (SMPS) Modules shall be provided with suitable filter at output with discharge arrangements on shut down of the modules. The Psophometric Noise and ripple shall be as per relevant standards.

14.3.18 Parallel Operation

SMPS modules shall be suitable for operating in parallel with one or more modules of similar type, make and rating, other output conditions remaining within specified limits.

The current sharing shall be within $\pm 10\%$ of the average current per rectifier module individual capacity of each rectifier module in the system (mounted in the same or different Panels) when loaded between 50 to 100% of its rated capacity for all other working conditions.

14.3.19 Protection

The SMPS module, which has failed (for any reason) shall be automatically isolated from the rest of the modules and an alarm shall be initiated for the failure.

14.3.19.1 DC Over voltage protection

DCPS shall be fitted with an internal over voltage protection circuit.

In case output DC voltage exceeds $-57V$ or as per the recommendations of the manufacturer of batteries, the over voltage protection circuit shall operate & shut off the faulty module. A tolerance of $\pm 0.25V$ is permitted in this case.

Shutting off of faulty SMPS module shall not affect the operation of other SMPS modules operating in the Panel. Operation of over voltage shut down shall be suitably indicated and extended monitoring/control unit. The circuit design shall ensure protection against the discharge of the Battery through the SMPS module in any case. The over voltage protection circuit failure shall not cause any safety hazard.

14.3.20 Fuse/Circuit Breakers

Fuses or miniature circuit breakers (MCB) shall be provided for each SMPS module as follows:

1. Live AC input line
2. Control Circuit

All fuses/circuit breaker used shall be suitably fault rated.

14.3.21 AC Under/Over Voltage Protection

AC input Under/Over voltage protection shall be provided as per clause 14.3.12 for Electrical Requirements.

14.3.22 Over Load/Short Circuit Protection

The SMPS shall be protected for Over load/Short circuit as per clause 14.3.14 Current Limiting (Voltage Droop).

14.3.23 Alarms and indicating lamps

Visual indications/display such as LEDs, LCDs or a combination of both shall be provided on each SMPS module for detection of SMPS module failure.

14.3.24 Termination

Suitable termination arrangements shall be provided in the panel for termination of inter cubicle cables from other equipment such as owners ACDB, Telecom and other associated equipments and alarm cables. All the termination points shall be easily accessible from front and top. AC and DC terminals shall be separated by physical barriers to ensure safety. All the terminals except AC earth shall be electrically isolated.

14.3.25 4.3.25 DC Terminations

All terminations including through MCBs shall be through lock and screw type terminations. Load and batteries shall be connected to DCPS through appropriate MCBs. The isolation of any of the battery from the load shall create an alarm. DC distribution shall be provided with adequate no of feeders (with three no of spare) with appropriate MCBs (6 Amp thru 32 Amp) for termination of the loads. Actual rating of the MCBs and no of feeders shall be finalized during the detail engineering.

DC distribution may be done either on wall mounted panel or on the DCPS panel. The proper rated MCB shall be provided at the combined output of the SMPS modules (if not provided at each SMPS module). All the AC, DC and Control/alarm cabling shall be supplied with the Panel. All DC +ve and -ve leads shall be clearly marked. All conductors shall be properly rated to prevent excessive heating.

14.3.26 Power Cables

All power cables shall be stranded copper conductor XLPE/PVC insulated and PVC sheathed, single core/two core/three core/four core, 1100V grade as per IS 1554 Part-I.

14.3.27 Earthing Cables

Earthing cables between equipment and grounding bus bars shall be minimum size 70 mm² stranded conductors copper/copper strip, rated at 300 volts. All hinged doors shall be earthed through flexible earthing braid. Signal and Safety earthing shall be provided separately.

14.3.28 Alarms

Following Visual indications/display such as LEDs, LCDs or a combination of both shall be provided to indicate:

Functional Indications for local monitoring:

- a) Mains available (not mandatory if provided at module level)
- b) DCPS/SMPSs in Float
- c) DCPS/SMPSs in Charge Mode

Alarm Indication for local monitoring:

- a) Load Voltage High /Low
- b) DCPS module/SMPS fail
- c) Mains out of range
- d) System Over Load
- e) Mains "ON"/Battery Discharge
- f) Temp. Compensation fail
- g) Battery fail/isolated

All the protections/alarms shall be within tolerance of 0.25V in case of DC voltage, 1% in case of DC current and $\pm 5V$ for AC voltage

Alarm Indication for remote monitoring:

- a) Input AC mains supply fail alarm
- b) Battery low voltage (Pre cut off) alarm
- c) DCPS module fail

Potential free Contacts in two numbers for each of the above remote monitoring alarms (one for remote alarm interfaced through RTU and one redundant for local monitoring at suitable location) shall be provided. All these potential free contacts are to be wired and terminated at the suitable location for termination to RTU.

14.3.29 Temperature Compensation for Battery

There shall be provision for monitoring the temperature of battery and consequent arrangement for Automatic temperature compensation of the SMPS output voltage to match the battery temperature dependant charge characteristics. The output voltage of the rectifier in Float/Charge operation shall decrease or increase at the rate of 72 mV (24 cell battery) per degree increase or decrease in temperature over the set voltage or as may be recommended by the VRLA Battery supplier. The output voltage shall decrease till the open circuit voltage of the battery is reached. The open circuit voltage range shall be settable between 2.1V/cell to 2.2V/cell. The increase in output voltage due to decrease in temperature has been taken care of by the tripping of the unit due to output voltage high (57V) protection. Failure of temperature compensation circuit including sensors shall create an alarm and shall not lead to abnormal change in output voltage.

14.3.30 Digital Meters/Display Unit

There shall be provision to monitor the following parameters through digital meters or digital display units:

- (a) Input AC voltage.
- (b) Output DC voltage
- (c) Output DC current of charger
- (d) Battery current
- (e) Load current.

The Digital display of meters or display unit shall be with minimum 31/2 digital display of height 12mm and shall have accuracy 1.5% or better.

14.3.31 Type Testing of DCPS

The contractor shall supply DCPS System, which was already type tested. The test reports for immunity, Emission and surge must be in accordance with relevant IEC/CISPR standards shall be submitted. The Contractor shall submit the DCPS type test reports of earlier conducted tests on the same make, model, type & rating which shall include the following tests. For type testing requirements in addition to provisions of this chapter 18 is also to be complied.

Type Tests on DCPS

- 1 Surge immunity (Level 4- as per IEC 61000-4-5)
- 2 Electrical Fast Transients/Burst (Level 4 – as per IEC 61000-4-4)

- 3 Electrostatic Discharge (Level 4 – as per IEC 61000-4-2)
- 4 Radiated Electromagnetic Field (Level 3 – as per IEC 61000-4-3)
- 5 Conducted disturbances induced by radio-frequency field
(Level 3 – as per IEC 61000-4-6)
- 6 Damped oscillatory magnetic field (Level 3 – as per IEC 61000-4-10)
- 7 Voltage dips, short interruptions and voltage variations
(Level 2 – as per IEC 61000-4-11)
- 8 Conducted Emission (Level - Class A, Group 1 as per IEC CISPR 11)
- 9 Radiated Emission (Level - Class A, Group 1 as per IEC CISPR 11)
- 10 Verification of Protection class (IP 21) for enclosure
- 11 Safety Tests (as per IEC 60950)
- 12 Burn in test for 72 hours at maximum operating temperature

14.3.32 Factory/Site Testing of DCPS

The factory/site tests to be carried out on DCPS system/module in the factory and site are listed respectively in Table below. The manufacturer shall conduct routine tests on all the systems/modules and submit the report before offering for FAT. The routine tests shall include at least the tests mentioned under FAT.

Sl. No.	Test	FAT	SAT
Tests on DCPS System			
1.	Mechanical & Visual Check Tests	√	√
2.	Insulation Test.	√	
3.	High Voltage Withstand Test	√	
4.	Switch On Test	√	√
5.	DCPS Low voltage & High voltage limits check Test	√*	√
6.	Pre-alarm test for Battery Voltage Low	√*	√
7.	Battery Low Voltage Disconnect Level Test	√*	√
8.	AC Input Low and High voltage limits check Test	√*	
9.	Rectifier Fail Alarm Test	√*	√
10.	Voltage Regulation Test	√*	√
11.	Current Sharing Test	√*	
12.	Total Output Power Test	√*	√
13.	Hot Plug In Test	√*	√
14.	Calibration & Parameter settings	√*	√
15.	Automatic Float cum Boost Charge Mode Change Over Test	√*	√

Sl. No.	Test	FAT	SAT
16.	Battery Path Current Limiting Test	√*	√
17.	Battery Charging and full load Current Test	√*	√
18.	Battery Temperature Compensation Test	√*	
19.	Total Harmonic distortion Test	√*	
20.	Burn in Test for 8 hours at max operating temperature	√*	
Tests on SMPS module			
21	Mechanical & Visual Check Test	√*	
22	Module-On Test	√*	
23	Input low/high voltage cut-off test	√*	
24	Voltage Droop Test	√*	
25	Voltage Regulation Test	√*	
26	Power Output & Current Limit Test	√*	
27	DC High Voltage Test	√*	
28	O/P Voltage Ripple Test	√*	
29	Psophometric Noise Test	√*	
30	Efficiency Test	√*	
31	Power Factor	√*	
32.	Input Current Limit	√*	
33.	Input AC Frequency Range Test	√*	
34.	Rectifier Dynamic Response	√*	
35.	Output Short Circuit Test	√*	
36.	Hold up Time Test	√*	

Note* : These tests (Sl. No. 5-36) shall be conducted on 10% samples of the offered batch and other tests (Sl. No 1-4) shall be conducted on each equipment during the FAT.

14.4 BATTERY REQUIREMENTS

The contractor shall supply Valve Regulated Lead Acid (VRLA) maintenance free Battery for UPS & DCPS system. Each battery set shall have sufficient capacity to maintain output at full rated load for duration as defined in **BOQ**. The Bidder shall furnish detailed battery sizing calculations along with all arrangements and supporting structures, for UPS and DCPS system being proposed, along with the bid. In all cases the battery is normally not allowed to discharge beyond 80% of rated capacity (80% DOD) at 10 hours rate of discharge.

The contractor supplying the cells/batteries as per this document shall be responsible to replace/repair free of charge, the battery/cell becoming faulty, owing to defective workmanship or material as per the provisions of the bid document.

Battery sizing calculation for UPS shall be done considering the actual charging achieved in eight hours i.e. in case 100% charging is not achieved in eight hours the Ah of the battery shall be enhanced by the ratio of charging actually achieved in eight hours.

14.4.1 Constructional Requirements

The design of battery shall be as per field proven practices. Partial plating of cells is not permitted. Paralleling of cells externally for enhancement of capacity is not permitted. Protective transparent front covers with each module shall be provided to prevent accidental contact with live module/electrical connections. It shall be possible to easily replace any cell of the battery at site in normal working condition.

14.4.2 Containers

The container material shall have chemical and electro-chemical compatibility and shall be acid resistant. The material shall meet all the requirements of VRLA batteries and be consistent with the life of battery. The container shall be fire retardant and shall have an Oxygen Index of at least 28%. The porosity of the container shall be such that so as not to allow any gases to escape except from the regulation valve. The tensile strength of the material of the container shall be such that so as to handle the internal cell pressure of the cells in the worst working condition. Cell shall not show any deformity or bulge on the sides under all working conditions. The container shall be capable of withstanding the rigors of transport, storage and handling. The containers shall be enclosed in a steel tray.

14.4.3 Cell Covers

The cell covers shall be made of suitable material compatible with the container material and permanently fixed with the container. It shall be capable to withstand internal pressure without bulging or cracking. It shall also be fire retardant. Fixing of Pressure Regulation Valve & terminal posts in the cover shall be such that the seepage of electrolyte, gas escapes and entry of electro-static spark are prevented.

14.4.4 Separators

The separators used in manufacturing of battery cells, shall be of glass mat or synthetic material having high acid absorption capability, resistant to sulphuric acid and good insulating properties. The design of separators shall ensure that there is no misalignment during normal operation and handling.

14.4.5 Pressure Regulation Valve

Each cell shall be provided with a pressure regulation valve. The valve shall be self re- seal able and flame retardant. The valve unit shall be such that it cannot be opened without a proper tool. The valve shall be capable to withstand the internal cell pressure specified by the manufacturer.

14.4.6 Terminal Posts

Both the +ve and -ve terminals of the cells shall be capable of proper termination and shall ensure its consistency with the life of the battery. The surface of the terminal post extending above the cell cover including bolt hole shall be coated with an acid resistant and corrosion retarding material. Terminal posts or any other metal part which is in contact with the electrolyte shall be made of the same alloy as that of the plates or of a proven material that does not have any harmful effect on cell performance. Both +ve and -ve posts shall be clearly and unambiguously identifiable.

14.4.7 Connectors, Nuts & Bolts, Heat Shrinkable Sleeves

Where it is not possible to bolt the cell terminals directly to assemble a battery, separate non-corroding lead or copper connectors of suitable size shall be provided to enable connection of the cells. Copper connections shall be suitably lead coated to withstand corrosion due to sulphuric acid at a very high rate of charge or discharge.

Nuts and bolts for connecting the cells shall be made of copper, brass or stainless steel. Copper or brass nuts and bolts shall be effectively lead coated to prevent corrosion. Stainless steel bolts and nuts can be used without lead coating.

All inter cell connectors shall be protected with heat shrinkable silicon sleeves for reducing the environmental impact including a corrosive environment.

14.4.8 Flame Arrestors

Each cell shall be equipped with a Flame Arrestor to defuse the Hydrogen gas escaped during charge and discharge. Material of the flame arrestor shall not affect the performance of the cell.

14.4.9 Battery Bank Stand

All batteries shall be mounted in a suitable metallic stand/frame. The frame shall be properly painted with the acid resistant paint. The suitable insulation shall be provided between stand/frame and floor to avoid the grounding of the frame/stand.

14.4.10 Capacity Requirements

When the battery is discharged at 10-hour rate, it shall deliver 80% of C (rated capacity, corrected at 27°Celsius) before any of the cells in the battery bank reaches 1.85V/cell.

All the cells in a battery shall be designed for continuous float operation at the specified float voltage throughout the life. Float voltage of each cell in the string shall be within the average float voltage/cell $\pm 0.05V$ band.

The capacity (corrected at 27°Celsius) shall also not be less than C and not more than 120% of C before any cell in the battery bank reaches 1.75V/cell. The battery voltage shall not be less than the following values, when a fully charged battery is put to discharge at C/10 rate:

- a) After Six minutes of discharge:
1.98V/cell
- b) After Six hours of discharge : 1.92V/cell
- c) After 8 hours of discharge : 1.85V/cell
- d) After 10 hours of discharge : 1.75V/cell

Loss in capacity during storage at an average ambient temperature of 35° Celsius for a period of 6 months shall not be more than 60% and the cell/battery shall achieve 85% of its rated capacity within 3 charge/discharge cycles and full rated capacity within 5 cycles, after the storage period of 6 months. Voltage of each cell in the battery set shall be within 0.05V of the average voltage throughout the storage period. Ampere-hour efficiency shall be better than 90% and watt-hour efficiency shall be better than 80%.

14.4.11 Expected Battery Life

The battery shall be capable of giving more than 1200 charge/discharge cycles at 80% Depth of discharge (DOD) at an average temperature of 27° Celsius. DOD (Depth of Discharge) is defined as the ratio of the quantity of electricity (in Ampere-hour) removed from a cell or battery

on discharge to its rated capacity. The battery sets shall have a minimum expected operational life of 5 years at normal operating conditions or 1200 charge / discharge cycles (whichever is early).

14.4.12 Routine Maintenance of Battery system

For routine maintenance of battery system, the contractor shall supply 1 set of following tools:

- a. Torque wrench.
- b. Tool for opening /closing of pressure regulation valve of battery.
- c. H a n d held digital Multimeter for measurement of resistance, AC/DC Voltages.

14.4.13 Testing of Battery

The contractor shall supply type tested battery as required for DCPS and UPS system. The Contractor shall submit the Battery type test reports of earlier conducted tests on the same make, model, type & rating as offered as per the IEC 60896 or equivalent IS/EN/BS standards. These Type test reports shall be submitted for the highest rating battery to be supplied under the contract. For type testing requirements in addition to provisions of this chapter 18 is also to be complied. The tests mentioned in the Table 4.2 shall be conducted on the battery at site and factory.

TABLE 4.2 LIST OF FACTORY & SITE TESTS FOR BATTERY

S. No.	Test	Factory Tests	Site Tests
1.	Physical Verification	√	√
2.	C/10 Capacity test on the cell	√	
3.	8 H r s . Charge and 30 minutes (duration as Specified) discharge test at full rated load for UPS.		√

14.5 Testing Requirements

The requirements for type tests, factory acceptance tests and field acceptance testing have been specified under the respective clauses. After completion of field acceptance testing the auxiliary power supply system shall be put under availability test for fifteen (15) days. Availability test shall be carried out by the employer/owner. During the availability test the APS shall be used as required to be used for rest of the life. In case of any failure or mal-operation during this period the contractor shall take all necessary action to rectify the problems. The APS shall be accepted only after rectification of the problems by the contractor in a manner acceptable to the employer.

14.6 2KVA UPS

Two KVA UPS shall be supplied for bill collection centers as per the quantity specified in the BOQ. The technical particulars of these UPS shall be as mentioned below:

Technical Specification for 2 KVA (1.6 KW) UPS

	Parameter	Requirements
INPUT	Voltage	230±15%V AC, 50Hz, Single phase
	Frequency	50 ± 5% Hz
OUTPUT	Power	2 kVA / 1.6 kW (at 0.8 pf)
	Voltage	230V AC Single phase (±1 %)
	Frequency	50 Hz & ±0.2%(Free Running)
	Regulation	±1%
	Transient Response	±5% for 100% load change and recovers to normal within 10 milliseconds
	Waveform	Pure Sine wave, THD <2% (linear load)
	Short term overload	110% for 15 minutes and 150% for 10 seconds
	Efficiency (Peak)	>90%
	Supported load pf	0.6-unity
	Change Over	Transfer time (in Sync Mode) less than 5 msec
BATTERY	Type	SMF/lead Acid tubular
	Backup time	4 hours
	Recharge Time	Maximum 12 hours*
	Life	Minimum 3 years (SMF)/ 8 years(LATB)
GENERAL	LED Indicators	Mains ON, Converter / Inverter faults, O/P high/low, Bypass mode, Inverter ON/OFF
	Audible Alarm	Main Failure, Low Battery, Overload
	Isolation	UPS output isolated from Mains Input
	Protection class	IP-21
	Temperature	0-45° C (Battery shall be sized at an average Temp. Of 27 Deg C.)
	Humidity	Upto 95% RH (Non condensing)

* **Note:** Battery shall be sized to deliver rated load for specified duration after charging for 12 hours from fully discharged state of battery (1.75V for VRLA).

14.7 Documentation

The following specific document for items covered under this chapter shall be submitted which shall be in addition to the applicable general document required under chapter 18

- Data Requirement Sheets (DRS)
- Battery sizing calculations
- Cable sizing calculations
- Inventory of the hardware
- Panel General Arrangement drawing
- Panel Internal General Arrangement drawing indicating modules, major devices/components location etc.
- Installation drawings
- Schematic drawings
- Type Test reports

- FAT plan & procedure
- SAT plan & procedure
- External cable laying & termination schedule details
- Availability test plan & procedure

14.8 Mandatory Spares

List of mandatory spares for UPS, DCPS are mentioned in the BOQ

End of Chapter 14

CHAPTER-15: SCADA ENABLERS

15.0 STANDARDS:

- a) The equipment delivered shall be new and of high quality, suitable for the purpose it is intended for, free from defects and imperfections and of the classifications listed herein, or their equivalents, subject to acceptance by the Utility.
- b) Materials used in the manufacture of the specified equipment shall be of the kind, composition and physical properties best suited to their various purposes and in accordance with the best engineering practices.
- c) The equipment design shall be suitable to render satisfactory operation under the conditions prevailing at site, and the equipment shall operate satisfactorily under normal load and voltage variations and frequency variations (50 Hz \pm 3%) ensuring the safety, further include all necessary provisions ensuring the safety of the operating and maintenance personnel.
- d) As part of customization, Utility may change control voltage 24/48 Vdc etc as per site requirement but shall be uniform accords state and vendor neutral and also the ambient /operational requirement as per site conditions such as high altitude over 2000m and low temperature, environment conditions Utility may specify location with altitude more than 2000m above MSL for compliance of in that project area
- e) However, the same shall be vendor neutral and serving objective of the scheme. Further, utility may opt RMUs / sectionalizer /AR with built in FRTU. In that case, The Quantity of the same shall be deducted from BOQ of FRTU and space for FRTU in the equipment may not be mandatory. **The FRTU optionally can be housed in separate enclosure suitable for outside installation.**
- f) The applicable standards of various equipment for the DMS project is as specified here below:

15.1 11kV 5 - 3 way Ring Main unit

Description	Standard
<u>11kV 5 way - 3 way Ring Main unit</u>	
AC metal enclosed switchgear and control gear for rated voltages above 1 kV and up to and including 52 kV	IS 3427/IEC 62271-200
Classification of degrees of protection provided by enclosures of electrical equipment	IS/12063IEC60529
High Voltage Switches	IS 9920 (Parts 1 to 4)/ IEC 62271
Specification for AC disconnectors and earthing switches for voltages above 1000 V	IS 9921 (Parts 1 to 5)/ IEC 62271-102
HV AC Circuit Breakers	IS 13118/ IEC 62271-100
Dimensions of terminals of HV Switchgear and Control gear	IS 10601
General requirements of switchgear and control gear for voltages exceeding 1000 V	IS 12729
High voltage/Low voltage prefabricated substations	IEC 1330
Common clauses for MV switchgear standards	IEC 62271-100/200
Monitoring and control	IEC 6081

Description	Standard
Current Transformers	IS 2705/ IEC61869-2
Voltage transformers	IS 3156/ IEC61869-3
Specification for Static Protective Relays	IS 8686/ IEC60255
Standards for high voltage metal clad switchgear up to 52 KV.	IEC 62271-200

15.1.1 Key RMU Configurations of Ring Main Unit

- **WAY RMU – Left or Right side extensible** Two (2) Motor operated load break switches (LBSs) **with manual operated earthing switches in SF6 and 1 vacuum circuit breaker** with Electrical closing and tripping along with disconnecter and earthing switches WITH BUS PT metering module and base channel and suitable space for mounting FRTU, battery charger, Auxiliary PT of suitable rating inside metering cubical. The Battery charger along with batteries required for Electrical operations of RMU is also in the scope of the Bidder.
- **WAY RMU - Left or Right side extensible** Two (2) Motor operated load break switches (LBSs) **with manual operated earthing switches in SF6 and (3) vacuum circuit breakers** with Electrical closing and tripping along with disconnecter and earthing switches WITH BUS PT metering module and base channel suitable space for mounting FRTU, battery charger, Auxiliary PT of suitable rating inside metering cubical. The Battery charger along with batteries required for Electrical operations of RMU is also in the scope of the Bidder.

15.1.2 Scope of Work

- The Package scope of work shall include design, manufacture, testing, delivery installation commissioning of **SCADA Compatible Ring Main Units** capable of being monitored and controlled by the SCADA/DMS. This also includes supply of relevant 11 kV cable termination kits including the jointing as per this tender specification
- Each RMU shall include its own power supply unit (including auxiliary power transformer, batteries, and battery charger), which shall provide a stable power source for the RMU. The RMUs will be connected to the FRTU including the power supply required will be procured, supplied and installed by SIA. Each new RMU shall be equipped with main-line load break switches and a fault passage indicator (FPI). Furthermore, to protect each of its lateral / transformer feeders, it shall be equipped with a corresponding set of circuit breakers and self-powered numerical relays. The RMU shall include potential-free contacts so as to connect to SCADA/DMS via FRTUs, so as to:
 - Monitor and control the open/closed status of the RMU circuit breakers and load break switches.
 - Monitor the local/remote position of RMU manually-operated switches that can be used to enable and disable remote monitoring.
 - Monitor the health of the power supply, which will include battery failure and low voltage indications.
 - Monitor the open/closed status of RMU earthing switches.

- **Facility for remote reset of FPI.**
- Monitor for low SF6 gas pressure indication.
- Monitor for circuit breaker relay operations.
- Monitor for indication of main-circuit fault detected by the RMU's FPI.
- The civil works, **foundations works** including providing of Earth pits and earth flat and their connectivity to earth pits for erection and commissioning of the RMU's are in the scope of the Bidder.
- **Any site/ equipment/ statutory approvals at site etc. required shall be in Utility scope.**

15.1.3 Environmental Conditions

All materials supplied shall be capable of operating under relevant environmental conditions are listed as follows:

- Maximum ambient air temperature: - 55 °C
- Minimum ambient air temperature : --10 °C
- Average ambient air temperature : - 40 °C
- Maximum relative humidity: - 0-100 %
- Average thunder storm days per annum: - 10
- Average rainfall per annum: - 400 mm
- Maximum wind speed: - 119 km/hr
- Utility may specify location with altitude more than 2000m above MSL for compliance of in that project area The above environmental conditions are indicative and utility, msy specify as per site conditions

15.1.4 Distribution Network Electrical Parameters

The main parameters of the distribution network are as follows:

- Nominal system voltage: - 11 kV (rms)
- Highest system voltage: - 12 kV (rms)
- Number of phases: - 3
- Frequency: - 50 Hz
- **Variation in frequency: - 50 ±3% Hz**
- Type of earthing: - Solid
- Power frequency withstand voltage: - 28 kV rms
- Basic impulse withstand voltage: - 75 kV peak

15.1.5 Testing

The specified RMUs shall be subject to type tests, routine tests, and acceptance tests. Where applicable, these tests shall be carried out as per the standards stated above. Prior to acceptance testing, the supplier shall prepare and submit a detailed test plan for review and approval by the Utility.

15.1.6 11 kV 5 way and 3 way RMU Technical Parameters

The scope of supply is supply 11 kV 5 Way RMU and 3 Way RMU suitable for outdoor application.

The RMU to be supplied shall be compact and shall meet the following requirements:

- Easy to install
- Safe and easy to operate
- Compact
- Low maintenance

It shall include, within the same metal enclosure number of MV functional units required for connection,

- Power supply including the battery bank for controlling the LBS and breakers
- Load break switches,
- Earthing Switches
- Breakers
- Relays
- BUS PT metering module, FPI's and other allied equipment.
- Space for FRTU

Equipment and material conforming to any other standard, which ensures equal or better quality, may be accepted. In such case copies of English version of the standard adopted shall be submitted.

The electrical installation shall meet the requirement of Indian Electricity Rules, 1956 as amended up to date; relevant IS code of practice and Indian Electricity Act, 1977. The Electricity Act, 2003 and Amendment if any shall also apply. In addition other rules and regulations applicable to the work shall be followed. In case any discrepancy the most stringent and restrictive one shall be binding.

The high-tension switchgear offered shall in general comply with the latest issues including amendments of the following standards but not restricted to them.

All design features of the proposed RMU, as described in the supplier's bid and in the bid's reference materials, shall be fully supported by the equipment actually delivered. The key design features include those that relate to:

- Maintainability, expandability, and life span
- Ability to operate in severe outdoor environmental conditions.
- Immunity to electrical stress and disturbance.
- Acceptable insulation properties.
- Convenient FRTU interconnection features.

15.1.7 Maintainability, Expandability and Life Span

15.1.7.1 Maintainability

The Utility intends to be self-reliant for RMU maintenance. To this end, the Supplier shall provide the support, documentation, and training necessary to operate and repair the RMU. The Utility will prefer RMU designs that do not require periodic preventive maintenance and inspections. To facilitate expansion and maintenance, the RMUs should be of modular type.

15.1.7.2 Expandability

The whole switchgear (RMU) should be suitable for extension on at least one side either left or right.

15.1.7.3 Life Span

Each RMU shall have a design life of at least 20 years from the date of final acceptance. The Contractor shall make available, at no cost to the Employer, the manufacturing drawings, wiring diagrams, bill of material, foundation detail drawings, unpacking and transportation instructions, operation & maintenance manual, As-built drawings, installation and commissioning manual, and other relevant documentation. The specific components of each component /sub-assembly shall be identified and referenced in Supplier-supplied documentation.

15.1.8 Outdoor Features

15.1.8.1 General

- The RMUs shall be designed specifically for outdoor installation with ingress protection degree of IP54. They shall also be suitable for conditions in which they will be exposed to heavy industrial pollution, and high levels of airborne dust.
- The Outdoor RMU shall be conformably coated to meet these climatic conditions. In this respect, standards such as IEC 62271-200, covering equipment, systems, operating conditions, and environmental conditions shall apply. In particular, the RMU equipment shall have been type tested for IP54 from a national NABL aggregated laboratory. Failure to conform to this requirement shall constitute grounds for rejection of the proposal
- In addition to the above, materials promoting the growth of fungus or susceptibility to corrosion and heat degradation shall not be used, and steps shall be taken to provide rodent proof.

15.1.8.2 Corrosion Protection

The main SF6 tank, housing the on-load break switches and the **vacuum circuit breakers** should be of **2.0 mm thick (minimum) stainless steel tank** so as to have high corrosion resistance and ensure high longevity. This tank containing SF6 to a **maximum pressure of 1.3 bars @ 20 deg C** should be hermetically welded and sealed for life, ensuring a leakage rate not more than 0.1 % per annum. Except for stainless steel, all steel surfaces that are not galvanized shall be treated to protect against corrosion. As a minimum, corrosion treatment shall include the following procedures:

- The surface shall be cleaned to bare material by mechanical or chemical means.
- Must be powder coated by means of seven tank process

- All outdoor metal enclosures shall be treated in 7 tank Pre-treatment process & should be painted with UV Resistant Pure Polyester Powder coating. The powder coated sheet steel fabrication shall fulfill 700 Hrs of Salt spray test. The thickness of Painting/Powder coating shall be of 100+/-25 microns to withstand tropical heat and extremes of weather.

15.1.8.3 Immunity to Electrical Stress and Disturbance

The electrical and electronic components of the RMU shall conform to relevant standards concerning insulation, isolation, and **the product shall comply with IEC 60270 Immunity** to electrical stress & disturbance. The ability to meet these requirements shall be verified by type tests carried out by accredited test laboratories that are independent of the bidder and/or the manufacturer of the RMU components. Certified copies of all available type test certificates and test results shall be included as part of the bidder's proposal.

15.1.8.4 Minimum Insulation of Equipment

The RMUs shall be of SF6 gas-insulated type with a maximum gas operating pressure up to **1.2 BAR @ 20 deg C**.

15.1.8.5 Nameplate Information

RMU nameplate information shall be determined in agreement with the Employer. This information may include for example:

- Name of manufacturer and country
- Type, design, and serial number
- Rated voltage and current
- Rated frequency
- Rated symmetrical breaking capacity
- Rated making capacity
- Rated short time current and its duration
- Rated lightning impulse withstand voltage
- Purchase Order number and date
- Month and year of supply

Each RMU shall also exhibit a Danger Board to indicate the presence of high voltage (11,000 V).

15.1.9 Interconnecting Cables, Wiring, Connectors, and Terminal Blocks

- The Contractor shall provide all interconnecting wires, cables, connectors, terminations and other wiring accessories such as terminal blocks required by the RMU.

15.1.9.1 Metallic Cables

- All metallic cables and wiring shall be of required cross-section solid or multiple strands of round copper conductors and have flame retardant insulation. All wiring shall be neatly laced and clamped.
- All wire and cable connectors and terminators shall be permanently labeled for identification. All connection points for external cables and wires shall be easily accessible for connection

and disconnection and shall be permanently labeled. Conductors in multi-conductor cables shall be individually color-coded.

15.1.9.2 Connectors

- **Nuts & Bolts type terminal blocks shall be provided in LV compartment for SCADA connectivity and to accommodate FRTU.**

15.1.9.3 RMU-FRTU Connectors

- For ease of installation and maintenance, the interconnection between the RMU and the FRTU, (FRTU to be installed by **SCADA Implementing agency (SIA)** in a separate enclosure shall be supported by having heavy-duty terminal blocks with **Nuts & Bolts type** terminals shall be provided by the supplier for necessary cable terminations. In using a terminal block, no more than two cables or wires shall be connected to any of its individual terminals.
- Making strips shall be used to identify all external connection blocks. Marking tags shall be read horizontally. All terminals to which battery or other high voltages are connected shall be provided with fireproof covers.
- All individual status input, AC voltage input, and control output points shall be isolatable without the need to remove wiring by means of individual terminal blocks of the removable link type. In order to avoid open circuits on the secondary side of CTs, termination blocks with by-pass bridges shall be provided for all AC current inputs.
- Terminal blocks shall comply with IEC 60947-7-1 (2009): Low-voltage Switchgear and Control Gear, Part 7-1: Ancillary Equipment, Terminal Blocks for Copper Conductors.

15.1.10 5.6 RMU Characteristics

- As a minimum, the RMUs shall be equipped with on-load break switches and a fault passage indicator (FPI), circuit breakers, and **self-powered** numerical relays for the protection of transformer feeders, and provision for wiring for multifunction transducer (MFT is not in the scope of the bidder, to be provided by **SCADA Implementing agency (SIA)**) for monitoring voltage, current, power, energy, and power factor readings and tripping and protection functionalities from the Communicable Numerical relay to be provided on the RMU. The Load Break Switches and earthing switches shall be housed in SF6 and the Circuit Breakers used in the RMU shall be **vacuum interrupter type**.
- In addition, each RMU shall be equipped with all necessary connectors, terminal blocks, and other accessories that will allow it to be connected to the FRTU, which in-turn will send required indications and measurements to the DMS via the communications system.

15.1.11 General Requirements

Each RMU shall include its own power supply, including battery and battery charger. In addition, RMU should have a bus connected PT panel (air insulated), which shall serve as the power supply's 230 V AC input.

Within this context, the general requirements of the RMU shall include, but shall not be limited to provision of the following monitoring and control features:

- Positions of local/remote switches as used to control local and remote access to circuit breakers and load break switches
- Power supply indications including battery failure and voltage alarms
- Open/closed position of load break switches, circuit breakers, and earthing switches

- SF₆ gas-pressure low indication.
- Circuit breaker relay indications
- Indications of fault in the RMU's main feeder circuit as detected by the FPI
- Load break switch and circuit breaker open/close control
- FPI remote reset.
- Earth switch open/Close status for remote.
- Door open potential free contact for SCADA.

15.1.12 Parameter Requirements

The RMUs shall be suitable for cable networks of 630 Amps and loop cable networks of 400 Amps. The minimum design parameters to which their major components shall conform or exceed are summarized in the following tables.

Table 1: System Parameters

Parameter	Value
Nominal System Voltage	11 kV
Highest System Voltage	12 kV
Rated Voltage	12 kV
System frequency	50 Hz
Number of Phases	3 Phase/3 Wire

Table 2: Circuit Breaker Parameters

Parameter	Value
Lightning Impulse Withstand Voltage Phase-to-Phase & Phase-to- Earth:	75 kV (peak)
Power Frequency Withstand Voltage to Earth, Between Poles, & Across Opening Span	28 kV rms for 1 minute
Rated Short Time Withstand/Breaking Current:	21 kA (rms)
Rated Duration of Short Circuit:	3 seconds
Rated Normal Current:	630 Amps (rms)

Table 3: Load Break Switch Parameters

Parameter	Value
Rated Short Circuit Making Capacity	52.5 kA peak at rated voltage

Parameter	Value
	(both LBS & Earthing Switch)
Rated Load Interrupting Current	630 Amps
Rated Cable Charging Interrupting Current	25 Amps

The RMU switchgear shall be capable of withstanding the specified currents without damage in accordance with the latest versions of IEC 60694 (Common Specifications for High-Voltage Switchgear and Control Gear Standards) and IS 3427 (AC Metal Enclosed Switchgear and Control Gear for Rated Voltages above 1 kV and up to and including 52 kV).

The equipment offered shall be as per the standards specified in the bid specification and if the offered equipment is tested with any other international standards which is superior to the standards specified they can also be considered and the bidder has to submit the documentary evidence for the same to Utility

15.1.13 Design Details

- The RMU shall be designed to operate at the rated voltage of 12 kV.
- It shall include, within the same metal enclosure, On-load break switch, circuit breakers and earthing switches for each Load Break Switch/Circuit Breaker.
- Suitable fool-proof interlocks shall be provided to the earthing switches to prevent inadvertent or accidental closing when the circuit is live and the concerned Load Break Switch/Circuit Breaker is in its closed position.
- The degree of protection required against prevailing environmental conditions, including splashing water and dust, shall be not less than IP 54 as per IS 12063.
- The active parts of the switchgear shall be maintenance free. Otherwise, the RMU shall be of low-maintenance type.
- **The tank shall be made of minimum 2.0 mm thickness of stainless steel.**
- The Stainless Steel tank should be completely welded so as to ensure IP 67 degree of protection and shall be internal arc tested.
- The RMU shall be suitable for mounting on its connecting cable trench.
- For each RMU enclosure, a suitably sized nameplate clearly identifying the enclosure and the electrical characteristics of the enclosed devices shall be provided.
- The access to the **cable compartment should be from the front** of the switchgear only to have minimum operating & maintenance space at site.
- The RMU design shall be such that access to live parts shall not be possible without the use of tools.
- The design shall incorporate features that prevent any accidental opening of the earth switch when it is in the closed position. Similarly, accidental closing of a Circuit Breaker or Load Break Switch shall be prevented when the same is in an open position.
- The RMU tank must be equipped with a suitable pressure relief device. The pressure relief must ensure that the escaping gases are dissipated to the rear / top/ bottom of the switchgear.

- The complete RMU shall be tested in an accredited INDIAN or FOREIGN laboratory and designed for an Internal Arc.

15.1.14 Earthing

- There shall be continuity between metallic parts of the RMUs and cables so that there is no dangerous electric field in the surrounding air and the safety of personnel is ensured.
- The RMU frames shall be connected to the main earth bars, and the cables shall be earthed by an Earthing Switch having the specified short circuit making capacity.
- The Earthing Switch shall be operable only when the main switch is open. In this respect, a suitable mechanical fail-proof interlock shall be provided.
- The Earthing Switch shall be provided with a reliable earthing terminal for connection to an earthing conductor having a clamping screw suitable for the specified earth fault conditions. The connection point shall be marked with the earth symbol. The flexible connections between the earthing blade and the frame shall have a cross-section of at least 50 mm² copper or equivalent in GI
- The Earthing Switch shall be fitted with its own operating mechanism. In this respect, manual closing shall be driven by a fast acting mechanism independent of the operator's action.

15.1.15 Incomer Load Break Switches

- The Load Break Switches shall be maintenance free. With outdoor canopy doors open, the position of power contacts and earthing contacts shall be clearly visible from the front of the RMU through the Mimic fascia.
- The position indicator shall provide positive contact indication in accordance with IS 9920. In addition, the manufacturer shall prove the reliability of indication in accordance with IS 9921. These switches shall have three positions (or states), i.e., Open, Closed, and Earthed, and shall be constructed in such a way that natural interlocking prevents unauthorized operations.
- The switches shall be fully assembled, tested, and inspected in the factory.
- In case of Manual operation without motors, opening and closing shall be driven by a fast-acting mechanism independent of manual operator action.
- The Load Break Switches shall be provided with a motorized operating mechanism suitable for SCADA control.
- A facility shall be provided with an electrical operating mechanism allowing an operator at the RMU site to operate the Load Break Switches without any modification of the operating mechanism and without de-energizing the RMU.
- The switch and earthing switch mechanisms shall have a mechanical endurance of at least 1,000 operations.

15.1.16 Circuit Breakers

- The Circuit Breakers shall be maintenance free and, when standing in front of the RMU with outdoor canopy doors open, their positions shall be clearly visible, through the Mimic fascia. The position indicator shall provide positive contact indication in accordance with IS 9920. The breakers shall have three positions (or states), i.e., Open, Closed, and Earthed, and shall be constructed in such a way that natural interlocking prevents unauthorized operations. They shall be fully assembled, tested, and inspected in the factory.

- An operating mechanism shall be used to manually close the Circuit Breaker and charge the mechanism in a single movement. It shall be fitted with a local system for manual tripping. There shall be no automatic reclosing. The Circuit Breaker shall be capable of closing fully and latching against the rated making current. Mechanical indication of the OPEN, CLOSED, and EARTHED positions of the Circuit Breaker shall be provided.
- Each Circuit Breaker shall operate in conjunction with a suitable protection relay under transformer feeder/ circuit phase and earth fault conditions. In addition, the Circuit Breaker shall be provided with a motorized operating mechanism that can be remotely controlled by the SCADA.

15.1.17 Cable Termination

- Bushings shall be conveniently located for working with the specified cables and shall allow for the termination of these cables in accordance with the prevailing practice and guidelines of cable manufacturers. The dimensions of the terminals shall be in accordance with IS 10601.
- A non-Ferro-magnetic cable clamp arrangement shall be provided for each cable to be terminated in the RMU.
- A suitable arrangement for the Circuit Breakers, Earthing Switches, and Load Break Switches shall be provided so that these devices can be padlocked in the "Open" and "Closed" positions.
- A permanent "Live Cable" indication as per IEC 61958 shall be provided for each cable using a capacitor voltage divider.
- It shall be possible to test the core or sheath insulation of the cables without disconnecting the cables in the cable compartment, after accessing the cable compartment. The cable end kits including the supply and erection is in the scope of the successful bidder.
- Two earth pits of 10 ohms each shall be provided diagonally and earthing to the equipment shall be done as detailed in the scope of supply.

15.1.18 Safety of Equipment

- With respect to the RMU's SF6-filled equipment, any accidental overpressure inside the sealed chamber shall be limited by the opening of a pressure-limiting device in the enclosure so that the gas will be released away from the operator and to the rear bottom or top of the tank without endangering the operator or anyone else in the vicinity of the RMU.
- All manual / motorized operations, monitoring of open/close position of switches/breakers, live line indicators, FPI indication, SF6 gas pressure indication and **access to the cable compartment shall be carried out from the front of the RMU only.**

15.1.19 Current and Voltage Transformers.

- The RMU shall be provided with current and voltage transformers. These CTs & PTs shall meet the electrical and mechanical ratings as per the relevant standards.

15.1.19.1 Current Transformers

- 3 Nos. ring type, single core CTs shall be provided in each incoming load break switch for metering purposes. A similar arrangement shall be provided in each circuit breaker cable compartment to mount a 3 Nos. single-core, ring type CT for protection purposes.
- The CTs shall conform to IS 2705. The design and construction shall be sufficiently robust to withstand thermal and dynamic stresses during short circuits. Secondary terminals of CTs shall be brought out suitably to a terminal block, which will be easily accessible for testing and terminal connections.

- Further characteristics and features distinguishing CTs used for metering from CTs used for protection are listed as follows:

15.1.19.1.1 CTs for Metering:

- Material : Epoxy resin cast
- Burden : 2.5VA
- Ratio : 400-200-100/1 A
- Accuracy Class : 0.5

15.1.19.1.2 CTs for Protection:

- Material : Epoxy resin cast
- Burden : 2.5VA
- Ratio : 400-200-100/1 A
- Accuracy Class : 5P10
- The RMU's other CTs / sensors, i.e., those used by Fault Passage Indicators (FPIs), shall be supplied by the FPI manufacturer. These CTs/sensors shall be an integral part of the FPI's design to ensure that they properly match the requirements of the FPI.

15.1.19.2 Voltage Transformers

- A 3 phase single or 3 nos. single phase potential transformers shall be provided. These should be housed in a separate air insulated PT Panel, directly connected to the RMU through main bus. The burden per transformer shall not be more than 50 VA and the voltage ratio shall be 11000 V/ root 3 /110 V/ root 3. The accuracy class shall be 0.5.
- HRC fuses shall be provided on the HV side.
- The PTs shall be of cast epoxy-resin construction, and they shall conform to IS 3156. Their design and construction, in particular, shall be sufficiently robust to withstand the thermal and dynamic stresses during short circuits.

15.1.20 Fault Passage Indicator for RMU

- The FPI shall facilitate quick detection of faulty section of line. The fault indication may be on the basis of monitoring fault current flow through the device. The FPI should be self-powered and should have internal lithium battery for external indication and setting of FPI in the absence of current.

15.1.20.1 The FPIs shall include:

- Fault detection - Phase to phase and Phase to earth faults.
- One potential-free output contacts for hardwiring to FRTUs. On this basis, the SCADA/DMS will be able to monitor phase / earth fault condition.
- Local fault indications - LCD display on FPI front panel along with LED indication on front panel of RMU enclosure.
- Multiple reset option –
- End of time delay (Adjustable from 2 to 16 Hrs)
- Remote reset (Via potential free input contact of FPI)
- Manual reset (Reset button on front panel of FPI)

- Automatic reset on current restoration.

15.1.20.2 The characteristics of the FPIs shall include:

- Phase fault thresholds configurable from at least 200 to 1200 A
- Earth fault thresholds configurable from at least 10 to 200 A
- Multiple number of steps for adjusting phase and earth fault thresholds.
- Fault current duration range configurable from at least 40 ms to 100 ms in 20 ms steps and further 100 ms to 300 ms in 50 ms steps.
- Variations with respect to these characteristics may be acceptable as long as they prove applicable and provide the same or better flexibility.

15.1.20.3 Protection Relay

The RMU shall be equipped with self-powered numerical relays (**Communicable relays shall be with auxiliary power which shall be given from battery but the tripping shall be self-powered philosophy**) communicable to trip the RMU circuit breakers

15.1.20.3.1 General

The Circuit Breaker in the RMU shall be fitted with a communicable-type, self-powered numerical relay, i.e., one for each outgoing circuit breaker. The protection relay's auxiliary contacts shall be provided for hardwiring to the FRTU. The relay shall also interface with the FRTU via an RS 232/485 port in order to send, as minimum, real-time readings using the MODBUS protocol.

The numerical relay shall be self-powered and should provide Inverse Definite Minimum Time (IDMT) and Instantaneous protection characteristics. On this basis, the relay as a minimum shall provide:

- Phase Overcurrent Protection (50/51)
- Earth Fault Protection (50N/51N)

The relay shall be provided with an input for remote tripping, which shall be realized via an electric output pulse even without presence of phase current. A flag indicator shall be installed for signaling the occurrence of trip conditions.

15.1.20.3.2 Features and Characteristics

The numerical relay shall have the following minimal features and characteristics noting that variations may be acceptable as long as they provide similar or better functionality and/or flexibility:

- It shall be housed in a flush mounting case and powered by the RMU power supply unit.
- It shall have three phases over current elements and one earth fault element.
- IDMT trip current settings shall be 50-200% in steps of 1% for phase over current and 10-80% in steps of 1% for earth fault.
- instantaneous trip current settings shall be 100-3000% in steps of 100% for phase over current and 100-1200% in steps of 100% for earth fault.
- Selectable IDMT curves shall be provided to include, for example, Normal Inverse, Very Inverse, Extreme Inverse, Long Time Inverse, and Definite Time. Separate curve settings for phase over current and earth fault shall be supported.

- For IDMT delay multiplication, the Time Multiplier Setting (TMS) shall be adjustable from 0.01 to 0.1 in 0.01 steps.
 - The relay shall also be provided with:
 1. Alphanumeric Liquid Crystal Display (LCD) for relay setting.
 2. Communications via a MODBUS RS232/RS485 port to provide the FRTU (and hence the DMS) with phase current measurements. It is also desirable that this same means of communication can be used by the FRTU to send setting and control commands to the relay.
 3. Parameter change capability that is password protected.
 4. LED indication on front panel eg battery , cable test
- FPI shall have atleast 2000 hours of flashing hours and support site tEst functions

15.1.21 Power Supply and auxiliary power transformer

Each RMU shall be fitted with a power supply, including batteries and battery charger, suitable for operating the motors of the On-load Isolators and Circuit Breakers. On this basis, the following operational specifications shall apply:

- The power supply unit shall conform to the following requirements:
 - 1) Input: 230 V AC nominal from the RMU's auxiliary power transformer allowing for possible variations from 190 to 300 V AC
 - 2) Output: Stable 24 V DC.
 - 3) Batteries: 24 V DC (2 Nos of 12 V DC each) SMF VRLA.

The auxiliary power transformer shall be of suitable rating as per the load calculation and the Auxiliary power transformer inputs shall be equipped with surge protection devices in accordance with IEC 62305.
- The 24 V DC batteries shall have sufficient capacity to supply power to the following devices with a nominal backup of 4 hours:
 - 1) RMU's motors for a minimum of five (5) operations
 - 2) RMU's trip coils, close coils, FPI.
- **The batteries shall be of sealed lead acid VRLA and shall have a minimum life of five (5) years at 25°C.**
- The battery charger shall be fully temperature compensated.
- To prevent deep discharge of the batteries on loss of AC power source, the battery charger shall automatically disconnect all circuitry fed by the batteries following a user-adjustable time period or when the battery voltage falls below a preset value. If the battery voltage falls below the preset value, the time to fully recharge all batteries shall not exceed twenty-four (24) hours.
- An automatic battery checking device shall be provided to check the battery's health and initiate a battery-failed alarm signal in case battery deterioration is detected. Such detection may be based on comparing measurement values with set values (e.g., internal resistance, voltage, etc.).
- The battery charger shall be provided with an alarm displayed at the local control panel and remotely at the DAS to account for any of the following conditions:
 - 1) Low battery voltage 2) Charger failed

15.1.22 Multi-Function Transducer (MFT)

The RMU main incoming On-load switches circuits shall be equipped with Communicable Numeric relays and the multi-function transducers to be supplied by **SCADA Implementing agency (SIA)** capable of providing distribution system voltage, current, power factor, power, and energy readings and is in the scope of the bidder. The wiring from metering current transformer shall be made available for connecting to MFT that is being provided by the **SCADA Implementing agency (SIA)**. The data from Communicable Numeric relay regarding the tripping functionalities shall be provided and data shall be integrated with the FRTU.

Each MFT shall have the following minimum features:

- Measurement, display, and communications capability of up to 31 parameters
- True rms measurement
- Digital communications
- Simple menu driven interface
- High quality LED display
- Able to monitor:
 - a) Voltage: line-to-line and line-to-neutral
 - b) Current: phase and neutral
 - c) Frequency
 - d) Power factor
 - e) Power (active, apparent, and reactive)
 - f) Energy (active and reactive)
 - g) Total harmonic distortion

15.1.23 Construction

The RMU shall be sufficiently sturdy to withstand handling during shipment, installation, and start-up without damage. The configuration for shipment shall adequately protect the RMU equipment from scraping, banging, or any other damage.

15.1.24 Enclosures

- All supplied enclosures shall be sized to provide convenient access to all enclosed components. It shall not be necessary to remove any component to gain access to another component for maintenance purposes or any other reason.
- The enclosures shall also be designed to ensure that the enclosure remains rigid and retains its structural integrity under all operating and service conditions with and without the enclosure door closed.
- The thickness of all enclosure panels shall be at least **2 mm (minimum)**. **The appropriate corrosion treatment and finish requirements shall apply to both inside and outside enclosure surfaces. Other required features are as follows:**
- Constructed of mild steel according to IEC 60529 with IP rating 54 or better. Must be grit/shot blasted, thermally sprayed with Zinc alloy, phosphate, and subsequently painted with

polyurethane based powder paint, the overall paint layer thickness including Zinc spraying shall be of the order of 80 to 90 microns

- A metal pocket attached to the inside of the front door to hold documentation, maintenance log sheets, and other such information.
- Door opening mechanism with built-in key-lock facility suitable for padlocking. An opening mechanism that is less prone to breaking than a projecting door handle is preferred, e.g., a push-button opening mechanism.
- A grounding terminal including grounding bolt and lock washer for connecting a 50 mm² copper or galvanized steel grounding conductor. The grounding bolt and lock washer shall be made of stainless steel/Zinc Passivated mild steel .
- Means of preventing moisture from condensing on electronic components mounted inside the enclosure proposed for housing the FRTU. If necessary, heaters providing adjustable thermostat-control within the range 20 to 60 °C shall be installed in the enclosure for this purpose.
- Means of protection against rain water, and high levels of airborne dust, should be provided.
- Means of enabling the SCADA to monitor the open/closed status of the enclosure door. A SCADA equipment alarm shall be produced whenever the enclosure door is open.
- The outdoor RMU shall include having a minimum protection class of IP 54. It shall be tested in accordance with the latest IEC 60529 standard.
- The outdoor canopy shall have a hinged front access door with a two-point latch locking system with a latch operating lockable handle. The door shall be fitted with a perimeter flange and gasket (rubber or neoprene) to prevent the entrance of water. In addition, a means of monitoring and indicating that the door is open shall be provided.

15.1.25 Motors

- The RMU shall be fitted with spring charging **24V DC** motors of high insulation class allowing the circuit breakers and load break switches to be operated without manual intervention.
- In addition to allowing circuit breaker tripping by the RMU's protection relays, the motorized operating mechanism shall be suitable for remote control by the SCADA.
- The motors along with the supplied control card and push buttons shall allow Utility's personnel to electrically operate the circuit breakers and load break switches at site without any modification of the operating mechanism and without de-energizing the RMU.

15.1.26 Inspection and Test

- Inspections and tests shall be performed to ensure RMU compliance with these Technical Specifications. Responsibility for conducting the inspections and tests shall rest with the Supplier. The Utility representatives will participate in the RMU inspections and will witness the testing as described in the following sub-clauses.

15.1.26.1 Inspections

- Utility's representatives shall be allowed access to supplier's facility where the RMU or its parts are being produced or tested. Such access will be used to verify by inspection that the RMUs are being or have been fabricated and tested in accordance with the Technical Specifications.

- The supplier shall give the utility's representatives 15 days' notice in writing concerning the date and place at which the equipment will be ready for inspection or testing. The supplier shall provide all the necessary assistance and facilities to utility's representatives to carry such inspections and test witnessing.
- The supplier shall provide any and all documentation that is necessary to complete the inspections. The representatives shall be allowed to inspect the supplier's quality assurance standards, procedures, and records. Inspections, as a minimum, shall include checks on inventory, general appearance, cabling, drawing conformance, and labeling.

15.1.26.2 Test Procedures

- The supplier shall provide test plans and detailed procedures for all required testing. The plans and procedures shall ensure that each test is comprehensive and verifies proper performance of the RMU under test and, in this respect, shall be submitted for review and approval by the Utility.
- The test plans shall include all routine tests and acceptance tests as per relevant BIS/IEC standards and shall describe the overall test process including the responsibilities of the test personnel and how the test results will be documented.
- The test procedures shall describe the individual tests segments and the steps comprising each segment, particularly the methods and processes to be followed.

15.1.26.3 Test Reports

- The tenderers should, along with the tender documents, submit copies of all Type test certificate of their make in full shape as confirming to relevant IS/IEC of latest issue obtained from a International/National Govt. Lab/Recognized laboratory.
- The above type test certificates should accompany the drawings for the materials duly signed by the institution that has type test certificate.
- The supplier shall maintain complete records of all test results. The records shall be keyed to the test procedures.
- Upon completion of each test, the supplier shall submit a test report summarizing the tests performed and the results of the tests.

15.1.26.4 Factory Acceptance Test

- A formal factory acceptance test shall be conducted to ensure that the RMUs have been designed to meet the utility's functional requirements in all respects. Utility representatives shall witness the test on a representative RMU, and the test shall be carried out in accordance with the supplier's test plan and procedures as approved by the Utility. Should the factory acceptance test prove unsatisfactory in any way, the Utility reserves the right to have further tests conducted and, if applicable, request further improvements in the supplier's RMU design.

15.1.26.5 Routine Factory Tests

- These tests shall be carried out during RMU manufacture as a quality control measure, i.e., to ensure each RMU to be delivered meets the Employer's minimum requirements including all relevant standards. Recording and reporting the routine test results shall be the responsibility of the Supplier.

- At the Utility’s discretion, Utility representatives will witness such testing. This may include requesting the Supplier to perform tests on RMUs selected at random from each batch of RMUs that the Supplier deems ready to be delivered to site. Should any such test prove unsatisfactory, the Utility reserves the right to have further tests conducted and for delivery not to take place until a mutually agreed course of action has been reached.
- Further for additional reliability of the manufactured RMU it is mandatory to have the complete assembled tank tested for partial discharge.

15.1.27 Operating Manuals

- The Supplier shall submit, operating manuals for all RMU components including items such as FPI, Relay, and other equipment provided by the bidder. These manuals shall be in English. They shall include the RMU operating instructions. Context sensitivity shall be used to go directly to the appropriate place in the manual.
- The manuals shall be organized for quick access to each detailed description of the operator procedures that are required to interact with the RMU functions. This shall include the procedures to define, build, edit, and expand all data points provided with the RMU.
- The manuals shall present in a clear and concise manner all information that operators, including maintenance personnel, need to know to understand and operate RMUs satisfactorily. The manuals shall make abundant use of diagrams and/or photographs to illustrate the various procedures involved.

15.1.27.1 As-Built Documents and Drawings

The supplier shall submit as built documents including applicable drawings for review and approval. All deliverable documents and drawings shall be revised by the supplier to reflect the as- built RMU components including all the FPI, LLI & Relay. Any errors in or modifications to an RMU resulting from its factory and/or site acceptance test shall be incorporated. Within this same context, all previously submitted documents that are changed because of engineering changes, contract changes, errors, or omissions shall be resubmitted for review and approval. The successful bidder has to provide his quality document to Utility.

15.2 11 KV Auto-recloser

Description	Standard
11 kV Auto recloser	
Requirements for overhead, pad mounted, dry vault, and submersible automatic circuit recloser and fault interrupters for AC systems (RI993)	ANSI/IEEE C37.60-1981 IEC 62271-111
Electrical relays	IEC 60255
High-voltage alternating-current circuit breakers. Amendment No. 1:1 992.	IEC 60056:1987
Degrees of protection provided by enclosures (IP Code).	IEC 60529:1989

Standard	Description	Level
IEEE C37.60	Requirements for overhead, pad mounted, dry vault, and submersible automatic circuit	

Standard	Description	Level
IEC 62271-111	recloser and fault interrupters for AC systems	
IEC 60255	Electrical relays	
IEEE C37.60.6.13	Control element surge withstand	
IEC 60529	Degrees of protection provided by enclosures (IP Code). -Electronic modules -Control enclosure - Dangerous voltage screening	IP65 IP44 IP2X
IEC 68-2-5	Temperature rise due to Solar radiation 1.1kW/m ²	
IEC68-2-6	Vibration in 3 axes	
IEC 61000-4-2	Electrostatic Discharge	4
IEC 61000-4-3	Radiated Electromagnetic Field	3
IEC 61000-4-4	Fast Transient	4
IEC 61000-4-5	Surge	4
IEC 61000-4-6	Conduced Disturbances	3
IEC 61000-4-8	Power Frequency Magnetic Field	5
IEC 61000-4-11	Voltage Dips and Interruptions	3
IEC 61000-4-16	Conducted Common mode disturbances 0-150kHz	4
IEC 61000-4-18	Damped Oscillatory Wave	3

15.2.1 Scope of Work

- The Package scope of work shall include design, manufacture, testing delivery, installation commissioning of **SCADA Compatible (built-in FRTU) Auto Reclosers** along with Lightning Arrestors capable of being monitored and controlled by the SCADA/DMS.
- Where relevant, the Auto recloser scope of work shall be coordinated with the work to be carried out under the project's other construction packages.
- Each Auto recloser shall include programmable protection features and integrated remote operation capability and that are intended for installation on 11kV Feeders on distribution networks to implement complete overhead network automation. Auto recloser should have own power supply unit (including auxiliary **11000V / 230V Dry Type Resin Cast** Power Transformer, batteries, and battery charger), which shall provide a stable power source for the controller of the Auto recloser including the FRTU.
- The Auto-recloser shall be connected to its controller by means of umbilical cable using suitable connector.

- A primary objective of this specification is to foster modularity and a maximum level of interchangeability and integration to a central SCADA system by supporting IEC 60870-5-104 communications protocol.
- The auto-reclosure shall be fixed on the existing **MS pole** or **if additional pole is required, one 9.1 M (height) Steel Girder Pole / Rail Pole or MS Box 175 X 85 mm X 2 Nos. back to back box pole** with all the hardware and clamping structures conductor, concreting and earthing of the equipment etc., is in the scope of the Bidder.

15.2.2 Applicable Standard

The following standards contain provisions that, through reference in the text, constitute requirements of this specification at the time of publication the revisions indicated were valid. All standards are subject to review and parties to purchasing agreements based on this specification are encouraged to investigate the possibility of applying the most recent revisions of the standards listed below.

Description	Standard
Auto reclosers	
Requirements for overhead, pad mounted, dry vault, and submersible automatic circuit reclosers and fault interrupters for AC systems (RI993)	ANSI/IEEE C37.60-1981/ IEC 62271-111
Electrical relays	IEC 60255
High-voltage alternating-current circuit breakers. Amendment No. 1:1 992.	IEC 60056:1987/ IEC 62271-1
Degrees of protection provided by enclosures (IP Code).	IEC 60529:1989

15.2.3 Definitions and Abbreviations

Automatic Protection Group Selection (APGS):

An automated feature to determine and activate a pre-programmed group of protection settings based on the direction of power flow.

Auto-recloser (AR)

A mechanical switching device that, after opening, closes automatically after a predetermined time. Several reclosers could occur before lockout.

Cold load pick-up (CLP) feature:

A feature that allows modification of the over-current protection characteristics in order to prevent nuisance tripping under conditions of system energization.

Dead time:

Also referred to as "Reclosing Interval". This is the time between the instant that the current is interrupted by the AR and the instant the contact of the AR closes as a result of an automatic reclose operation. [IEC 50-448-04-09]

Definite time lag (DTL) protection element:

A protection element with a settable time delay that is constant above the pick-up current setting.

Delayed protection operation:

The protection functionality enabling delayed circuit-breaker operation, whether this is due to an IDMTL or DTL protection element.

Effectively earthed system:

An earthed system in which the healthy phase power frequency phase-to-earth over voltages associated with earth faults are limited to 80% of the highest phase-to-phase voltage of the system.

Fast curve protection element:

A family of curves with operating times approximately constant (slightly inverse) relative to the multiple of pick-up setting.

Instantaneous protection element:

An element with no intentional time delay active above a pre-determined pick-up current setting.

Inverse definite minimum time (IDMT) protection element:

A protection element of which the minimum operating time is adjustable and is inversely proportional to the fault current.

Lockout:

Where the recloser remains open and will not reclose automatically.

Pole-mounted remote terminal unit (PMRTU):

A remote terminal unit that is designed for pole mounting and that operates specific pole-mounted equipment remotely.

Rapid protection operation:

The protection functionality enabling rapid circuit-breaker operation, whether this is due to an instantaneous, fast curve, or a definite time delay protection element with relatively short definite time delay.

Reset time:

The time duration after a circuit-breaker close operation for which the measured currents are below a fault detecting level. On the expiry of this time the protection sequence resets.

Secure control:

A single mechanically non-latching switch that effects one state of a control function only. An example of which is either a non-latching switch or two separate push buttons that effect one state of a control function only in each position. If a control is activated repeatedly it only effects that state and does not change the state of the control.

Sensitive earth fault (SEF) relay:

A relay that is sensitive to very low earth fault currents and in which the operating settings are for current magnitude and definite time delay.

Supervisory:

Remote control and indications of an AR or a PMRTU by means of a telecommunications link.

Toggled control:

A single mechanically non-latching switch/push-button that enables a single control function on the first operation of the switch/push-button and disables the function on the second operation of the same switch/push button.

Sequence co-ordination:

The feature that allows protection devices to maintain sequence co-ordination for combinations of rapid and delayed protection operations.

15.2.4 Requirements

15.2.4.1 General

The AR shall be suitable for use on effectively earthed networks and under the system conditions and service conditions as follows.

The Auto recloser shall have insulation media and interruption with Vacuum Interrupter.

15.2.4.2 Environmental Conditions

All materials supplied shall be capable of operating under relevant environmental conditions are listed as follows: (Utility may change as per site requirement within logical limit and applicability)

- Maximum Ambient Air Temperature - 60°C
- Average ambient Air temperature - 40°C
- Minimum ambient Air Temperature - -5°C
- Relative Humidity - 0 to 100%
- Altitude - Utility may specify location with altitude more than 2000m above MSL for compliance of in that project area
- Annual rain fall - 750 mm
- Rainy Months - JUNE to OCTOBER
- Average no. of Rainy Days - 60
- Average no of Thunder Storms - 10
- Average Wind speed - 15-30 kmph

Environmental parameter specified are indicative only, utility may specify as per site conditions and standard product

The main parameters of the distribution network are as follows:

- a) Nominal system voltage (U) (r.m.s.) - 11 kV;
- b) Maximum system voltage (Um) (r.m.s.) - 12 kV;
- c) Load current - 630 A;
- d) Short circuit-breaking capacity - 12.5 KA/1 Sec;
- e) Lightning Impulse Withstand Voltage (BIL) - 75kV peak
- f) System frequency - 50 HZ
- g) Number of phases - 3;
- h) Interrupting medium - Vacuum

- | | | |
|--------------------------------------------|---|----------------------------|
| i) Insulation medium | - | SF6 |
| j) Minimal number of rated load operations | - | 10000 |
| k) Operating Mechanism | - | LV motor/Magnetic Actuator |

15.2.4.3 Testing

The specified Auto reclosers shall be subject to type tests, routine tests, and acceptance tests. Where applicable, these tests shall be carried out as per the standards stated above. Prior to acceptance testing, the supplier shall prepare and submit a detailed test plan.

15.2.4.4 Mounting Features of Autorecloser

The AR shall be suitable for single pole mounting and provided with the mounting bracket. Adequately rated lifting eyes shall be provided and they shall be designed to allow the completely assembled Auto recloser. The diameter of the eyes shall be a minimum of 30mm. Suitable mounting brackets for surge arresters shall be provided. The AR shall have laser cut markings on each bushing marked I, II, III for the normal line side and X, XX, XXX for normal load side. All support structures and associated bolts and nuts with these parts, shall be hot-dip galvanized.

15.2.4.5 Bushings

Bushings Terminals - The preferred arrangement for connection to overhead conductor is using crimp lugs with holes. The material for bushing shall be outdoor Cycloaliphatic epoxy resin / hydrophobic Cycle aliphatic epoxy / HECP. There shall be encapsulated CVTs for voltage measurement on bushings required for auto-reconfiguration of the network.

15.2.4.6 Finish

All interior and exterior ferrous surfaces of auto recloser and control cabinets shall be manufactured from 304 or better grade stainless steel.

15.2.4.7 Control Equipment

Control cabinet

- Electronic control and protection modules shall be mounted in a weather-proof outdoor cabinet with access to the contents through one door. The cabinet will be mounted independently of the AR.
- The cabinet shall be manufactured from 304 or better grade stainless steel.
- Suitable ultraviolet-resistant cable, 7 m long, shall be provided to connect the AR to the control cabinet.
- It shall be possible to disconnect the cable at the AR while the AR is connected to the power system, without causing damage or malfunction: care shall be taken that CTs are not open circuited. A robust, multi-pin weatherproof connector shall be supplied. The female part of the connector shall be mounted on the AR and the male part shall be mounted on the cable. Preference will be given to products supplying connectors at both the AR and the control cabinet.
- Cabinets shall be adequately sealed with ingress protection rating of IP55. Internal module design and placement will avoid the need for moisture control heaters.
- The supplier shall ensure that the equipment housed in the control cabinet can withstand the heating effect of direct solar radiation without causing failure and/or malfunction. Details shall be provided in the tender documentation.

- The cabinet shall make provision for bottom entry of three cables (excluding the cable connected to the AR). All holes shall be pre-punched, two with a diameter of 20 mm and one with a diameter of 32 mm. The holes shall be suitably blanked off.
- Ventilation holes shall be provided to drain water and avoid hydrogen build-up.
- The cabinet shall be fitted with an external M12 earthing stud with a nut, lock nut and a serrated washer.
- The door of the cabinet shall be fitted with a robust locking arrangement that is capable of being secured by a padlock that has a shackle of 10 mm diameter. A minimum of two latching points shall be provided. The cabinet door shall be removable for replacement in the field.
- A door stay shall be fitted to keep the door open while operators are attending the unit.
- Front door entry shall allow access to the operator interface, accessory equipment and communication cables. If an internal swing panel is fitted, the panel shall have a door stay fitted, shall weigh less than 5kg, shall not have any sharp edges and there shall not be any danger of pinching or guillotining an operator's fingers or hands
- All connections that could potentially expose the operator to dangerous voltages will be shielded to IP2X. These connections include the terminals used for current transformers, primary power supply and voltage measurement inputs.

The controller shall provide following integrated features:-

- Local human machine interface (HMI) shall be menu driven via 6 menu display groups.
- Protection flags and counters displayed on LCD.
- Large 4 lines by 40 characters LCD or as per manufacturers std.
- Four configurable quick keys.
- Operator Interface turns on when opening the door.
- Close and Open indications LEDs.
- Trip & close circuit isolation shall be through large rocker switches/ user configurable function keys.
- Front mounted isolated RS 232 data port for local communication at site.
- It shall be with automatic and manual battery health monitoring.
- Electronic modules shall perform continuous diagnostic monitoring and shall contain hardware and software watchdog checking.

Protection, Measurement & Power Quality characteristics.

Following protection element shall be provided with at least 4 independent protection group settings.

- Phase Instantaneous Overcurrent
- Earth Instantaneous Overcurrent
- Phase Time Overcurrent.
- Earth Time Overcurrent.

- Phase time Overcurrent Protection.
- Loss of Phase (LOP) protection..
- Sensitive Earth fault (SEF) protection
- Earth fault protection
- Voltage Imbalance
- Negative Sequence Instantaneous Overcurrent.
- Sensitive Earth Fault Instantaneous Overcurrent.
- Under frequency & over frequency protection / auto-restoration
- Under Voltage & over Voltage protection.
- Cold load pickup control.
- Phase Directional protection
- Earth Directional Protection
- Directional Blocking.
- Loop Automation.
- Directional Protections.

The ratio of drop-off current to pick-up current shall be at least 95 % for all protection functions.

The E/F and SEF functions shall be equipped with harmonic filtering to prevent operation when harmonics are present in the primary residual earth currents

All protection functions, i.e. over-current (O/C), earth fault (E/F) and sensitive earth fault (SEF) shall have elements with characteristics that comply with IEC 255.

All the basic protection parameters shall be provided with Standard inverse (SI), very inverse (VI) or extremely inverse (EI), definite time curve.

In addition to above, provision for at least four customer programmable curves shall be provided.

LOP shall be provided to ensure the protection functionality; auto recloser should trip with no autoreclose , in case if there is a loss of voltage on one or two phases on the upstream part of the line. Loss of supply on all three phases shall not generate the protection trip. There shall be facility to turn LOP ON or OFF without affecting other protection functions of the device.

6SEF a primary earth fault current of 4A to 20A in steps not exceeding 1A shall be detectable. Delayed protection operation shall be possible by selecting a definite time protection element with time delay from 3s to 25s, in 1s steps.

The AR and Control element shall support multiple protection groups and this shall meet the requirements specified below:

- The AR shall have minimum 4 independent protection groups. The Protection Groups shall have clear indication and shall be marked as "I, II, III, IV" or "A, B, C, D"
- Each protection group shall have the facility to configure O/C, E/F and SEF trip current and specify the number of the protection trips independently from others.

- Changes to any of the protection parameter to any of the not active protection group shall not affect the protection functionality of the active protection group.
- Information about activation of any of the protection group shall be recorded in history and shall be easily assessable. Information about protection trip shall clearly indicate the protection group, active at the time of fault.
- AR and Control element shall have the facility for Automatic protection group selection. Automatic Protection Group Selection shall have the facility to be turned ON or OFF with pass-word protection or other form of access control.
- **The auto re-closures shall have the facility including the software of connecting in LOOP AUTOMATION. Supply outage management is in the scope of bidder.**
- The Modem required for the Auto recloser will be provided by the **SCADA Implementing agency (SIA)**.
- The earthing of auto recloser as per the standard including providing of earth pit, and connection to the control cabinet and other allied equipment is in the scope of bidder.

15.2.5 Auto recloser Operation parameters

The number of sequential trips to reach lockout shall be selectable to be either 1, 2, 3 or 4.

Reset times shall ideally be separately selectable for SEF and the combination of over-current and earth fault functions. The reset time shall be selectable from 5s to 120s in 1s steps.

Dead times shall ideally be separately selectable for SEF and the combination of over-current and earth fault functions. The dead time between each -successive recloser shall be independently selectable from instantaneous to 5s for the first recloser and from a minimum of 2s up to a maximum of 120s for subsequent reclosers.

A close instruction initiated locally or remotely during a dead time shall result in lockout if the fault is still present upon closure.

15.2.6 Auto Recloser Statistical Measurement Functions

The Measurement shall be done with one of the following methods i.e. three-phase-3-wire method; and or the three-phase-4-wire method and made available at HMI and remote location.

Quantities to be measured/calculated with specified accuracy are:

- Phase Voltage (V) $\pm 2.5\%$ of auto-recloser rated voltage.
- Line Voltage (V) $\pm 2.5\%$ of auto-recloser rated voltage.
- Phase Current (A) $\pm 2.5\%$ of auto-recloser rated current.
- Three phase active Power (kW) $\pm 5\%$;
- Three phase reactive power (kVAr) $\pm 5\%$;
- Total three-phase active energy (kWh) $\pm 5\%$;
- Power factor $\pm 5\%$;
- Maximum demand $\pm 5\%$.
- Phase Angle ± 10 deg.
- Total Pwr (KW, KVA, KVAr) $\pm 5\%$.

The real power energy and maximum demand measurement shall be integrated with respect to

time. Energy values shall be calculated with selectable time integration periods of 30 min. The data buffer shall work on the FIFO principle and a minimum size for the data buffer shall store values for 4 months on the 30 minutes integration period.

Supply Outage management (SOM) which is a part of SCADA system.

The following parameters shall be recorded in SCADA

- Cumulative total number of outages.
- Cumulative total outage duration.
- Time and duration of each outage

15.2.7 Power Quality analysis characteristics

- **Waveform Capture** It shall capture the Waveform and store in flash memory filtered and scaled raw data (32 samples per cycle) of the **3 line to earth or 3line to line voltages and 4 currents** for a predefined time window either side of a user-defined trigger. The user shall be able to configure a pre and post trigger time ratio for data to be stored.
- **Harmonic Analysis: It shall able to calculate for voltages and currents of 2nd to 7th harmonic and Total Harmonic Distortion (THD) for 4 currents and 3 line to line voltages or 3 line to earth voltages.**
- Sag and Swell monitoring, when sag/surge is identified then an event shall be logged. The same shall be downloadable at the remote through communication interface.

15.2.7.1 Local Engineering

The AR controller shall contain a real time clock (with leap year support) that can be set both locally and remotely.

A facility for selecting all the protection, operating and communications characteristics shall be locally available in the control cabinet. Optional password protection against unauthorized changes shall be available.

15.2.7.2 Event Records

- **The controller shall provide, non-volatile memory storage shall be sized to store at least 3,000 logs :**
- All operating, protection and communications parameters.
- **An event record containing at least 3,000 events.**
- All setting change logging.
- Maximum demand shall have the facilities to be configured for weekly or monthly demand.
- Demand Logging shall be daily, weekly, monthly.
- It shall record wide range of parameters such as current, voltage, **including the monitoring of the battery and its healthiness, gas pressure etc. with IEC 104 / 101/103/ Modbus**
- **It shall also record specific information including temperature pertaining to Control box**

- Facility for configuring the interval in minutes shall be provided.

A pointer shall be provided to indicate up to where the data was last read. This will enable regular uploading of the data without re-loading of previously read data.

All events shall be time and date stamped with a resolution of at least 10 ms relative to the onboard real time clock.

15.2.7.3 Tele Control Requirements

The AR controller shall detect and report disconnection of the control cable between the controller and AR.

It shall be possible to operate AR, change the active protection group, turn Auto-Recloser capabilities ON/OFF and turn E/F and SEF ON/OFF remotely using the protocol specified.

15.2.7.4 Communication

As a minimum, one independent RS-232, & two Ethernet communication ports that allow for simultaneous operation shall be provided, to be used as follows

A USB port shall be provided to upload the non-volatile data to and from a personal computer.

To interface to remote communications equipment (modems, radio-modems, GSM/GPRS/MPLS-4G and Fiber Optic) [GSM/GPRS/MPLS-4G modem will be supplied through **SCADA Implementing agency (SIA)**].

As a minimum, it shall be possible for serial ports to operate at the following speeds :

- 1200 bps
- 2400 bps
- 9600 bps
- 19200 bps

Provision shall be made for mounting modems

It shall be possible to disconnect the RS-232-to-modem interface to facilitate local protocol and communications troubleshooting. Alternatively, a low-level protocol monitor shall be integrated in the software and accessible via the diagnostic port.

The protocol to be supported by the AR controller for remote communications shall be IEC 60870-5-104 Protocol

The serial ports shall have IEC 60870-5-101 protocol and shall be available as a backup port.

15.2.7.5 Power Supply

The AR system shall provide power for the electronics, operation of the AR and Controller operation and Modem being provided separately. The **Dry Type (Resin Cast) 11000/230 V AC Control Transformer shall be used for supplying at least 100VA** or higher suitable for self-operation of AR and Modem.

Primary supply: Preference will be given to the ability to obtain primary power directly from the HV power system requiring no additional primary supply connection.

Test supply: The AR shall accept an external AC 230 V 50 Hz supply.

Auxiliary supply: An auxiliary supply with the following minimum characteristics shall be provided

One battery and constant voltage charger with current limiting shall be part of the AR. Battery standby time shall not be less than 24 hours and shall allow for a minimum of ten (10) sequences of LRC trip-close operations and a transmit/receive standby duty cycle of 10/90 percent with respect to the GPRS/MPLS-4G modem. The battery shall recharge to 80 % of its capacity in a maximum of 15 h. The total number of circuit-breaker operations under the above communications scenario shall be at least 10 AR operations preventing closing if the battery will not have enough stored energy to open the circuit- breaker for a protection trip condition.

Batteries shall be disconnected at the manufacturer's specified minimum voltage.

Battery Low' indication shall be available locally and remotely and shall include a battery test. The indication of "Battery Low" status shall allow for a further ten AR operations.

The minimum battery life expectancy shall be 5 years. Details of the guaranteed life expectancy of the battery shall be stated in the tender documentation.

15.2.7.6 Maintenance and commissioning

All the communications equipment shall be easily accessible in the control cabinet. Wiring of "communications links in the control cabinet shall permit the connection of a temporary protocol-Monitor. It shall be possible to perform secondary injection testing while the AR is communicating with the center.

It shall be Possible to disconnect the AR circuit breaker and connect a simulated breaker to the control cabinet for testing purposes.

The AR shall not malfunction while the modem is transmitting via an antenna in close proximity and the control cabinet door is open.

Provision shall be made in the control cabinet for individually isolating the power supply to/from the following:

- Battery;
- Battery charger;
- GPRS/MPLS-4G modem; and
- Primary supply to the control cabinet electronics.

15.2.7.7 Rating Plate

Each AR shall bear a rating plate of an intrinsically corrosion-resistant material, indelibly marked with the sea-level rating for which the equipment has been type tested. The rating plate shall be indelibly marked with:

- The manufacturer's name;
- The equipment type designation and serial number of the AR;
- The mass, in kilograms;
- The date of manufacture;
- The voltage transformer ratio, class and burden.
- Auxiliary supply voltage (if applicable).
- Purchase Order number and date.
- Each AR shall also exhibit a Danger Board to indicate the presence of high voltage.

15.2.7.8 Additional Information

The following shall be submitted with the tender.

Circuit breaker details

- Manufacturer;
- Type designation;
- Place of manufacture;
- **Short circuit breaking capacity: 1s**
- Asymmetrical breaking current;
- Peak making current; and
- Critical current (maximum instantaneous peak).

A schematic-wiring diagram of the AR offered.

A general-arrangement drawing of the AR offered.

Details of the maintenance and operating equipment and procedures needed and a detailed parts list of the various components.

A description of the AR operation, with instruction and maintenance manuals, including maintenance schedules, protection characteristics, communications facilities, the method of applying settings to relays and controls, together with any software required and the cost thereof. The software requirements shall be stated in the tender documentation.

Details and the cost of any available portable calibration and diagnostic test set that may be used to perform the functionality described.

A list of recommended spares and tools, quoting the prices of each item and its availability.

If protection setting changes are accomplished by resistors, electronic cards or modules or computer programs, the price and range of such items. The method of changing protection settings shall be stated in the tender documentation.

Details of technical back-up facilities available. These details shall be stated in the tender documentation.

Details of the class, ratio(s) and burden of the protection current transformer and voltage transformer, if supplied, shall be stated in the tender documentation.

The supplier shall include the following details of measurement current transformers (not internal to the AR) that can be supplied with the AR. The following details shall be provided:

- Available ratio(s) and accuracy class;
- Method of fitting; and
- Effect on Creepage distance and BIL

Details of AR service history:

- How many in service, where and for what period;
- Contact names and numbers.

Details of LV trip/close coil if available as an option

Power requirements for a close operation

The maximum achievable separation between the control unit and the circuit breaker.

Full details of the protocol implementation and the complete point database.

15.2.7.9 Tests

Type Tests

The AR shall have been type tested in accordance with, and found to comply with, the requirements of either IS or ANSI/IEEE C37.60-2003/IEC 62271-111 for the following, and the appropriate. Values shall be stated.

- Interrupting performance (automatic operation).
- Interrupting performance (manual operation).
- Operating duty.
- Making current.
- Minimum tripping current.
- Insulation (dielectric tests).
- Radio interference voltage.
- Temperature rise.
- Mechanical operations.
- Control equipment surge withstand capability.

Test records (on identical equipment) in the form of validated copies of test certificates issued by a recognized testing authority shall be submitted with the tender documentation.

Routine tests

- Routine tests, as required in the relevant standards, shall be carried out as a normal requirement of the contract and, unless otherwise agreed upon, shall be witnessed by the purchaser or by his appointed representative. No additional charge shall be levied for such tests or for the production or presentation of documentation related to routine tests.
- Duplicate copies of routine test certificates shall be supplied together with the equipment when the latter is delivered to the final destination stated in the order.

15.2.7.10 Packing and Documentation

Packing

All equipment shall be carefully packed to prevent damage or deterioration during normal transportation, handling and storage. Each container shall bear the following information on the outside of the container:

- The address of the destination
- The gross mass, in kilograms
- The name of the manufacturer
- The purchaser's order number and port of destination

Documentation

Each AR shall be supplied complete with the documentation specified in Items, together with the routine test certificates specified above.

15.3 11 KV Sectionalizer

Description	Standard
11 kV Sectionalizers	
High Voltage Switches	IEC 60265-1
Degrees of protection provided by enclosures (IP Code).	IEC 60529:1989

15.3.1 Scope of Work

This specification covers requirements for outdoor **SCADA Compatible Pole-mounted Sectionalizer / load break switches along with Lightning Arrestors and 11KV 400A Conv. AB Switch with Single break** that have programmable fault detection with built-in FRTU and the Sectionalizer features and integrated remote operation capability and that are intended for installation on 11kV Feeders on distribution networks to implement complete overhead network automation.

A primary objective of this specification is to foster modularity and a maximum level of interchangeability and integration to a central SCADA system by supporting IEC 60870-5-104 communications protocol.

The **Sectionalizer** shall be fixed on the existing **MS pole** or **if additional pole is required, one 9.1 M (height) Steel Girder Pole / Rail Pole or MS Box 175 X 85 mm X 2 Nos. back to back box pole** with all the hardware and clamping structures conductor, concreting and earthing of the equipment etc., is in the scope of the Bidder.

15.3.2 Applicable Standard

The following standards contain provisions that, through reference in the text, constitute requirements of this specification at the time of publication the revisions indicated were valid. All standards are subject to review and parties to purchasing agreements based on this specification are encouraged to investigate the possibility of applying the most recent revisions of the standards listed below.

Description	Standard
High Voltage Switches	IEC 60265-1
Degrees of protection provided by enclosures (IP Code).	IEC 60529:1989

15.3.3 Construction

15.3.3.1 General

The Sectionalizer / load break switch shall be suitable for use on non-effectively earthed and effectively earthed networks and under the system conditions and service conditions as follows:

15.3.3.2 Environmental Conditions

All materials supplied shall be capable of operating under relevant environmental conditions are listed as follows:

- Maximum ambient air temperature : 50 °C
- Minimum ambient air temperature : 0 °C
- Average ambient air temperature : 40 °C
- Maximum relative humidity : 0-100 %
- Average thunder storm days per annum : 10
- Average rainfall per annum : 400 mm
- Maximum wind speed : 119 km/hr
- Utility may specify location with altitude more than 2000m above MSL for compliance of in that project area
- Environmental parameter specified are indicative only, utility may specify as per site conditions and standard product

15.3.3.3 Distribution Network Electrical Parameters

The main parameters of the distribution network are as follows:

- 1) Nominal system voltage (U) (r.m.s.) - 11 kV;
- 2) Maximum system voltage (Um) (r.m.s.) - 12 kV;
- 3) Load current - 400 A;
- 4) **Lightning Impulse Withstand Voltage (BIL)** - **75 kVpeak**
- 5) System frequency - 50 / 60Hz;
- 6) Number of phases - 3
- 7) **Interrupting medium** - **SF6**
- 8) **Insulation medium** - **SF6**
- 9) Minimal number of rated load operations - 600
- 10) Minimal number of no load mechanical operation - 3000
- 11) **Operating Mechanism** - **LV motor**

15.3.4 Definitions And Abbreviations

Automatic Detection Group Selection (ADGS):

An automated feature to determine and activate a pre-programmed group of detection settings based on the direction of power flow.

Cold load pick-up (CLP) feature:

A feature that allows modification of the over-current fault detection characteristics in order to prevent false fault detection under conditions of system energization.

Dead time:

Also referred to as "Reclosing Interval". This is the time between the instant that the current is interrupted by the AR and the instant the contact of the AR closes as a result of an automatic reclose operation.

Definite time:

A fault detect event occurs if the current exceeds the fault threshold setting for a time equal to the definite time setting.

Effectively earthed system:

An earthed system in which the healthy phase power frequency phase-to-earth over voltages associated with earth faults are limited to 80% of the highest phase-to-phase voltage of the system.

Pickup:

The fault detection elements are monitored and an element “picks up” when the measured current exceeds the preset level of the specific element. Typical detection elements are Phase, Earth and Sensitive Earth Fault (SEF).

Pole-mounted remote terminal unit (PMFRTU):

A remote terminal unit that is designed for pole mounting and that operates specific pole-mounted equipment remotely.

Sequence reset time:

The time duration after a supply interruption occurred before the sectionalising sequence resets if the sectionaliser does not detect another fault.

Sectionalising:

The ability of the load break switch to count the operations of an upstream AR and to open during the dead time of the AR after a configurable number of supply interrupts.

Secure control:

A single mechanically non-latching switch that effects one state of a control function only. An example of which is either a non-latching switch or two separate push buttons that affect one state of a control function only in each position. If a control is activated repeatedly it only effects that state and does not change the state of the control.

Sensitive earth fault (SEF):

A relay that is sensitive to very low earth fault currents and in which the operating settings are for current magnitude and definite time delay.

Supervisory:

Remote control and indications of an LBS or a PMRTU by means of a telecommunications link.

Supply Interruption:

A fault pickup followed by a “no current” and “no voltage” condition is called a Supply Interruption. This condition typically occurs when an upstream recloser trips due to a downstream fault.

Toggled control:

A single mechanically non-latching switch/push-button that enables a single control function

on the first operation of the switch/push-button and disables the function on the second operation of the same switch/push button.

15.3.5 Testing

The specified Sectionalizer shall be subject to type tests, routine tests, and acceptance tests. Where applicable, these tests shall be carried out as per the standards stated above. Prior to acceptance testing, the supplier shall prepare and submit a detailed test plan.

15.3.6 Mounting of Sectionalizer

The LBS shall be suitable for single pole mounting and shall be provided with mounting brackets. Adequately rated lifting eyes shall be provided and they shall be designed to allow the completely assembled LBS. The diameter of the eyes shall be a minimum of 30mm. Suitable mounting brackets for surge arresters shall be provided. The LBS shall be fitted with an external M12 Earthing stud, complete with a nut, lock nut and spring washer. The earth stud shall be welded to the tank for optimal Earthing connection. All support structures and associated bolts and nuts with these parts, shall be hot-dip galvanized.

The earthing of sectionalizer as per the standard including providing of earth pit, and connection to the control cabinet and other allied equipment is in the scope of bidder.

15.3.7 Bushings

The preferred arrangement for termination is an insulated bushing arrangement achieved by using **epoxy resin bushing/ HECP**. The material for bushing shall be outdoor aromatic epoxy resin with silicon rubber boots details of the type and Creepage shall be provided.

15.3.8 Finish

All interior and exterior ferrous surfaces of the LBS and control cabinets shall be manufactured from marine grade 304 or 316 Stainless steel.

15.3.9 Control Equipment

Control cabinet

Cabinets that house equipment for detection and control shall be mounted independently of the LBS. The cabinet shall be manufactured from 304 or 316 grade stainless steel.

Suitable ultraviolet-resistant cable shall be provided to connect the LBS to the control cabinet.

It shall be possible to disconnect the cable at the LBS while the LBS is connected to the power system, without causing damage or mal-operation: care shall be taken that CTs are not open circuited.

A robust, multi-pin weather proof connector shall be supplied. Preference will be given to products supplying connectors at both the LBS and the control cabinet.

Cabinets shall be adequately sealed and dust protected and shall be internally treated to prevent moisture condensation. The degree of protection shall be suitable for purpose.

The control cabinet shall be for all – weather access & vandal resistant.

The door of the cabinet shall be fitted with a robust fastening arrangement that is capable of being secured by a padlock that has a two point locking mechanism system.

The cabinet shall be fitted with an external Earthing stud with a nut, lock nut and a serrated

The control cabinet shall house Control and detection enclosure, which shall incorporate all the electronic modules. These electronic circuits shall fulfill the functions ,detection ; Network