

PACKAGE- 4A

**TENDER FOR ELECTRICAL HIGH SIDE WORK FOR OUTREACH
BUILDING AT PROPOSED PERMANENT CAMPUS (PHASE I)**

OF

NALANDA UNIVERSITY, AT RAJGIR, BIHAR.



TECHNICAL SPECIFICATIONS

NALANDA UNIVERSITY, RAJGIR, BIHAR.

Every care has been taken while preparing this document to cover all necessary information, matters, specifications, general conditions, special conditions & provisions for smooth and complete execution of works. However, in case of any omission in the tender/ contract document, the most recent version of correction slips (**as on 31st January 2018**) of Electrical Specifications for CPWD Works shall be the reference manual.

A. TECHNICAL SPECIFICATIONS.

A.1 HT PANEL (11kV)

A.1.1 Scope

The scope of work shall include:

1. Supplying, installation testing and commissioning of 11kV HT Panel.
2. Panel handling, loading unloading and storage.
3. Associated inter panel and intra panel wirings including both ac and dc wirings as well as control cabling, from panel to panel and from panel to DB.

A.1.2 Definitions

The definitions shall be as per IEC-62271 and other relevant IEC standards.

A.1.3 Codes & Standards

The contractor is required to follow all relevant IS and IEC codes as per latest amendments, however in particular following codes may be applied in addition.

1. IEC-62271 - Standard for medium voltage switchgear and assemblies.
 - A) IEC 62271-1 General specification for MV switchgear.
 - B) IEC 62271-100 specification for Circuit Breaker.
 - C) IEC 62271-200 specification for the switchgear assembly.
2. IEC-60044 - Standard for instrument transformer.
3. IEC-60099- Standard for surge arrester.
4. IEC: 60255- Measuring relays and protection equipment
5. Accuracy Class-1 as per IEC 62053-21 and Class-0.5 as per IEC-62053-22- All multifunction meter, ammeter, voltmeter
6. NEC- 2008 - National electrical code.
7. NBC-2016 - National building code.
8. IER-1956 : Indian electricity rules.
9. IEA-2007 : Indian electricity act 2007
10. Any other local bye-law or supply company norm as applicable.

A.1.4 Service conditions

System particulars

- a. Nominal system voltage - 11kV
- b. Rated system voltage - 12kV
- c. Frequency- 50Hz $\pm 3\%$
- d. No. of phases- 3
- e. System neutral- Solidly earthed
- f. Short circuit rating - 25kA for 3sec
- g. Automation compatibility : SCADA compatible

Tropical conditions

- a. Ambient temperature : 50 degree celsius
- b. Relative humidity (avg.) : 60
- c. Isokeraunic level : 33
- d. Seismic Zone : Zone-4
- e. Climate type : hot and humid

The climatic conditions are prone to wide variations in ambient conditions and hence the equipment shall be of suitable design to work satisfactorily under these conditions.

Tolerances and creepage distance

Tolerances (on all the dimensions) and creepage distances shall be in accordance with provisions made in the relevant Indian/IEC/BIS standards and in these specifications. Otherwise the same will be governed by good engineering practice in conformity with required quality of the product.

A.1.5 Specifications

Panel Cubical

- Panel body shall be fabricated out of CRCA/ Alu zinc sheet steel throughout and shall have undergone 14 tank process or better. Thickness of sheet steel shall be as per the type test design of the manufacturer.
- The panel body shall be completely dust, corrosion and vermin proof. The panel shall be powder coated with coating thickness of 80 micron.
- Self adhesive type, neoprene or cross linked poly ethylene gaskets shall be provided wherever required.
- The panel shall be mechanically rugged to withstand the load of switchgears and busbars without any external bracing.

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- The panel shall have metal clad construction, fully compartmentalized with partition thickness of 2 mm or as per the type test design of manufacturer. The panel shall have separate compartment for switchgears and controlgears.
- Panel shall be fully wired in factory complete in all respect. It is preferred to have fabrication done through automatic advanced machines, CNC, robotic machines to ensure best quality of fabrication.
- Panel shall be fully extendable from both sides and shall be easy to operate and maintain i.e. bus bar, metering, circuit breaker chamber, cables and cable box chamber should have proper access for maintenance. Separate compartments shall be provided for switchgears, Bus PT, metering & controlgears, cable compartments.
- Width of each compartment shall not exceed 800mm. Total height of panel shall not exceed 2400mm.
- The compartments shall be designed such that breakers of same frame size up to 1250A are interchangeable in any of the compartments. Circuit breaker cubical shall be at the bottom and metering and control gear compartment shall be on the top.
- Breaker and withdraw able PT compartments shall be provided with viewing window. The same shall be internal arc tested.
- All wiring in control compartment shall be routed through PVC ducts and shall be terminated on to stud type terminal with plastic cover. Internal wiring shall be done through FRLS copper stranded wires / cables.
- Control cable entry shall be from front and there should be a possibility of terminating to LV chamber from both right hand and left hand side.
- Provision for lamp operated with door limit switch and a 6A socket operated through a toggle switch shall be made in control gear compartment.
- Suitable guiding rails shall be provided in circuit breaker compartment for roll on floor type circuit breakers.
- The panel shall be well ventilated and shall have provision of cable entries from the bottom.
- Gland plates shall be 3mm thick / or as per type test design of OEM in case of Alu zinc panel. Holes shall be plugged in with fire retardant sealant.
- The panel shall have IP-4X ingress protection and shall be resistant to high mechanical impact.
- All doors shall be hinged type with a provision of padlocking.
- Provision of space heaters shall be made to absorb moisture in the panel compartments.
- The panel shall be suitable for grouting upon floor or MS channel. Bolt size and channel size shall be suitably selected in accordance with seismic one compliance.
- Cable compartment shall be on the rear side with bolted box type back covers. There shall be an inspection window at the rear back cover enabling operator to have visual inspection without opening back cover in live condition.
- Cable box shall accommodate required number of cables as per designed SLD.
- Sufficient headroom shall be provided for cable termination. Creepage distances and clearances shall be as per BIS/IS/IEC criteria.

Earthing

- There shall be a continuous copper earth bus of size required size running at the bottom of the panel.
- Earth bus shall be robust and shall be capable of carrying full short circuit current for 1 second.
- Doors, covers and all non-current carrying metallic parts shall be earthed through flexible FRLS copper wires of required sizes.
- Earth continuity shall be maintained for each component in the panel board including its body and gland plates.

Bus bars

- Bus bar shall be provided in tubular/ rectangular cross section made up of high electrolytic grade copper having good conductivity, suitable to carry rated current under steady state and shall be capable to withstand the thermal and electrodynamic stress during transient conditions for 3 sec.
- Bus bar shall be designed for suitable current density not exceeding 1.6A/sqmm.
- Bus bar shall be designed for a temperature rise of 40 degree celsius (above ambient) and 45 degree celsius for all bolted joints (above ambient).
- The bus bar shall be designed for a temperature of 190 degree celsius during transient conditions.
- Busbar shall be supported upon non-breakable, non-hygroscopic epoxy resin or glass fiber reinforced polymer insulated support suitable to withstand operating temperature of 110 degree celcius at regular interval. Busbar supports shall be capable to withstand the electrodynamic forces during transient conditions.
- Busbars shall be provided with heat shrinkable sleeves of equivalent voltage grade and shall run throughout the switchgear. PVC sleeves shall not be acceptable.
- Phase barriers of required material and thickness shall be provided in busbar wherever required. In case manufacturer has required type test certificate without phase barriers the same shall be acceptable.
- The bus bar edges/ ends shall be rounded off/ chamfered so that there will not be any sharp edges/projections.
- All fasteners (nuts bolts) used for bus bar connections shall be of non magnetic stainless steel. Washers shall be provided for each nut bolt. If the fasteners used are not of stainless steel the tenderer shall state in their offer the material used and confirm that the same is non-magnetic and is superior to stainless steel.
- The busbar shall be color coded using identifying colored sleeves / rings. Red, yellow and blue colors shall be used for phase and black color shall be used for neutral for each shipping section of panel. The earth busbar shall be identified with green color
- Clearances for 11kV busbars shall be as per the type test design of manufacturer.

Circuit Breaker

- The circuit breakers shall be vacuum circuit breakers and of horizontal draw out horizontal isolation type.
- All the three interrupters of individual phases shall be mounted on a common phase segregated epoxy body mounted on a truck for better insulation and avoidance of non-simultaneity of poles.
- Breakers shall be of 3 pole design for use in 11 kV indoor switchgear. Circuit breaker shall be suitable for rapid reclosing cycle i.e. O-0.3 sec.-CO-3 min.-CO.
- The circuit breaker shall be provided with motor operated spring charged closing. Spring charging motor shall be suitable for 240V, 50 Hz, single phase AC.
- Provision shall be available for charging the springs manually as well, and to close circuit breakers mechanically.
- Provision for padlock shall also be available.
- Tripping of the circuit breakers shall be through "shunt trip" coils rated for 110V DC auxiliary supply. It shall be possible to trip the breaker manually in case of necessity.
- All circuit breakers shall have mechanical ON/OFF indicator and spring charge indicator. These shall be visible from the front without opening the panel door. Also there shall be provision for mechanical (manual) tripping and also for manual charging of the springs.
- Vacuum circuit breaker (VCB) shall be mounted on a withdrawable truck which shall roll out horizontally from service position to isolated position with ease and it shall also be possible to take out the breaker truck from cubicle smoothly on to the floor without use of any separate handling equipment.
- It is preferable to provide three point guide for withdrawal and insertion of truck into the cubicle with ball bearing arrangement on the top of the truck. Truck shall have distinct 'SERVICE' and 'TEST' position.
- Isolated position by defeating the interlock shall also be inside the cubicle so that the front door of breaker compartment can be closed even in breaker isolated position.
- Special more than three point hinged locking arrangement shall be provided to prevent opening of door in the event of internal arc in breaker compartment.
- Adequate numbers of "NO/NC" contacts of the circuit breaker shall be wired upto the terminal block for connection to the remote supervisory desk for indication, SCADA and other interlocks etc. as required.
- Safety shutters which close automatically to prevent accidental contact with the live bus after withdrawal of the circuit breaker shall be provided.
- Wherever the breaker is provided with earth switch, the same shall be mechanically interlocked with the circuit breaker. The earth switch shall be connected on line side of VCB.
- Where integral earth switches are not provided, suitable earthing trolleys shall be offered to facilitate earthing of out-going feeder circuits. Separate earthing truck shall be provided for bus earthing and cable earthing.

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- The earthing truck shall be so designed that it is impossible to earth a live. It shall be provided with capacitive voltage divider and complete with audio visual annunciation.
- In addition to scrapping earth in auxiliary plug and socket proper arrangement should be made so that during engagement of the breaker in service condition earthing contacts is made first before isolating power contacts are engaged.
- The auxiliary supply to these earthing trolleys shall be through 110V DC supply. Emergency mechanical push to trip button shall be provided for emergency manual tripping with front door closed. Auxiliary plug and socket shall be of minimum 24 pin plug type and shall have scrapping earth feature.
- Touch panel type, high resolution HMI screen shall be provided in front fascia with each panel so as to see the status of switchgears and meters in it.
- Typical parameters for 11kV circuit breaker shall be as follows respectively :

a. Rated voltage : 12kV

b. Basic insulation level (BIL) : 75kV

c. Power frequency voltage withstand (1 min) : 28kV

d. Rated symmetrical breaking capacity for 3 sec : 25kA

e. Rated steady state current rating : 630A

Electrical features and safety interlocks

- The panel shall be internal arc tested for 1 sec for rated fault level of incoming switchgear for all front , rear and lateral side of each compartment. Each compartment of panel shall be fully type tested as per criteria laid under IEC norms, from CPRI or ERDA.
- High voltage compartments shall be provided with pressure discharge flap for the exit of gas due to internal arc to insure operator safety.
- The switchgear panels shall be suitable for loss of service continuity LSC 2B as per IEC-62271-200 so that in case one compartment is under service , the other compartments shall not loose supply continuity.
- Safety shutters shall be metallic and shall be provided to cover up the fixed high voltage contacts on bus bar and cable sides when the truck is moved to Test / isolated position. The shutters shall move automatically, through a linkage with the movement of the truck and shall be of gravity fall type only. It shall be possible to padlock shutters individually.
- Door interlocking features shall be provided in all front and rear doors/cabinets. Racking interlock shall be provided for all switchgear compartments .
- Switch gear cubicle shall have seal off bushing arrangement between the circuit breaker compartment and bus bar / C.T. cum cable compartment, i.e. the fixed isolating contacts shall be embedded in epoxy cast bushing so these act as seal off bushing to prevent transfer of arc from one compartment to the

- other in the event of internal arc within the cubicle & must be tested for internal arc in all three HV compartments as per IEC 62271-200.
- Circuit breaker can be inserted only in open position. Likewise circuit breaker in closed position cannot be withdrawn. Attempt to draw out closed breaker shall not trip the breaker.
 - The circuit breaker shall operate only in one of the three defined positions i.e. service, test and isolated. The breaker shall not close in any of the intermediate positions.
 - The circuit breaker cannot be inserted into service position till auxiliary contacts are made. Similarly interlock prevent auxiliary contacts from being disconnected, if circuit breaker is in service position.
 - It will not be possible to rack out the withdraw able part from service to test position when the switching device is switched ON. Similarly, it will not be possible to rack in the withdraw able part from test to service position, if the switching device is switched ON.
 - Any attempt to rack out withdraw able part from service to test position will not result in switching off of the circuit breaker instead the service position will be locked till switching device is 'ON'.
 - It will not be possible to rack in or rack out withdrawable truck when the front high voltage door is open. However, a suitable defeat interlock mechanism is provided for emergency purpose.
 - It will not be possible to rack in the withdrawable truck from test to service position when the low voltage control plug is not in position and locked on the truck itself.
 - It will not be possible to close the door if the low voltage control plug is not engaged.
 - Pull out type, rotary switch shall be provided for breaker to cut off the power manually during any emergency. This switch shall latch the breaker in off state in such a manner that untill the switch is rotated back to its normal position the breaker should not turn on under any circumstance.
 - Two position, selector type, auto manual switch shall be provided, with clear markings of Auto and manual positions engraved with good quality and shall be long lasting. Once the selector switch is put on to manual position all remote functions shall get defeated. Potential free contact shall be provided to send the status of auto / manual switch to SCADA.

Potential transformer (PT)

- Potential transformer shall cast resin type with copper windings and good quality ferromagnetic core.
- Losses shall be as per relevant standards.
- PTs shall have inbuilt fuses on primary side rated at 11KV and shall be suitable to be mounted on the incoming line VCB
- PT shall have external fuses rated at 110V on secondary and tertiary sides and shall be provided with isolating plugs.
- Bus PT shall be withdraw able type and shall be housed in a separate compartment.

- Trolley shall be provided to safely rack out PT.
- PT windings shall be connected in star configuration with its neutral grounded with suitable size conductor to the grounding bus of panel through terminal links.
- Typical parameters for 11kV PT shall be as follows respectively :
 - a. Rated primary voltage / phase : (11/1.732) kV
 - b. Rated secondary voltage / phase : (110/1.732) V
 - c. Class : Metering class - 0.5, Protection class - 3P
 - d. Burden : 100VA

Current transformer (CT)

- Current transformer shall cast epoxy / resin type with copper windings and good quality ferromagnetic core.
- Current transformers shall be single core type suitable for cable or bus mounting as required.
- CTs characteristics shall be suitably matched for differential and restricted earth fault protection so as to avoid nuisance operations.
- Vendors shall have to furnish CT calculations during the time of approval of product data.
- Losses shall be as per relevant standards.
- Manufacturer shall provide suitable CTs with all its required characteristic curves.
- CTs shall be provided with open able switch type shorting CT links.
- Grounding terminal of CT shall be grounded with suitable size conductor to the grounding bus of panel through terminal links.
- Typical parameters for 11kV CT shall be as follows respectively :
 - a. Rated voltage: 11kV
 - b. Rated secondary current :1A
 - c. Class : Metering class - 0.5
 - d. Class : Protection class - PS (for differential and restricted earth fault)
Protection class - 5P10 (elsewhere)
 - e. Burden :As specified

Surge arrester

- Surge arrester shall be made up of metal oxide varistor, with air gaps suitable for mounting inside 11kV HT panel.
- Surge arrester shall be connected to each phase.

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- Complete assembly of surge arrester shall be housed in a polymer housing.
- Surge arrester shall be capable to withstand both lightning and switching surges.
- Grounding terminal of surge arrester shall be properly grounded with suitable size conductor to the grounding bus of panel.
- Typical parameters for 11kV PT shall be as follows respectively :
 - a. Rated voltage: 9kV
 - b. Rated current : 10KA
 - c. Peak current : 100kA

Note : Other parameters and characteristics shall be as per IEC-60099.

Indication lamps

- LED type Indication lamps shall be provided as per BOQ schedule and single line diagram .
- **Indicating lamps shall have surge, Low wattage and low voltage glow protection (LVGP).**
- Lamps shall be capable to operate on 63.5V-110V AC / 110 bipolar DC as required.
- Lamp circuit shall be protected by a control fuse or MCB as required.
- Color of lamps shall be as per standard industrial practice or as required.

Annunciation window

- Annunciation window shall have compartmentalized windows of required numbers and sizes and shall be suitable for mounting in panel front.
- Engraving shall be with a good quality material and shall be long lasting.
- Manually written stickers or test hand written with markers are not acceptable.
- Color of each window shall be red with letters engraved in black.
- Size of the letters shall be such that the same is readable from at least 1.5 meters from the line of sight and shall be as required.
- Annunciation window shall be suitable for 230V, 50Hz, AC UPS supply.
- Required window of annunciation panel shall glow in case of receipt of control signal.
- Max power consumption shall not exceed 3W.
- Annunciation window shall have a provision of acknowledge, reset and power off in the front fascia.
- Annunciation window shall have IP-40 protection.

Hooter

- Hooter shall be electronic type and shall be suitable for mounting in panel front.
- Hooter shall be able to deliver 80db sound level at every 3 meters.
- Hooter sound shall be selectable for both hooting and siren type.

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- Hooter shall be suitable for 230V, 50Hz, AC UPS supply.
- Max power consumption shall not exceed 5W.
- Hooter shall be capable to operate up to 70 degree celsius.
- Hooter shall have red LED indication for power on.
- Hooter shall stop once the alarm is acknowledged from annunciation window.
- Hooter shall have a provision of reset and power off in the front fascia.
- Hooter shall have IP-40 protection.

Relay

- Relays shall be numeric type, microprocessor based for feeder protection and shall have following required programmable protections:
 - a. Instantaneous (overcurrent and earth fault.)
 - b. Overcurrent
 - c. Earth fault
 - d. Overvoltage
 - e. Undervoltage
 - f. Frequency
 - g. CT / PT supervision
 - h. Phase sequence
 - i. Broken conductor protection based on negative sequence current to positive sequence current.
- Relays shall be numeric type, microprocessor based for transformer protection and shall have following required programmable protections:
 - a. Differential
 - b. Restricted earth fault
 - c. High oil temperature
 - d. High winding temperature
 - e. Sudden pressure.
- Relays shall be hinged armature type, electromechanical, for following required protections:
 - a. DC failure
 - b. Trip circuit supervision
 - c. Lockout
- Relays and circuit breakers shall be fully co-ordinated to achieve total discrimination up to main LT panel inside each distribution substation.
- Separate numeric relay shall be provided for feeder and transformer protection.
- Relay shall confirm to IEC-61850 and shall be provided with Ethernet IP communication port. Relay shall have dual port for PR to PR communication. All protection relays shall be connected in ring topology with Ethernet switch.
- Relay used for transformer protection shall have a feature to bypass the harmonic switching current at the time of transformer switching so as to prevent the breaker trip during switching of transformer. Circuit breaker shall be capable to handle the current at the same time.
- Numeric relays shall have self supervision function and shall be able to communicate and provide indication in case of internal fault in relay.
- Relays shall have inbuilt volatile and non volatile memories and shall be

- capable to record and store at least 100 events with date and time, with last five faults stored in non volatile memory.
- Relays shall be completely SCADA compatible and shall have Ethernet IP port available for communication.
 - 4 spare binary inputs and 4 spare binary outputs shall be provided in addition to those required.
 - The operation of the relay shall be practically free from errors due to normal variations in frequency, waveforms & from ambient temperature effects range between - 20 degree to +55 degree C.
 - The relay shall have 3 independent time delayed O/C stages. The first stage should be programmable to have either a DT characteristics or IDMT characteristics described as follows and shall have a current setting range of 10% to 2500% and time setting range of 0 ms to 150 sec. The second and third settings shall have a current setting range of 50% to 4000%.
 - The relay should have 3 independent time delayed E/F stages. Should have a current setting range 1% to 800% and time setting range of 0 ms to 100 sec. The lower setting is critical to take care of system which have low earth fault currents.
 - The relay shall have reverse blocking or busbar blocking feature.
 - The relay shall have 8 Indication LEDs out of which minimum 4 should be freely programmable.
 - Relay shall be able to record at least 5 oscillographic disturbance records each of minimum 3 seconds.
 - Relay shall have independent setting groups.
 - Relay shall have at least 4 shots of autoreclose function, switch on to Fault function, circuit breaker failure function, cold load pick up function. and inbuilt output relay latching function
 - Relay shall have keypad buttons at front of the relay to configure the relay and shall be easily programmable and maintainable.
 - Aux Supply input voltage shall be 110VDC however relay shall be capable to operate at 24-250VDC / 240VAC.
 - Relay shall have its LCD display and any other control feature required in the relay shall be provided by the contractor at the time of product data approval at no extra time and cost.

Multifunction meter

- Multifunction meter shall be electronic, digital type with inbuilt selector switches suitable to show parameters on 11kV
- Multifunction meter shall be suitable for panel mounting, flushed type of size min 96 x 96 mm and shall be fully communicable with provision of Ethernet IP port and shall be SCADA compatible.
- Meter shall have distinct indication upon front LCD screen for following (but not limited to) data and values :
 - a. Current (for all three phases)
 - b. Voltage (for lines and phases)
 - c. Power factor (Avg. and individual phases)

- d. Active power kW (Avg. and individual phases)
- e. Reactive power kVAr(Avg. and individual phases)
- f. True power KVA
- g. Frequency
- h. Energy kWh (Avg., current , max in a day along with date and time, min in a day along with date and time)
- i. Reactive kVArh(Avg, current)
- j. Energy kVAh
- k. Total harmonic distortion THD %
- l. Current harmonics THDi (for harmonics up to 15th order)
- m. Voltage harmonics THDv (for harmonics up to 15th order)
- Multifunction meter shall have accuracy class of 0.5 and shall have 2 DI/DO ports.
- Multifunction meter shall be fully programmed from factory along with its CT ratio settings.

Analog voltmeter

- Voltmeter shall be analog type suitable with external selector switch.
- Voltmeter selector switches shall be four position type. Selector switch shall be suitable for semi flush mounting with only switch front plate and operating handle projecting out.
- Range of voltmeter shall be 0-12000V for 11kV
- Voltmeter shall be PT operated with accuracy class 0.5
- Deflection needle shall be self adjustable type.
- Front fascia shall have glass/polycarbonate cover.
- Range shall be properly engraved in the front fascia and shall be easily identifiable.

Installation

- HT panel shall be installed upon base channel ISMC -100 and shall be properly grouted on to the floor internally through bolts of proper size.
- Installation shall be in compliance with seismic zone-4 and sizes of bolts and complete grouting have to be structurally verified with respect to that.
- Panel shall be installed and aligned straight with tolerance of +/- 2mm.
- Shims below the panel shall not be accepted at all.
- Panel shall be installed so that required clearances are met and cable termination is easy.
- Installation shall ease operation and maintenance in future.

Testing

- The equipment offered in the tender should have been successfully type tested at CPRI/ERDA/NABL laboratories for following tests in line with the relevant standard and technical specification, within the last 5 (five) years from the date of **approval of drawing**.
- The bidder shall be required to submit complete set of the type test reports

alongwith the offer.

- In case these type tests are conducted beyond five years, all the type tests as per therelevant standard shall be carried out by the successful bidder at CPRI/ERDA/NABL laboratories in presence of employer's representative free of cost before commencement of supply.
- The undertaking to this effect should be furnished along with the offer without which the offer shall be liable for rejection.
- If above tests are carried out on higher capacity of offered equipment, then the offer is considered for placement of order. However, successful bidders have to carry out the said type tests on offered type equipment before commencement of supply at their own expense.
- Type test and routine test shall be conducted in accordance with the provisions made in IS/IEC. However following type test and routine test in particular shall be conducted :

A. Switchgear panel (with circuit breaker installed)

- A.1 Impulse voltage withstand test – Type test
- A.2.H.V. dry 1 min power frequency withstand test. – Type & Routine test
- A.3.Short time and peak withstand current test.- Type test
- A.4.Short circuit test with basic duties.- Type test
- A.4.Single phase breaking capacity test.- Type test
- A.6.Temperature rise test – Type and routine test
- A7.Internal arc test (front, lateral and rear) at rated short circuit for 1 sec in all individual compartments. - Type test
- A.8. IR test on busbars. – Routine test
- A.9. Phase rotation test. – Routine test

B. Circuit breaker

- B.1 Mechanical endurance test.
- B.2.Contact resistance test.
- B.3.Primary Injection test.
- B.4 IR test.
- B.5.High voltage test.

C. Current transformer

- C.1 Short time current test
- C.2 Impulse voltage withstand test
- C.3 Temperature rise test
- C.4 CT turn ratio test.
- C.5.Overvoltage inter turn test (OVIT)
- C.6. Knee voltage test.

D. Potential Transformer

- D.1. Impulse voltage withstand test.
- A.2. Temperature rise test

E. Relay

- E.1. Accuracy test.
- E.2. Internal fault test.

Note : For Impulse voltage withstand test, short time peak current withstand test , short circuit test, internal arc test, only type test certificate for similar rating and design of equipment shall be submitted by the manufacturer for establishing quality.

Inspection and commissioning

- After receiving approval on GA drawings, the concerning vendor shall invite the owner's representative at factory works once single unit of each type of panel is ready.
- Owner's representatives shall be provided open access at factory works to see and analyze any part of process.
- Testing at factory shall be witnessed fully by the owner's representative.
- Once the panel is cleared from factory testing and is received at site, after its complete installation and testing, commissioning shall be done with all pre functional and functional tests, as required by the owner's representatives.

D.2 TRANSFORMER

A.2.1 Scope

The scope of work shall include:

1. Supplying, installation testing and commissioning of dry type transformers.
2. Transformer handling, loading unloading and storage.
3. Associated wirings including both ac and dc wirings as well as control cabling within transformer and from transformer to other panels / DBs.

A.2.2 Definitions

The definitions shall be as per IS 1180 and other relevant IEC standards.

A.2.3 Codes & Standards

The contractor is required to follow all relevant IS and IEC codes as per latest amendments, however in particular following codes may be applied in addition.

1. IS 2026 - Specifications for power transformer.
2. IS 1180 - Specifications for distribution transformer.

3. IEC-60076- Standard for power transformer.
4. IEC- 60726- Standard for dry type transformers.
5. IEC- 60354- Standard for transformer loading.
6. IEC- 60616- Standard for transformer marking.
7. NEC- 2008 - National electrical code.
8. NBC-2016 - National building code.
9. IER-1956: Indian electricity rules.
10. IEA-2007: Indian electricity act 2007
11. Any other local bye-law or supply company norm as applicable.

A.2.4 Service conditions

System particulars

- a. Primary system voltage - 11kV
- b. Secondary system voltage - 415V
- c. Frequency- 50Hz $\pm 3\%$
- d. No. of phases- 3
- e. System neutral- Solidly earthed
- f. Short circuit rating -25kA, 2sec on 11kV HV side and 50kA, 1sec on 415V LV side.
- g. Automation compatibility : SCADA compatible

Tropical conditions

- a. Ambient temperature: 50 degree celsius
- b. Relative humidity (avg.) : 60
- c. Isokeraunic level: 33
- d. Seismic Zone: Zone-4
- e. Climate type : hot and humid

The climatic conditions are prone to wide variations in ambient conditions and hence the equipment shall be of suitable design to work satisfactorily under these conditions.

Tolerances and creepage distance

Tolerances (on all the dimensions) and creepage distances shall be in accordance with

provisions made in the relevant Indian/IEC/BIS standards and in these specifications. Otherwise the same will be governed by good engineering practice in conformity with required quality of the product.

A.2.5 Specifications

Distribution Transformers (Dry type)

- Transformer core shall be made up of high quality ferromagnetic material of CRGO (cold rolled grain oriented) class M-4 or better. The laminations of transformer core shall be lapped one over the other in such a way that there shall be no air gap and hence magnetic flux leakage shall be very minimal.
- Both high voltage and low voltage windings of transformer s shall be made up of double wound copper and shall be suitable for respective voltage grade.
- Windings shall be helical in construction.
- Transformer shall be air cooled suitable for continuous indoor duty.
- It is preferred to have transformer manufacturing done through automatic advanced machines, CNC, robotic machines to ensure best quality of product.
- Transformer accessories shall be provided as per the schedule.
- Complete transformer assembly shall be corrosion/dust/vermin proof and shall be made up of sheet steel, pre painted and galvanized.
- Complete assembly shall be suitable for rated fault withstand for 1 sec.
- Phase barriers of required thickness and materials shall be provided on both primary and secondary side of transformers.
- Transformer losses shall be as per ECBC guidelines.
- Flux density at rated voltage shall be limited to 1.5Tesla (max)at rated voltage and frequency.
- Magnetization current shall be limited to 1% of rated current.
- Typical parameters for power transformer shall be as follows:
 - a. Rated Power: 500 kVA
 - b. Primary voltage : 11000 volts
 - c. Secondary voltage : 415 volts
 - d. Percentage Impedance : 4%
 - e. Vector Group : DYN-11
 - f. Grounding: Solidly grounded with copper
 - g. Insulation class : Class-F
 - h. Cooling : ANAN (air natural air natural)
 - i. HV Bushings : Porcelain (suitable for 11000V)
 - j. LV Bushings : Porcelain (suitable for 415V)
 - k. Primary winding fault withstand capacity : 25 kA for 2 sec
 - l. Secondary winding fault withstand capacity : 50kA for 1 sec
 - m. Temperature rise : As per schedule
 - n. Tap changer type : On load tap changer (OLTC) for all other ratings and OCTC for 100kVA transformer
 - o. Remote tap changing : through RTCC, buit not applicable for 100kVA transformer

- p. Tapping range : +5 to - 15% in the steps of 2.5
 - q. BIL for primary windings : 75kV (BIL) / 28kV (dry power frequency for 1 minute)
 - r. BIL for secondary windings:12kV (BIL) / 3kV (dry power frequency for 1 minute)
 - s. Operation : continuous indoor
- Tap changing range shall be site adjustable on both +ve and –ve side and may change as per the site condition.
 - OLTC shall be housed in a separate compartment on HV side and motor used for changing tap shall be IE-2 rated with its winding made up of copper and connected in delta. Appropriate capacity of OLTC motor shall be decided by the manufacturer and duly approved by owner's representatives.
 - OLTC compartment shall have auto / manual switch for local and remote operation of OLTC.
 - OLTC shall be dry type.
 - The on load tap changer shall include the following –
 - (a) An Air / Vacuum tap selector and arcing switch or arc suppressing tap selector, provided with reactor or resistor for reduction of make and break arcing voltages and short circuits.
 - (b) Motor driven mechanism.
 - (c) Control and protection devices.
 - (d) Local/Remote tap changer position indicator.
 - (e) Manual/Electrical operating device.
 - (f) Voltage tapping range on H.V. side will be (+5%) to (-15%) in steps of 2.5%.
 - The tap selector and arcing switch or arc suppressing tap selector switch shall be located in one or more air/vacuum compartments.
 - A suitable pressure relieving arrangement should be provided to take care of sudden pressure rise in the compartment.
 - The manual operating device shall be so located on the transformer that it can be operated by a man standing at the level of the transformer track. It shall be strong and robust in construction.
 - The control scheme for the tap changer shall be provided for independent control of the tap changers when the transformers are in independent service.
 - Visual indication during the operation of motor shall also be incorporated.
 - The tap change control must ensure step by step operation under all operating conditions.
 - The contactors and associated gear for the tap change driving motors shall be housed in a local kiosk mounted on the transformer. The motors shall be suitable for operation with 3- phase 400 volts, 50 cycle external power supply.
 - RTCC panel shall be wall mounted type accessible from front (for both operation and maintenance)
 - RTCC circuit shall be provided with inbuilt AVR, with front LCD/LED screen showing tap position, raise/lower, AVR voltage etc. proper ferruling shall be done for circuit identification.

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- RTCC panel shall be provided with separate hooter and annunciation window for any fault in AVR and internal circuit.
- RTCC shall be SCADA compatible
- RTCC panel shall be provided with thermostat operated fans and space heater and lamp controlled with door limit switch, 6/16A socket controlled with a toggle switch.
- Control wirings from /WTI/NCT/PSRetc shall be brought into a separate terminal block inside marshalling box from where the same shall be fed to respective switchgears as per design and schedule.
- Proper ferruling shall be done inside marshalling box for circuit identification.
- Marshalling box shall be provided with thermostat operated space heater and lamp controlled with door limit switch, 6/16A socket controlled with a toggle switch.
- Winding Temperature Indicator (WTI) shall be designed to measurement of temperature indication and controllers for transformers for implementation of SCADA in distribution network automation.
- The WTI should be of better accuracy and repeatability for longer periods. These instruments should be electrically isolated from input power supplies and hence safe to use in a computerised data acquisition system or recorder.
- The scheme should be used to indicate the WTI of oil-immersed transformers in remote control room. This should have an output of 4mA to 20mA DC proportional to the temperature ranges.
- Actual temperature display should be of 3 digit, 7 segment LED . Temperature range should be 0°C - 150°C
- Resolution of 1°C
- Output should be of
 - a) 4mA - 20 mA analogue output 1
 - b) 4mA - 20 mA analogue output 1 corresponds to 0°C -150 °C
 - c) 4mA - 20 mA analogue output 2
 - d) 4mA - 20 mA analogue output 2 corresponds to 0°C - 150 °C
- Multiple temperature setting range
1°C - 150°C
- Operating ambient temperature
0°C - 50°C
- Power supply
230 V AC and 30Volt DC
- Housing
Molded ABS
- Method of fixing
By brackets screwed in from the side.
- Serial communication ports with several on-board communication protocols.
- Two active serial communication ports, through RS-232 & RS-485.
- The instrument should be properly interfaced with the transducer in the RTU

Installation

- Power transformer shall be provided with bi-direction rollers and lifting lugs in such a way that transformer can be rolled in both vertical and horizontal planes upon suitable size guiding rails.
- Distribution transformers shall be plinth mounted inside substation room, installed upon base channel of suitable size and shall be properly grouted on to the floor internally through bolts of proper size.
- Complete installation shall be in compliance with seismic zone-4 and sizes of bolts and complete installation have to be structurally verified with respect to that.
- Transformer shall be installed and aligned straight with tolerance of ± 2 mm.
- Shims below the transformers shall not be accepted at all.
- Transformer shall be installed so that required clearances are met and cable termination is easy.
- Installation shall ease operation and maintenance in future.

Testing

- The transformer offered in the tender should have been successfully type tested at CPRI/ERDA/NABL laboratories for following tests in line with the relevant standard and technical specification, within the last 5 (five) years from the date of **approval of drawing**.
- The bidder shall be required to submit complete set of the type test reports along with the offer.
- In case these type tests are conducted beyond five years, all the type tests as per the relevant standard shall be carried out by the successful bidder at CPRI/ERDA/NABL laboratories in presence of employer's representative free of cost before commencement of supply.
- The undertaking to this effect should be furnished along with the offer without which the offer shall be liable for rejection.
- If above tests are carried out on higher capacity of offered equipment, then the offer is considered for placement of order. However, successful bidders have to carry out the said type tests on offered type equipment before commencement of supply at their own expense.
- Type test and routine test shall be conducted in accordance with the provisions made in IS/IEC. However following type test and routine test in particular shall be conducted :

A. Type & routine test

A.1. Transformer winding resistance measurement.

A.2. Transformer ratio test.

A.3. Transformer vector group test

A.4. Measurement of impedance voltage/short circuit impedance (principal tap) and load loss (Short circuit test).

A.5 Magnetic Balance Test (MBT)

A.4. Measurement of no load loss and current (Open circuit test).

A.6. Measurement of insulation resistance.

A.7. Dielectric tests of transformer.

A.8. Temperature rise test of transformer.

A.9. Tests on on-load tap-changer.

A.10. Vacuum tests on tank and radiators.

A.11. Oil pressure test on transformer to check against leakages past joints and gaskets. (In case of oil type transformer only).

A.12 Measurement of no-load current.

Inspection and commissioning

- After receiving approval on GA drawings, the concerning vendor shall invite the owner's representative at factory works .
- Owner's representatives shall be provided open access at factory works to see and analyze any part of process.
- Testing at factory shall be witnessed fully by the owner's representative.
- Once the transformer is cleared from factory testing and is received at site, after its complete installation and testing, commissioning shall be done with all pre functional and functional tests, as required by the owner's representatives.

A.3 RING MAIN UNIT (RMU)

A.3.1 Scope

The scope of work shall include:

1. Supplying, installation testing and commissioning of ring main unit at CSS

A.3.2 Definitions

The definitions shall be as per IEC-62271 and other relevant IEC standards.

A.3.3 Codes & Standards

The contractor is required to follow all relevant IS and IEC codes as per latest

amendments, however in particular following codes may be applied in addition.

1. IEC-62271 - Standard for medium voltage switchgear and assemblies.
2. IEC-60044 - Standard for instrument transformer.
3. IEC: 60255- Measuring relays and protection equipment
4. NEC- 2008 - National electrical code.
5. NBC-2016 - National building code.
6. IER-1956: Indian electricity rules.
7. IEA-2007: Indian electricity act 2007
8. Any other local bye-law or supply company norm as applicable

A.3.4 Service conditions

System particulars

- a. Nominal system voltage - 11kV
- b. Rated system voltage - 12kV
- c. Frequency- 50Hz $\pm 3\%$
- d. No. of phases- 3
- e. System neutral- Solidly earthed
- f. Short circuit rating - 21kA for 3sec
- g. Automation compatibility : SCADA compatible

Tropical conditions

- a. Ambient temperature : 50 degree celsius
- b. Relative humidity (avg.) : 60
- c. Isokeraunic level : 33
- d. Seismic Zone : Zone-4
- e. Climate type : hot and humid

The climatic conditions are prone to wide variations in ambient conditions and hence the equipment shall be of suitable design to work satisfactorily under these conditions.

Tolerances and creepage distance

Tolerances (on all the dimensions) and creepage distances shall be in accordance with provisions made in the relevant Indian/IEC/BIS standards and in these specifications. Otherwise the same will be governed by good engineering practice in conformity with required quality of the product.

A.3.5 Specifications

RMU Cubical

- RMU body shall be fabricated out of CRCA sheet steel throughout with partition thickness **and overall thickness as per the type test design.**
- The RMU body shall be completely dust, corrosion and vermin proof. The RMU shall be powder coated with coating thickness of 60-80 micron.
- Self adhesive type, neoprene or cross linked poly ethylene gaskets shall be provided wherever required.
- The RMU shall be mechanically rugged to withstand the load of switchgears and bus bars without any external bracing.
- The RMU shall have metal enclosed construction, with 2 motorized load break switch, busbar and one VCB enclosed in IP-67 SF6 filled SS sealed tank.
- RMU shall be fully wired in factory complete in all respect. It is preferred to have fabrication done through automatic advanced machines, CNC, robotic machines to ensure best quality of fabrication.
- RMU shall be non extendable and shall be easy to operate and maintain.
- All wiring in control compartment shall be routed through PVC ducts and shall be terminated on to stud type terminal with plastic cover. Internal wiring shall be done through FRLS copper stranded wires / cables.
- Control cable entry shall be from front and there should be a possibility of terminating to LV chamber from both right hand and left hand side.
- Provision for lamp operated with door limit switch and a 6A socket operated through a toggle switch shall be made in control gear compartment.
- The RMU shall be well ventilated and shall have provision of cable entries from the bottom.
- Gland plates shall be 3mm thick and holes shall be plugged in with fire retardant sealant.
- The RMU shall have IP-4~~X~~ ingress protection and shall be resistant to high mechanical impact.
- All doors shall be hinged type with a provision of padlocking.
- Provision of space heaters shall be made to absorb moisture in the RMU compartments.
- The RMU shall be suitable for grouting upon floor or MS channel. Bolt size and channel size shall be suitably selected in accordance with seismic one compliance.

Earthing

- There shall be a continuous copper earth bus of size required size running at the bottom of the RMU

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- Earth bus shall be robust and shall be capable of carrying full short circuit current for 1 second.
- Doors, covers and all non-current carrying metallic parts shall be earthed through flexible FRLS copper wires of required sizes.
- Earth continuity shall be maintained for each component in the RMU including its body and gland plates.

Bus bars

- Bus bar shall be provided in **tubular** /rectangular cross section made up of high electrolytic grade copper having good conductivity, suitable to carry rated current under steady state and shall be capable to withstand the thermal and electrodynamic stress during transient conditions for 3 sec.
- Bus bar shall be designed for suitable current density not exceeding 1.6A/sqmm.
- Bus bar shall be designed for a temperature rise of **40** degree celsius (above ambient) and **45** degree celsius for all bolted joints (above ambient).
- The bus bar shall be designed for a temperature of 190 degree celsius during transient conditions.
- **Busbar shall be supported upon non-breakable, non-hygroscopic epoxy resin or glass fiber reinforced polymer insulated support suitable to withstand operating temperature of 110 degree celcius at regular interval. Busbar supports shall be capable to withstand the electrodynamic forces during transient conditions.**
- Gland plates shall be 3mm thick / **or as per type test design of OEM in case of Alu zinc panel.** Holes shall be plugged in with fire retardant sealant.
- The bus bar edges/ ends shall be rounded off/ chamfered so that there will not be any sharp edges/projections.
- All fasteners (nuts bolts) used for bus bar connections shall be of non magnetic stainless steel. Washers shall be provided for each nut bolt. If the fasteners used are not of stainless steel the tenderer shall state in their offer the material used and confirm that the same is non-magnetic and is superior to stainless steel.
- **Clearances for 11kV bus bars shall be as per the type test design of manufacturer.**

Circuit breaker and load break switch

- Load breaker switch shall be motorized and shall be make before break type rated at 630A, 3 pole, **21kA** for 3 sec.
- Load break switch shall be provided with an integrated earth switch connected on the cable side and mechanically interlocked with load break switch.
- In addition to motor operation, the load break switch shall be manually operated, through mechanical rod, when auto manual switch is kept in manual position.
- Motor inside load break switch shall be 240V, 1phase, AC actuated.
- The circuit breakers shall be non with drawable type vacuum circuit breakers..
- Breakers shall be of 3 pole design for use in 11 kV indoor switchgear. Circuit

- breaker shall be suitable for rapid reclosing cycle i.e. O-0.3 sec.-CO-30 sec.-CO.
- The circuit breaker shall be provided with motor operated spring charged closing. Spring charging motor shall be suitable for 240V, 50 Hz, single phase AC (UPS) / 110V dc
 - Provision shall be available for charging the springs manually as well, and to close circuit breakers mechanically.
 - Provision for padlock shall also be available.
 - Tripping of the circuit breakers shall be through "shunt trip" coils rated for 110V DC auxiliary supply. It shall be possible to trip the breaker manually in case of necessity.
 - Adequate numbers of "NO/NC" contacts of the circuit breaker shall be wired upto the terminal block for connection to the remote supervisory desk for indication, SCADA and other interlocks etc. as required.
 - Each RMU shall be provided with fault passage indicators in loop in as well as loop out feeders.
 - Each RMU shall be provided with an FRTU (Feeder remote terminal unit) which shall be capable to communicate with other FRTU's and fault passage indicator so as to identify the location of fault and restore the supply automatically by providing a remote closing command to associated circuit breaker.
 - Emergency mechanical push to trip button shall be provided for emergency manual tripping with front door closed. Typical parameters for 11kV circuit breaker shall be as follows respectively :

a. Rated voltage: 12kV

b. Basic insulation level (BIL) :75kV

c. Power frequency voltage withstand (1 min): 28kV

d. Rated symmetrical breaking capacity for 3 sec: 21kA

e. Rated steady state current rating : 630A

Electrical features and safety interlocks

- The RMU shall be internal arc tested for 1 sec for rated fault level of incoming switchgear for all front and lateral side of each compartment. Each compartment of panel shall be fully type tested as per criteria laid under IEC norms, from CPRI or ERDA.
- Door interlocking features shall be provided in all front doors in such a way that it becomes impossible to open the front panel unless earth switch is ON.
- SF6 gas pressure indicating manometer shall be provided with alarming feature in case gas pressure falls low inside the RMU tank.
- Pull out type, rotary switch shall be provided for breaker to cut off the power manually during any emergency. This switch shall latch the breaker in off

state in such a manner that until the switch is rotated back to its normal position the breaker should not turn on under any circumstance.

- Two position, selector type, auto manual switch shall be provided, with clear markings of Auto and manual positions engraved with good quality and shall be long lasting. Once the selector switch is put on to manual position all remote functions shall get defeated. Potential free contact shall be provided to send the status of auto / manual switch to SCADA.

Current transformer (CT)

- Current transformer shall cast epoxy / resin type with copper windings and good quality ferromagnetic core.
- Current transformers shall be single core type suitable for cable or bus mounting as required.
- Vendors shall have to furnish CT calculations during the time of approval of product data.
- Losses shall be as per relevant standards.
- Manufacturer shall provide suitable CTs with all its required characteristic curves.
- CTs shall be provided with open able switch type shorting CT links.
- Grounding terminal of CT shall be grounded with suitable size conductor to the grounding bus of RMU through terminal links.
- Typical parameters for 11kV CT shall be as follows respectively :

a. Rated voltage: 11kV

b. Rated secondary current : 1A

c. Class : Metering class - 0.5

d. Burden : 2.5VA

Annunciation window

- Annunciation window shall have compartmentalized windows of required numbers and sizes and shall be suitable for mounting in panel front.
- Engraving shall be with a good quality material and shall be long lasting.
- Manually written stickers or test hand written with markers are not acceptable.
- Color of each window shall be red with letters engraved in black.
- Size of the letters shall be such that the same is readable from at least 1.5 meters from the line of sight and shall be as required.
- Annunciation window shall be suitable for 230V, 50Hz, AC UPS supply.
- Required window of annunciation panel shall glow in case of receipt of control signal.
- Max power consumption shall not exceed 3W.
- Annunciation window shall have a provision of acknowledge, reset and power off in the front fascia.

- Annunciation window shall have IP-40 protection.

Hooter

- Hooter shall be electronic type and shall be suitable for mounting in panel front.
- Hooter shall be able to deliver 80db sound level at every 3 meters.
- Hooter sound shall be selectable for both hooting and siren type.
- Hooter shall be suitable for 230V, 50Hz, AC UPS supply.
- Max power consumption shall not exceed 5W.
- Hooter shall be capable to operate up to 70 degree celsius.
- Hooter shall have red LED indication for power on.
- Hooter shall stop once the alarm is acknowledges from annunciation window.
- Hooter shall have a provision of reset and power off in the front fascia.
- Hooter shall have IP-40 protection.

Relay

- Relays shall be numeric type, microprocessor based for feeder protection and shall have following required programmable protections:
 - a. Instantaneous (overcurrent and earth fault.)
 - b. Overcurrent
 - c. Earth fault
- Numeric relays shall have self supervision function and shall be able to communicate and provide indication in case of internal fault in relay.
- Relay shall confirm to IEC-61850 and shall be provided with Ethernet IP communication port. Relay shall have dual port for PR to PR communication. All protection relays shall be connected in ring topology with Ethernet switch.
- Relays shall have inbuilt volatile and non volatile memories and shall be capable to record and store at least 100 events with date and time, with last five faults stored in non volatile memory.
- Relays shall be completely SCADA compatible and shall have Ethernet IP port available for communication.
- 4 spare binary inputs and 4 spare binary outputs shall be provided in addition to those required.
- The operation of the relay shall be practically free from errors due to normal variations in frequency,waveforms & from ambient temperature effects range between - 20 degree to +55 degree C.
- The relay shall have 3 independent time delayed O/C stages. The first stage should be programmable to have either a DT characteristics or IDMT characteristics described as follows and shall have a current
- setting range of 10% to 2500% and time setting range of 0 ms to 150 sec. The second and third setting shall have a current setting range of 50% to 4000%.
- The relay should have 3 independent time delayed E/F stages. Should have a current setting range 1% to 800% and time setting range of 0 ms to 100 sec. The lower setting is critical to take care of system which have low earth fault currents.
- The relay shall have reverse blocking or busbar blocking feature.

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- The relay shall have 8 Indication LEDs out of which minimum 4 should be freely programmable.
- Relay shall be able to record at least 5 oscillographic disturbance records each of minimum 3 seconds.
- Relay shall have independent setting groups.
- Relay shall have at least 4 shots of autoreclose function, switch on to Fault function, circuit breaker failure function, cold load pick up function. and inbuilt output relay latching function
- Relay shall have keypad buttons at front of the relay to configure the relay and shall be easily programmable and maintainable.
- Aux Supply input voltage shall be 110VDC however relay shall be capable to operate at 24-250VDC / 240VAC.
- Relay shall have its LCD display and any other control feature required in the relay shall be provided by the contractor at the time of product data approval at no extra time and cost.

Installation

- RMU shall be installed upon base channel ISMC -100 and shall be properly grouted on to the floor internally through bolts of proper size.
- Installation shall be in compliance with seismic zone-4 and sizes of bolts and complete grouting have to be structurally verified with respect to that.
- RMU shall be installed and aligned straight with tolerance of +/- 2mm.
- Shims below the RMU shall not be accepted at all.
- RMU shall be installed so that required clearances are met and cable termination is easy.
- Installation shall ease operation and maintenance in future.

Testing

- The equipment offered in the tender should have been successfully type tested at CPRI/ERDA/NABL laboratories for following tests in line with the relevant standard and technical specification, within the last 5 (five) years from the date of **approval of drawing**.
- The bidder shall be required to submit complete set of the type test reports along with the offer.
- In case these type tests are conducted beyond five years, all the type tests as per the relevant standard shall be carried out by the successful bidder at CPRI/ERDA/NABL laboratories in presence of employer's representative free of cost before commencement of supply.
- The undertaking to this effect should be furnished along with the offer without which the offer shall be liable for rejection.
- If above tests are carried out on higher capacity of offered equipment, then the offer is considered for placement of order. However, successful bidders have to carry out the said type tests on offered type equipment before commencement of supply at their own expense.
- Type test and routine test shall be conducted in accordance with the

provisions made in IS/IEC.

- **Note** : Impulse voltage withstand test, short time and peak current withstand test and short circuit test, internal arc test shall not be carried on the panel being supplied. Type test certificate for similar rating and design of equipment shall be submitted by the manufacturer for establishing quality.

Inspection and commissioning

- After receiving approval on GA drawings, the concerning vendor shall invite the owner's representative at factory works once RMU is ready.
- Owner's representatives shall be provided open access at factory works to see and analyze any part of process.
- Testing at factory shall be witnessed fully by the owner's representative.
- Once the RMU is cleared from factory testing and is received at site, after its complete installation, commissioning shall be done with all pre functional and functional tests, as required by the owner's representatives.

A.4 HT CABLE AND TERMINATION

A.4.1 Scope

The scope of work shall include:

1. Supplying, laying, testing and commissioning of 11kV grade HT cables as per cable schedule.
2. Handling, loading, unloading and storage of 11kV grade HT cables.
3. Civil works, piping works and ducting works required for cable laying as per tender document.
4. Cable termination using heat shrinkable termination kit.

A.4.2 Definitions

The definitions shall be as per IS 7098-Part 2, IEC 60050-461 and IEC 60502-2

A.4.3 Codes & Standards

The contractor is required to follow all relevant IS and IEC codes as per latest amendments, however in particular following codes may be applied in addition.

1. IS 7098-Part 2- Specifications for XLPE insulated thermoplastic sheathed cables, for working voltage 3.3 kV and up to 33kV (including 33kV)
2. IS-1255 - Code of practice for installation and maintenance of power cable up to 33KV rating
3. IEC 60502-2- Standard for cables for rated voltage from 6KV up to 30KV (Um=36kV)

4. IEC-60050-461- Definitions for cables.
5. IEC-60811 - Common test methods for cable insulation.
- 6.IS : 10418 Specification for drums for electric cables.
7. IS : 8130 : Specification for conductors for insulated electrical cables and flexible cords
8. IS : 5831 : Specification for PVC insulation and sheath of electrical cable.
9. NEC- 2008 - National electrical code.
10. NBC-2016 - National building code.
11. IER-1956: Indian electricity rules.
12. IEA-2007: Indian electricity act 2007
13. Any other local bye-law or supply company norm as applicable.

A.4.4 Service conditions

System particulars

- a. Primary system voltage - 11kV
- b. Frequency- 50Hz $\pm 3\%$
- c. No. of phases- 3
- d. System neutral- Solidly earthed
- e. Short circuit rating - 25kA,3sec on 11kV HV side

Tropical conditions

- a. Ambient temperature: 50 degree celsius
- b. Relative humidity (avg.) : 60
- c. Isokeraunic level: 33
- d. Seismic Zone: Zone-4
- e. Climate type : hot and humid

The climatic conditions are prone to wide variations in ambient conditions and hence the equipment shall be of suitable design to work satisfactorily under these conditions.

Tolerances and creepage distance

Tolerances (on all the dimensions) and creepage distances shall be in accordance with

provisions made in the relevant Indian/IEC/BIS standards and in these specifications. Otherwise the same will be governed by good engineering practice in conformity with required quality of the product.

A.4.5 Specifications

HT Cables:

- HT cables shall be **unearthed type for 11kV.**
- **Cables shall be heavy duty type.**
- HT cable shall be an extruded dielectric i.e. XLPE (cross linked polythene) insulated with maximum operating temperature of 90 degree celsius.
- The insulation shall have a temperature withstand capacity of 250 degree celsius for 5 seconds during short circuit conditions.
- Thickness of insulation shall be not less than 3.4 mm.
- The cable shall also be capable to withstand the temperature rise due to short circuit in accordance with IEC-60986.
- The cable shall be sheathed with PVC (Poly vinyl chloride). Both inner and outer sheath of the cable shall be made up of PVC with outer sheath being provided with FRLS (Fire retardant low smoke) insulation.
- The conductors shall be made up of plain aluminium or aluminium alloy with metallic layer surrounding the cores, either individually or collectively.
- Screening of individual cores shall consist of a conductor screen and an insulation screen. The conductor screen shall be non-metallic and shall consist of an extruded semi-conducting compound, which may be applied on top of a semi conducting tape.
- The extruded semiconducting compound shall be firmly bonded to the insulation.
- The insulation screen shall consist of a non metallic, semi conducting layer in combination with a metallic layer. The non metallic layer shall be extruded directly upon the insulation of each core and consist of either a bonded or strippable semiconducting compound.
- A layer of semi conducting tape or compound may then be applied over individual cores or the assembly. The metallic layer shall be applied over either the individual cores or the core assembly collectively.
- The inner coverings shall be extruded with approximate thickness of covering to be 2mm.
- The material used for covering shall be suitable for the operating temperature of the cable and also shall be compatible with the insulation material.
- Cables shall be armoured and type of armouring shall be wound type made up of galvanized steel, hot or cold rolled of commercial quality.
- Armouring shall be done on the inner covering as described. The thickness of armouring shall not be less than 0.8mm.
- Cable shall be provided with an oversheath (black in color) and made up of a thermoplastic or elastomeric compound. This oversheath shall be suitable for operating temperatures of cable as specified. Termite protection shall be provided in the oversheath.
- The thickness of this oversheath shall be min $(0.035D + 1)$ mm, where D is the diameter of cable.
- Typical parameters for 11kV cables shall be as follows :

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- a. Rated Maximum Voltage: 12 KV (rms)
- b. Rated Frequency: 50 Hz
- c. Grounding: Unearthed cable (UE)
 - d. Rated Power Frequency Withstand Voltage (5 min): 28 KV (rms)
 - e. Impulse withstand BIL Line to earth: $\pm 95\text{kVp}$
 - f. Rated short time withstand current for 1sec: as per fault level
 - g. Conductor material / size: Aluminium / as per cable schedule.

HT cable termination:

- All joints and terminations, except for separable insulated connectors shall be of the heat-shrink, cold-shrink, or cold-applied polymeric type design, manufactured and tested to meet the requirements of the relevant standards, including AS/NZS 4805 Parts 1 and 2 or equivalent and shall be suitable for application to selected cables as specified.
- All separable insulated connectors and accessories forming part of the connector system shall be of the dead-break shielded / screened type with a screen break, manufactured and tested to meet the relevant standards, including AS 2629. The separable insulated connectors shall be suitable for connecting particular single core polymeric cables to provide 11kV test points adjacent to substation switchgear.
- All joint and termination kits shall be supplied complete in unit lots suitably packaged for storage containing all necessary materials.
- All joints and termination kits shall be supplied with the required cleansing solvents, cloth and abrasives.
- Vendor shall provide with their Safety Data Sheets (SDS) for nominated solvents.
- No unapproved solvents shall be provided without prior agreement of the Purchaser. If required, sealants shall be supplied to effect seals on joints and terminations and shall be able to accommodate the creep or relaxation that may occur during installation of the accessories during the normal cyclic loading of the cables.
- The sealant shall have adhesion properties to maintain hermetic seals at all times between components and the various cable sheath materials and connectors.
- Suitable lubricant shall be provided with the kits for separable connectors (elbows, tee connectors and plugs) to facilitate separation of the connector from the bushing or plug socket.
- All joints and terminations shall be designed so that a phase cross can be made in the joint or termination without stressing the cable insulation or insulation components.
- The quality of joint should be such that it does not add any resistance to the circuit. The materials and techniques employed should give adequate mechanical and electrical protection to the joints under all service conditions. The joint should further be resistant to corrosion and other chemical effects.

Civil works:

- General material specifications for civil works shall be followed.

A.4.6 Installation, Testing & Commissioning

- Cables shall be supplied in wooden or steel drums of heavy construction of suitable size and packed conforming to IS 10418 or applicable internationally accepted standards.
- Wooden drum shall be properly seasoned sound and free from defects. Wood preservatives shall be applied to the entire drum. A layer of waterproof paper shall be applied to the surface of the drums and over the outer most cable layer.
- Each drum shall carry the manufacturer's name, the purchaser's name, address and contract number and type, size and length of the cable, net and gross weight stenciled on both sides of drum.
- A tag containing the same information shall be attached to the leading end of the cable.
- An arrow and suitable accompanying wording shall be marked on one end of the reel indicating the direction in which it should be rolled.
- Packing shall be sturdy and adequate to protect the cables, from any injury due to mishandling or other conditions encountered during transportation, handling and storage.
- Both cable ends shall be sealed with hermetically sealed by means of water blocking compound followed by heat shrinkable caps totally coated inside with mastic so as to prevent to cable for moisture penetration during transit, storage and laying.
- The vendor shall consider supply of cable on returnable drums basis. Contractor shall take back all the cable drums from site after successful laying, testing and commissioning of cables. The bidder may quote the prices accordingly.
- Embossing of outer sheath: the following details on the other sheet of cable at a regular interval of 1(one) meter:
 - a. Name of customer: Nalanda University
 - b. Conductor size, type of insulation and voltage grade.
 - c. Manufacturer's name along with ISI mark
- Cable shall be laid as per the drawings, in different mediums as mentioned in drawings
- The cable trench work involves earth excavation for cable trench, back filling and removal of excess earth from site. The work site shall be left as clean as possible.
- The bottom of the excavated trench should be leveled flat and from any object which would damage the cable.
- Any gradient encountered shall be gradual.
- The excavated cable trench shall be drained of all water and the bed surface shall be smooth, uniform and fairly hard before paying out the cable. The cable shall be rolled in the trench on cable rollers, spaced out of uniform

- intervals.
- The paying out process must be smooth and steady without subjecting the cable to abnormal tension.
 - The cable on being paid out shall be smoothly and evenly transferred to the ground after providing the cushion.
 - The cables shall never be dropped. All snake bends shall be straightened.
 - Suitable size cable stocking pulling eye shall be used for pulling the cable.
 - While pulling the cable by winches or machines, the tension loading shall be by tension indicator and shall not exceed the permissible value for the cable.
 - The cable end seals shall be checked after laying and if found damaged shall immediately be resealed.
 - Sufficient number of heat shrinkable cable end sealing caps shall be stocked at site stores for testing and jointing work.
 - The integrity of the outer sheath shall be checked after the cable is laid in position. The inspection of cable on receipt, handling of cables, paying out, flaking, cushioning with sand or sieved compacted soil, back-filling, reinstatement of road surface, providing and fixing joint markers, route indicators, precautions of joint holes, sump holes and all necessary precautions that are required shall be carefully planned and in general conform to IS 1255-1983 or its equivalent.
 - Buried cable trenches for the cables as specified shall be made including supply and installation of warning tape, protective tiles/ bricklayer of minimum class designation 50 (50kg./sq. cm.) cable protection covers for entire route, construction of jointing bays, backfilling of trenches and restoration as per specification.
 - The cable shall be completely surrounded by well-compacted cable sand to such a thickness and of such size that the cable is protected against damage.
 - The thickness of the cable sand should normally be a minimum of 10 cm in all directions from the cable surface. Based on the evaluation of soil thermal resistivity along the cable route and after approval from the employer the contractor shall design, specify, supply, lay and monitor the installation of thermal backfill surrounding the cables.
 - The option on the use of the material that immediately envelopes the cable viz., thermal backfill or sand or sieved native soil rests with the employer.
 - The contractor shall seek prior approval on the use of the envelop material from the Employer before execution of the works.
 - Normally back filling shall consist of the material earlier excavated. However, bigger stones or pieces of rock should be removed.
 - A pre-warning, red color plastic/PVC tape, 250 mm wide 100 microns thick, shall be laid at approx. 0.4 m above the cable specified depth, throughout the cable route.
 - The tape shall carry the legend printed in black continuously as under CAUTION: 11000V CABLES.
 - After the cables have been laid in the trench and until the cables are covered with protective covering, no sharp metal tool shall be used in the trench or placed in such a position that may fall into the trench.
 - Straight and curved rollers used shall have no sharp projecting parts liable to damage the cable. While pulling through pipes and ducts, the cable shall be

- protected to avoid damage due to sharp edges.
 - The cables shall never be bent, beyond the specified bending radius.
 - Roads other crossings will be through HDPE/RCC hume pipe for each cable and restoration as per specification.
 - Cable markers shall be provided all along the route and at the bending. Also the location of underground cable shall be clearly indicated on the marker.
 - Permanent means of indicating the cable route shall be fabricated, supplied and erected as per approved drawings.
 - Markers provided shall be as per the field requirement, if the route passes through open fields, markers should be conspicuously visible above ground surface.
 - The marker should incorporate the relevant information-the name of the owner, voltage, circuit and distance of cable from the marker.
 - The vendor shall ensure supply and installation of all critical installation materials like trefoil clamps, neoprene cushions, support brackets etc. as required for complete route to avoid damages of the cable.
 - Neoprene cushion shall be provided at road crossings to avoid damage of cable due to vibrations during movement of vehicles.
 - The emphasis should be laid on quality and selection of proper cable accessories, proper jointing techniques and skill and workmanship of the working personnel
 - At cable terminating end sufficient length of spare cable shall be left in the ground and at cable tray also at switchgear end, for future needs.
 - The rise of the cable immediately from the ground shall be enclosed in PVC/PE pipe of suitable diameter to protect against direct exposure to the sun.
 - The cable shall be properly fastened using non-metallic clamps.
 - Protection from contact with the exposed metal work at the termination shall be provided by resin bonded glass fiber shroud.
-
- All routine and acceptance tests shall be conducted as per IEC 60502-2 / 61442. All type tests conducted during last five years from the date of **approval of drawing** as per IEC 60502-2.
 - In particular following test shall be conducted at site :
 - a. Torque wrench test on bolted connections.
 - b. Insulation Resistance Test.
 - c. Hi-Pot test.
 - d. Phase test

A.5 LT CABLE AND TERMINATION (AC and DC cables)

A.5.1 Scope

The scope of work shall include:

1. Supplying, laying, testing and commissioning of 1.1kV grade power cables and

control cables suitable for 415V, 3Phase , 50Hz AC supply and also for 230V, 1Phase , 50Hz AC supply.

2. Supplying, laying, testing and commissioning of 1.8kV grade, DC power cables suitable for 325V, bipolar DC supply.

2. Handling, loading, unloading and storage of both AC and DC cables.

3. Civil works, piping works and ducting works required for cable laying as per tender document.

4. Cable termination using double compression brass glands and lugs (cu lugs for cu cables and Al lugs for Al cables) as specified

A.5.2 Definitions

The definitions shall be as per IS 7098-Part 1, IEC 60050-461 and IEC 60502-2

Abbreviation used to define the following are stated in front of the entity

Aluminum Conductor - A

XLPE Insulation - 2X

Steel round wire armor - W

Steel strip armor - F

Steel Double round wire armor - WW

Steel Double strip armor - FF

Non-magnetic (A1.) round wire armor - Wa

Non-magnetic (A1.) strip armor - Fa

PVC outer sheath - Y

A.5.3 Codes & Standards

The contractor is required to follow all relevant IS and IEC codes as per latest amendments, however in particular following codes may be applied in addition.

1. IS 7098-Part 1- Specifications for XLPE insulated thermoplastic sheathed cables, for working voltage up to 1.1kV (including 1.1kV)

2. IS-1255 - Code of practice for installation and maintenance of power cable up to 33KV rating

3. IEC 60502-1- Standard for cables for rated voltage from 1KV up to 6kV (Um=1.2kV)

4. IEC-60050-461- Definitions for cables.
5. IEC-60811 - Common test methods for cable insulation.
- 6.IS : 3961- Part 2: Recommended current ratings for cables.
7. IS : 8130 Conductors for insulated cables.
- 8.IS : 5831 XLPE Insulation and outer sheath of electric cables.
- 9.IS : 10418 Specification for drums for electric cables.
10. NEC- 2008 - National electrical code.
11. NBC-2016 - National building code.
12. IER-1956: Indian electricity rules.
13. IEA-2007: Indian electricity act 2007
14. Any other local bye-law or supply company norm as applicable.

A.5.4 Service conditions

System particulars

- a. System voltage - 415/230 V for AC cables and ± 325 V for DC cables
- b. Frequency- 50Hz $\pm 3\%$ for AC cables
- c. No. of phases- 3 for AC / 2 (poles) for DC
- d. System neutral- Solidly earthed
- e. Short circuit rating - As per system fault level

Tropical conditions

- a. Ambient temperature: 50 degree celsius
- b. Relative humidity (avg.) : 60
- c. Isokeraunic level: 33
- d. Seismic Zone: Zone-4
- e. Climate type : hot and humid

The climatic conditions are prone to wide variations in ambient conditions and hence the equipment shall be of suitable design to work satisfactorily under these conditions.

Tolerances and creepage distance

Tolerances (on all the dimensions) and creepage distances shall be in accordance with provisions made in the relevant Indian/IEC/BIS standards and in these specifications.

Otherwise the same will be governed by good engineering practice in conformity with required quality of the product.

A.5.5 Specifications

LT Cables (AC & DC):

- Cables shall be XLPE insulated PVC sheathed, Al or Copper conductor as specified.
- Cable shall be heavy duty type.
- Stranded Aluminum/Copper conductor shall be used.
- All Aluminum/Copper XLPE cables insulation shall be of high grade Cross-linked Polyethylene for insulation for extrusion process. Cores laid up.
- The inner sheath shall be bonded over with thermoplastic material for protection against mechanical and electrical damage.
- Armoring should be provided over the inner sheath to guard against mechanical damage.
- Armoring should be Galvanized steel wires or galvanized steel strips as specified.
- In single core cables used in A.C. wires/strips, round steel wires should be used; where diameter over the inner sheath does not exceed 13 mm, flat steel armor should be used.
- Insulation shall be of XLPE type as per latest IS general-purpose insulation for maximum rated conductor temp 90 degree C.
- The Conductor shall be stranded Aluminum/Copper circular/sector shaped and compacted.
- In multi core cables the core shall be identified by red, yellow, blue and black coloring of insulation.
- Conductor shall be of electrolytic Aluminum/Copper conforming to IS: 8130 and are compact circular or compact shaped.
- In Inner sheath laid up cores shall be bonded over with thermo-plastic material for protection against mechanical and electrical damage.
- Insulation, inner sheath and outer sheath shall be applied by extrusion and lapping up process only. The outer sheath shall have FRLS properties.
- Repaired cables or cables made up of re-used copper / aluminium shall not be used.
- The cables shall be suitable for laying in racks, ducts, trenches, conduits and underground buried installations with uncontrolled back fill and chances of flooding by water.
- Progressive automatic in line sequential marking of the length of cables in meters at every one meter shall be provided on the outer sheath of all cables.
- Both ends of the cables shall be properly sealed with PVC/Rubber caps so as to eliminate ingress of water during transportation, storage and erection.
- Embossing of outer sheath: the following details on the other sheet of cable at a regular interval of 1(one) meter:
 - a. Name of customer : Nalanda University
 - b. Conductor size, type of insulation and voltage grade.
 - c. Manufacturer's name along with ISI mark

- Typical parameters for AC cables shall be as follows :
 - a. Rated Maximum Voltage: 1.1 kV (rms)
 - b. Rated Frequency: 50 Hz
 - c. Rated Power Frequency Withstand Voltage (5 min): 3 kV (rms)
 - d. Rated short time withstand current for 1 sec: as per fault level
 - e. Conductor material: Aluminium / Cu. as per cable schedule.
- Typical parameters for DC cables shall be as follows :
 - a. Rated Maximum Voltage: 1.5 kV
 - b. Maximum permissible DC voltage : 1.8 kV
 - c. Voltage withstand for 5 minutes : 6.5kV
 - d. Rated short time withstand current for 1 sec: as per fault level
 - e. Conductor material: Aluminium / Cu. as per cable schedule.

LT cable termination:

- All cable glands shall be made out of brass and of good quality as approved.
- All cable glands shall be of double compressions type.
- Termination/ Joining of power and control cables shall be done by means of compression methods using solder less tinned copper or Aluminum terminal lugs.
- For control cables terminations, ring tongue or reducer pin type lugs shall be used to suit the purpose.
- Proper crimping tools with crimping paste shall be used to maintain proper conductivity and avoid any air gap.

Cable Tags:

- Cable tag shall be made out of stainless steel minimum 1.2 mm thick and 25 mm x 100 mm size with holes provided to tag the cable.
- Following information shall be engraved in the cable with good quality material and the lettering height shall be 4.5mm
 - a. Source of the Cable from where it is supplied power.
 - b. Destination where the cable is terminated.
 - c. No of cores of cables.
 - d. Cross sectional area of the cable
 - e. Complete notation as described under definition part of cable specification.

A.5.6 Installation, Testing & Commissioning

- Cables shall be stored in a dry covered place to prevent exposure to climate conditions and wear and tear of wooden drums and it should be preferably concrete surface.
- All drums should be stored in such a manner as to leave sufficient space between them for air circulation. It is desirable for drums to stand on battens directly placed under the flange.

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- In no case should the drums be stored “on the flat” i.e. flange horizontal.
- Both ends of the cables shall be properly sealed with PVC/Rubber caps so as to prevent ingress of water, miniaturization of cores and armors during transportation, storage and erection.
- On receipt of cable drums visual inspection of drums should be carried out for any damages to these cables.
- While unloading the cables certain precautions are to be taken to ensure the safety of cables. The cable end to be opened on one side and tested for its insulation and continuity.
- The cable drums should not be dropped or thrown from the trucks/railway wagons etc. during unloading operations as shock may cause serious damage to cable layers.
- A crane may be used for unloading cable drums. While lifting the cable drums with crane, it is recommended that the lagging should be left in place to prevent the flanges from crushing on the cables.
- If crane is not available a ramp should be prepared with approximate inclination of 1: 3 or 1: 4.
- The cable drums should be rolled over the ramp by means of ropes and winches. Additionally a sand bed at the foot of the ramp may be prepared to brake the rolling of the cable drum.
- Cable should not be dragged along the earth surface. Drums should be rolled in the direction of arrow only.
- For laying of cables special care is to be taken to prevent sharp bending, kinking, twisting.
- Cable should be unwound from drum by proper mounting the cable drum on a cable wheel making sure the spindle is strong enough to carry the weight without bending and that it is lying horizontally in the bearings, so as to prevent the drum creeping to one side or the other, while it is rotating.
- The maximum safe pulling force (when pulled by pulling eye) proper and safe method of pulling of cable should be used depending upon the site conditions to avoid any kind of damage to the cables. Following pulling forces to be noted.
 - a. Aluminum Conductor cables: 3.0 Kg/mm²
 - b. Copper conductor cables: 5 Kg/mm²
- Special care is to be taken while laying cable at bends. Following are the recommended bending radius for power and control cables.

Sr. No.	Voltage rating (kV)	PVC / XLPE cables	
		Multi core	Single core
1	Up to 1.1 kV	12D	15D
2	Above 1.1 kV to 33 kV	15D	15D

D = D is over all diameter of cable.

- Armored cables are to be laid on cable trays/ underground as per relevant design drawing and specifications.
- All flexible cables shall be laid inside exposed / cased conduits (rigid /

- flexible)/ raceways or as per relevant design drawing and specifications.
- After the cable trench has been properly excavated and straightened, it shall be covered with 100 mm thick layer of sand, the cable shall then be lifted and placed over the sand cushion.
 - It may be planned to lay down the cables in stacks under the trench and under such circumstances, cables shall be laid with the help of angular supports or cable trays suitable to take the load of the cable.
 - In case the cable is laid with the help of angular supports inside the trench, such supports shall be provided at regular intervals so that the cable does not sag due to its weight.
 - After laying the cable the complete trench shall be filled with sand / earth up to 200 mm depth from the ground level.
 - A layer of silver sand along with a good quality caution tape with warning written in Hindi and regional language shall be laid throughout along the length of the trench at this level to indicate that electrical cables are running below and the area shall not be further excavated without suitable precautions and permissions.
 - The complete trench may then be backfilled with earth up to ground level.
 - Riggers shall ensure that while laying, the cable should not be subjected to any form of damage. Cables shall be laid by skilled and experienced workmen using adequate rollers to minimize stretching of the cable.
 - The cables shall not be laid in such a fashion that one cable crosses over the other. Proper spacing shall be left between two cables as mentioned in the GFC or as specified or directed by engineer-in-charge.
 - Drain points shall be ensured inside these trenches so that in case of water logging, the water ejects out through these drain points as a result of natural gradient provided.
 - Man-holes shall be provided at strategic locations so as to ease the pulling of cables and maintenance. The manhole shall be covered with suitable covers of mentioned material and dimensions as per GFC.
 - When laid in cable trays above ground, power cables to be placed at the bottom most layer and control cables at the top most layer. In case of multi core power cables, cables shall be laid side by side with spacing not less than half the diameter of larger cable.
 - Multi-core cables shall be clamped by means of mild steel galvanized saddles. All cables below 1.1 KV single core cables if any should be clamped by means of non-magnetic saddles.
 - The saddles / clamps shall not be placed at the intervals more than 1500 mm for horizontal and 1200 mm for vertical runs.
 - Multi core control cables can be laid touching each other in cable racks and wherever required may be taken in two layers. These cables should be clamped by means of PVC straps for horizontal and vertical runs. Fabricated aluminum clamps may be used at regular intervals.
 - All the cable shall be properly identified at regular intervals and care shall be exercised in laying cables to avoid forming kinks.
 - The relative position of the cables, laid on the cable tray shall be preserved and the cables shall not cross each other.
 - At all changes in direction in horizontal and vertical planes, the cable shall be

- bent smooth with a radius as recommended by the manufacturers.
- All cables shall be laid with minimum half diameter gap and shall be clamped at every meter to the cable tray and shall be tagged for identification with cable tag and clamped properly.
- Tags shall be provided at both ends and all changes in directions both sides of wall and floor crossings.
- All cable shall be identified by embossing on the tag the information as laid down under this specification.
- If there is a need to joint the cable due to finishing of cable in cable drum such joints shall be made through the approved straight through joints and jointing kits as directed by and approved by engineer-in-charge at site.
- Cables shall be fully tested (both type and routine test) as per the specification laid under Indian standards. In particular following test shall be done at site.
 - a. Insulation resistance test.
 - b. Continuity test.

A.6 Cable trays

A.6.1 Scope

The scope of work shall include:

1. Supplying, laying, testing and commissioning of cable trays and its allied accessories.
2. Handling, loading, unloading and storage of cable trays
3. Civil works associated with the said job.

A.6.2 Definitions

The definitions shall be as per NEMA-VE-2

Accessory: Components used to supplement the function of a straight section or fitting. Examples include, but are not limited to, dropout, cover, conduit adapter, hold-down device, and divider cable tray support.

Span: The distance between the centerlines of supports.

Cable tray system: A section or assembly of sections, and associated fittings, forming a mechanical system used to support cables and raceways.

Channel cable tray: A fabricated structure consisting of a one-piece ventilated- or solid-bottom channel section.

Connector: A component that joins any combination of cable tray straight sections and fittings.

A.6.3 Codes & Standards

The contractor is required to follow all relevant IS and IEC codes as per latest amendments, however in particular following codes may be applied in addition.

1. NEMA VE-2 -2013
2. IS 1079 - Cable trays and their accessories
3. NEC- 2008 - National electrical code.
4. NBC-2016 - National building code.
5. IER-1956: Indian electricity rules.
6. IEA-2007: Indian electricity act 2007
8. Any other local bye-law or supply company norm as applicable.

A.6.4 Service conditions

System particulars

- a. System voltage - 415/230 V for AC
- b. Frequency- 50Hz $\pm 3\%$ for AC cables
- c. No. of phases- 3 for AC
- d. System neutral- Solidly earthed
- e. Short circuit rating - As per system fault level

Tropical conditions

- a. Ambient temperature: 50 degree celsius
- b. Relative humidity (avg.) : 60
- c. Isokeraunic level: 33
- d. Seismic Zone: Zone-4
- e. Climate type : hot and humid

The climatic conditions are prone to wide variations in ambient conditions and hence the equipment shall be of suitable design to work satisfactorily under these conditions.

Tolerances and creepage distance

Tolerances (on all the dimensions) and creepage distances shall be in accordance with provisions made in the relevant Indian/IEC/BIS standards and in these specifications. Otherwise the same will be governed by good engineering practice in conformity with required quality of the product.

A.6.5 Specifications

Perforated cable tray:

- Cable tray system shall comprise of hot dip galvanized G.I cable trays, with galvanizing thickness of 65 micron and standard length of 2.5 meters made out of 2 mm thick perforated sheet metal for cable trays which are 600mm wide and above and 1.6mm thick for cable trays whose width is below 600mm.
- The construction of the cable trays shall be as per the approved GA drawing from Vendor.
- The construction of cable tray shall follow NEMA standards.
- The cable trays shall be hot dip galvanized with perforations not more than 17.5% and factory fabricated out of G.I., angle iron, tee, bends, sections, flats and perforated sheet for different loads.
- All accessories shall follow NEMA VE-2 standards

A.6.6 Installation, testing and commissioning

- The Complete installation of cable trays shall be in accordance with NEMA VE-2 standards.
- Before installing cable in the cable tray, examine cable paths to ensure all areas are free of debris that may interfere with cable installation.
- Cable tray should never be used as a walkway.
- Most cable installations require the use of cable pulling tools. On horizontal straight runs, cables generally ride on rollers mounted in or on cable trays.
- These rollers should be properly spaced, depending on the size and weight of the cable, to prevent the cable from sagging and dragging in the cable tray during the pull.
- Cable manufacturer shall be contacted for information regarding proper roller spacing. Cables may be fastened to the cable tray by means of cable clamps or cable ties. Generally, cables shall be fastened every 450 mm (18 in) on vertical runs.
- Although not required by the NEC, single conductor cables can be fastened on horizontal runs to maintain spacing and ensure that the cable is confined within the cable fill area.
- When using cable clamps, the clamps should be sized correctly and tightened only enough to secure the cable without indenting the jacket.
- The same precaution should be observed with cable ties, and they should be applied with a pressure limiting device.
- Extremely long vertical drops introduce a new set of issues requiring special consideration.
- The weight per meter (foot) of the cable multiplied by the number of meters (feet) in the vertical drop, in many cases, exceeds the load carrying capacity of the cable tray component. The one or two rungs supporting this weight are likely to be damaged, and the vertical load could exceed the allowable cable tension.
- The cable weight should be supported in such a manner as to

- prevent damage to the cable tray or cable during this type of installation.
- As the cable is installed, intermediate supports should be installed on the vertical drop to break the cable load into segments supported at multiple places.
- Once the cable is installed in an open cable tray system, care must be taken to protect the exposed cables from falling objects or debris that could cause damage to the cable.
- In areas where the cable tray is to be covered, covers should be installed as soon as possible. Temporary protection for the cables and cable tray can be constructed of available wood or metal materials until the risk of damage has passed.
- Complete installation shall be in accordance with seismic requirements.

D.7 UPS

A.7.1 Scope

The scope of work shall include:

1. Supplying, installation testing and commissioning of UPS for substation buildings.
2. UPS and battery handling, loading unloading and storage.
3. Associated racks and other works to install the UPS.

A.7.2 Definitions

The definitions shall be as per relevant IEC/IEEE standards.

A.7.3 Codes & Standards

The contractor is required to follow all relevant IS and IEC codes as per latest amendments, following codes shall be followed in particular:

1. IEEE Standard 446-1987: Emergency and standby power systems.
2. IEC 146 : Performance testing of UPS.
3. ANSI C 37.90a, IEEE Standard 472 : Surge withstand capability test.
4. ANSI C 34.2 : Practices and requirements for semiconductor power rectifiers.
5. ANSI C 34.2 : Practices and requirements for semiconductor power rectifiers.
6. ANSI C 37.90 : Relays and relay system associated with electrical power apparatus.
7. IS 2208 & IS 9224 : Cartridge fuses for voltages up to and including (Part 1&2) (IEC 269) 650 V.
8. IS 9224 (Part - 4) : Fuses for protection of semiconductors.

9. BS 2709 (I.E.C 119) : The Electrical Performance of Semiconductor Rectifiers. (Metal Rectifiers)
10. BS 4417 (I.E.C 146) : Semi-conductor Rectifier Equipments.
11. IS 1652 & IS 1652 : Lead-acid stationary cells and batteries.
12. NEC- 2008 - National electrical code.
13. NBC-2016 - National building code.
14. IER-1956 : Indian electricity rules.
15. IEA-2007: Indian electricity act 2007.
16. Any other local bye-law or supply company norm as applicable.

A.7.4 Service conditions

System particulars

- a. Nominal system voltage - 415V
- b. Rated system voltage - 1.1kV
- c. Frequency- 50Hz $\pm 3\%$
- d. No. of phases– 3P + neutral + Integrated earth
- e. System neutral- Solidly earthed
- f. Short circuit rating - 50kA for 1sec on LV side.

Tropical conditions

- a. Ambient temperature : 50 degree celsius
- b. Relative humidity (avg.) : 60
- c. Isokerauniclevel : 33
- d. Seismic Zone : Zone-4
- e. Climate type : hot and humid

The climatic conditions are prone to wide variations in ambient conditions and hence the equipment shall be of suitable design to work satisfactorily under these conditions.

Tolerances and creepage distance

Tolerances (on all the dimensions) and creepage distances shall be in accordance with provisions made in the relevant Indian/IEC/BIS standards and in these specifications. Otherwise the same will be governed by good engineering practice in conformity with required quality of the product.

A.7.5 Specifications

- The UPS system shall be of microprocessor based and so carefully designed to maximize the availability of power for critical loads and to ensure that equipments is protected to the extent possible against power failure and quality problems.
- UPS system shall constitute of (but not limited to) following
 - a. Transient Voltage surge suppression (TVSS)
 - b. Rectifier
 - c. Inverter
 - d. Static bypass switch
 - e. Manual / Maintenance by-pass switch
 - f. Display Panel
 - g. Control Logic
 - h. Isolation Transformer
 - i. Battery Monitoring system
 - j. Temperature compensating battery charging
 - k. Audible Alarm
 - l. SMF Battery Bank
- All components of the UPS equipment shall have surge withstand capability (SWC) to meet the requirements of ANSI C 37.90a, IEEE Standard 472-1974.
- All components of UPS system shall withstand short circuit current without any damage.
- Fuses shall not be larger than 125% of the transformer primary circuit current where the secondary circuit fuse protection has not been provided. where the secondary fuses are sized not greater than 125% of the secondary current of the transformer, fuses shall not be required in the primary circuit, provided the primary feeder fuses are not larger than 250% of the transformer primary current.
- All the neutral conductors in three phase UPS systems shall be sized equal to at least 200% of the maximum phase current. In addition, all the isolators and circuit breakers used in three phase UPS system shall also to be rated such that the neutral poles shall take at least 200% of the maximum phase current.
- All control shall be designed and positioned such that possibilities of inadvertent or accidental operations are eliminated.
- All UPS system cabinets, frames and power equipment shall be double earthed.
- The various overload capacities of inverters, static switch, step down transformer/voltage stabilizer as specified herein are the minimum requirements. However, if the firm's offered system has better overload capacities for the above devices, the same shall be highlighted by the bidder in his bid.
- Maximum humming noise level of UPS shall be 75 dB one meter away from the UPS cabinets.
-
- The system shall be fully microprocessor based and monitored through SCADA.
- The system shall be on line double conversion i.e. load independent from

- both main's voltage and frequency. Ensure server-grade high quality of power.
- The system shall have IGBT based PWM inverter resulting perfect sine wave voltage.
 - The system should be wide input voltage tolerance (+10/-10%).
 - The system should be wide input frequency tolerance (+ / - 6%)
 - The system shall be advance battery management system with programmable automatic battery testing, constantly monitors the health of the battery pack keeping the battery ready to work for emergency situations.
 - The system shall be high overload capacity of static bypass (10 times for 100ms.)
 - The system shall be built in maintenance bypass.
 - Front access shall be provided for easy replacement and maintenance.
 - The system shall have overload capacity :
 - a. Below 105% rated output current, continuous operation
 - b. 105% ~ 125% UPS output current, 5 minutes
 - c. 125% ~ 150% UPS output current, 1 minute
 - The system shall have selectable timer.
 - The system shall have adjustable frequency synchronization window upto +/- 1% in the static bypass.
 - The system shall have hardware for fault diagnostic unit, data logger and power monitoring system.
 - The system shall have comprehensive display panel having three functional sections such as
 - a. Mimic :LED Display indicates the status of UPS.
 - b. Control :Touch membrane switches for ON, OFF, RESET, audible alarm and STOP functions.
 - c. Display :LCD display indicates operating parameters and alarm conditions.
 - Each UPS shall give regulated filtered & uninterruptible power supply as described in the specifications.
 - In case the calculated /specified UPS capacity is not the same as one of the standard KVA ratings of the UPS manufacturer, the next higher standard KVA rating shall be selected. UPS of non standard rating shall not be acceptable.
 - UPS system supplied shall be the latest state of the art technology system fully digitalized using microprocessor controlled, IGBT based full wave rectification and IGBT inverter.
 - Batteries shall be valve regulated lead acid specially meant for UPS application.
 - Monitoring and control system shall also be state of the art technology LCD touch panel type providing all relevant data described in this document.
 - The monitoring and control system shall be capable of RS485 input software for connecting to customer's computer system for data display and monitoring.
 - All necessary components required for protecting UPS equipment and connected inputs and outputs shall be furnished as an integral part of the UPS system.
 - The UPS systems shall include but not be limited to the following equipment:
 - a. UPS system including 100% capacity float-cum-boost charger with 100%

sealed valve regulated lead acid batteries with guaranteed battery life of 5 years.

b. Suitable factory built battery cabinet for housing the batteries, including terminal isolator / breaker and power disconnect device.

c. All cables, connectors, accessories like trunking, cable trays, conduits etc. required for connection between battery and the UPS unit.

Rectifier

- The static converter (rectifier) shall be a multi-functional converter providing functions of power conversion, battery charging and shall have the additional functions of input power factor improvement and current harmonics reduction.
- The rectifier shall be a solid state, IGBT based, static PWM converter utilizing Intelligent Power Module (IPM) and shall include intelligent features like the drive circuitry, over current protection, over temperature protection, control power failure protection and short circuit protection. The IPM transistors shall enable high speed switching at 6 KHz thus reducing the heat dissipation in the UPS and thereby providing high efficiency. The PWM converter shall utilize the above and achieve unity power factor and reduce input current harmonics as given earlier and thus improve the overall power factor of the converter achieving input KVA savings. During any step inverter load change (0-100%) the converter shall only supply 100% current to the inverter.
- The rectifier equipment shall include all necessary control circuitry and device to conform requirements like voltage regulation, current limiting, wave shaping, transient recovery, automatic synchronization etc.
- The rectifier logic shall provide input current limiting by limiting the DC output current. Two (2) line side current transformers shall be employed as a means of sensing the current amplitude. The rectifier shall be capable of supplying overload current in excess to the full load rating. The DC output current limit values shall be as follows:
 - a. Rectifier output current (maximum) 100%
 - b. Rectifier output current (aux.) 25% - 100% variable.Note : 100% current shall be under the battery recharging mode.
- The rectifier logic shall provide current limiting function of battery charging to prevent the battery from damage. The following battery current limit and protection shall be provided.
 - a. Battery charge current limit 10% of battery Ah rate.
 - b. Over-current protection at 120% of above item.
- The rectifier / charger output voltage shall not deviate by more than +/- 1% of the nominal output voltage, due to the following conditions:
 - a. From 0 to 100% loading.
 - b. Rectifier input variations of voltage and frequency within the limitations
 - c. Environmental condition variations
- The rectifier logic shall employ circuitry to allow a delayed and timed ramping of input current. Subsequent to energizing the rectifier input, the ramping of current shall be delayed by a maximum of 3 seconds. Upon starting the walk-in process, the ramping of current is timed to assume the load gradually within 1 through 60 seconds (every 1 second selectable).
- The A/C input fuses shall be provided at the rectifier input as a means of overload protection. The AC maximum current shall be controlled by the

rectifier.

- During any step inverter load change (0-100%), only the rectifier shall supply 100% current to the inverter.
- The rectifiers shall be suitable to be fed from the normal power supply source.
- Basic parameters of rectifier shall be as follows :
 - a. Nominal Voltage: 415V, 3 Phase, 3 Wire
 - b. Voltage Range.: + 10 % / - 10% AC
 - c. Frequency Range : + 6 % / - 6% AC
 - d. Input Power Factor : 0.98 lagging or more at full load(PF improvement)
 - e. Input Harmonic Current THD: 7% typical at 100% load 6% maximum at 50% load
 - f. Duty : Continuous
 - g. Cooling : Forced cooling using fans with thermal relays using a latched cut out for re-setting as protection for cooling fans. Each individual fan shall have its own thermal relay. Ambient operating temperature range: 0 to 45 deg.C maximum.

Inverter

- The static inverter shall be of solid state type using proven pulse width modulation (PWM) technique. The inverter equipment shall include all necessary control circuitry and devices to conform requirements like voltage regulation, current limiting, wave shaping, transient recovery, automatic synchronization etc. as given below.
- The inverter shall utilize IGBT which shall provide intelligent features like the drive circuitry, over-current protection, over temperature protection, control power failure protection and short circuit protection.
- The IGBT / IPM transistors shall enable high speed switching of 6 Khz thus reducing the heat dissipation in the UPS and thereby providing high efficiency.
- The UPS shall utilize both voltage and current feedback control circuits so that the inverter shall act not only as a constant voltage source but also as a load required current source. This shall enable the inverter to quickly adapt to the changing load current value and wave shape.
- The inverter output voltage shall not deviate by more than + 2% RMS due to the following steady state conditions :
 - a. From 0 to 100% loading
 - b. Inverter DC input voltage varies from maximum to minimum.
- The inverter output frequency shall be controlled by an oscillator internal to the UPS module logic. The inverter output frequency shall not vary during steady state or transient operation due to the following conditions:
 - a. From 0 to 100% loading.
 - b. Inverter DC input varies from maximum to minimum.
- The inverter output shall limit the amount of harmonic content to the values stated in section. The use of excessive or additional filtering shall not be required to limit the harmonic content thus maintaining a high level of efficiency, reliability and original equipment footprint.
- The inverter output shall be capable of providing an overload current while maintaining rated output voltage to the values stated. An LED indicator shall be located on the control panel to identify this condition. If the time limit

associated with the overload condition expires or the overload is in excess of the set current amplitude, the load shall be transferred to the bypass source without interruption.

- The inverter output shall be limited to 150% of rated load current.
- The AC output from the inverter shall utilize fuses for overload protection. The inverter shall utilize a contactor to isolate the inverter output from the critical bus. The inverter fuses shall be the fast acting semiconductor type. The inverter output isolation contactor shall be located in the UPS module and shall be controlled by the internal UPS module system logic.
- The inverter shall meet the following specifications in addition to other requirements stated herein:
Voltage Input : Three Phase UPS
- Nominal DC (Range 300 V to 420 V DC to maximum DC bus voltage during charging the batteries).
- Nominal Voltage Output : 415 V + 1% AC 3 Phase, 4 Wire
- Voltage Regulation :
 - a. For 0 to 100% loading: $<+ 1\%$
- Transient Voltage Regulation :
 - a. At 100% step load change : $<+ 3\%$
 - b. At loss or return of AC input : $<+ 1\%$
 - c. At load transfer from bypass to inverter : $<+ 3\%$
 - d. Total voltage harmonic distortion : $< 5\%$ THD for 100% linear load $< 7\%$ THD for 100% non-linear load
 - e. Output power factor > 0.9
 - f. Duty : Continuous
 - g. Cooling : Forced cooling using fans.
 - h. Ambient operating temperature range : 0 to 40 deg.C maximum continuous.
 - i. Output : Suitable terminals are provided for termination of cables for connecting inverter output to AC distribution board.

Isolation transformer and bypass switches

- This shall provide neutral separation which shall mean that output neutral will be independent of incoming neutral, hence critical load shall be isolated from the problems like incoming neutral open or, short or, variations in neutral to earth voltage due to sudden loading in neighboring installation. The isolation transformer shall be connect so as to protect any unwanted voltage fluctuations in neutral to protect the UPS
- In the event of Phase sequence reversal at the input, UPS system shall continue to work and shall not trip the UPS system.
- A bypass circuit shall be provided as an alternate source of power other than the inverter. A high speed switch and wrap-around contactor shall be used for the critical load during automatic transfers to the bypass circuit. The static switch and wrap-around contactor shall drive power from an upstream bypass feed circuit breaker internal to the UPS module provided for overload protection. The wrap-around contactor shall be electrically connected in parallel to the static switch and shall at the same time as the static switch, energize and upon closure, maintain the bypass source. The static switch shall only be utilized for the time needed to energize the wrap-around

- contactor thus increasing reliability. The bypass circuit shall be capable of supplying the UPS rated load current and also provide fault clearing current.
- The UPS system logic shall employ sensing which shall cause the static switch to energize within 150 microseconds thus providing an uninterrupted transfer to the bypass source when any of the following limitations shall exceed:
 - a. Inverter output under voltage or over voltage.
 - b. Overload beyond the capability of the inverter
 - c. DC circuit under voltage or over voltage
 - d. Final end voltage of system battery is reached.
 - e. Bypass source present and available
 - f. System failure (eg.Logicfail, fuse blown, etc.)
 - Keeping the above requirements in view, the static switch shall have the following minimum rating.
 - a. Capacity continuous equal to 100% of continuous rating of the inverter.
 - b. Capacity overload equivalent to overload characteristics specified for UPS.
 - c. Nominal bypass input voltage: 415 V, 3 phase, 4 wire
 - d. Voltage Range :+/- 10% of nominal
 - e. Nominal Frequency : 50 Hz
 - f. Frequency range :+ 6%
 - g. Output Fault Clearing : Current : 1000%, Duration : 20 milli seconds
 - h. Duty : Continuous
 - In the event that the critical load must be transferred to the bypass source due to an overload, the UPS system logic monitors the overload condition and, upon the overload being cleared, performs an automatic re-transfer back to the inverter output.
 - The UPS shall be capable of transferring the critical load to / from the bypass source via LCD touch panel. When performing manual transfer to inverter or automatic re-transfers, the UPS system logic shall force the inverter output voltage to match the bypass input voltage and then parallel the inverter and bypass source providing a make-before-break transition allowing a controlled walk-in of load current to the inverter.
 - The UPS shall include as standard equipment, a zero energy maintenance bypass switch. Full UPS wraparound enables personnel to do work inside the UPS module or maintenance bypass switchboard without danger for high voltage conditions.
 - The UPS shall have built-in protection against: surges, sags, and over-current from the AC rectifier input source, over-voltage and voltage surges from output terminals of paralleled sources, and load switching and circuit breaker operation in the distribution system.
 - The UPS shall be protected against sudden changes in output load and short circuits at the output terminals. The UPS shall have built-in protection against permanent damage to itself and the connected load for all predictable types of malfunctions. Fast-acting current limiting devices shall be used to protect against cascading failure of solid-state devices. Internal UPS malfunctions shall cause the module to trip off-line with minimum damage to the module and provide maximum information to maintenance personnel regarding the

reason for tripping off line. The load shall be automatically transferred to the bypass line uninterrupted, should the connected critical load exceed the capacity of the available on-line modules. The status of protective devices shall be indicated on a graphic display screen on the front of the unit.

Battery system

- The battery system shall be sized to provide 30 minutes backup time when the UPS is supplying 100% rated load at 0.9 load power factor.
- The battery system design shall be provided with necessary devices to prevent deep discharge beyond recommended limits to prevent the batteries discharging beyond end cell voltage specified by the battery maker. The connections from battery to battery shall be by using copper cable and BCB (Battery circuit breaker).
- All batteries shall be clearly identified and identification numbers marked on the batteries and a schematic diagram along with the complete calculations, including manufacturers supporting curves, shall be submitted with the tender.
- Batteries shall be VRLA (Maintenance-Free) type. Constant current boost charging, constant voltage boost charging, float charging (float charging compensation) and EOD protection are available for different kinds of batteries.

Charging: In addition to supplying power to the load, the battery converter shall be capable of producing a battery charging current sufficient to replace 95% of the battery discharge power within ten (10) times the discharge time. Ripple voltage at the battery terminal (RMS) should be less than 1%, and ripple current must not exceed 5% (of C-10 Ah rating) nominal discharging current. (Number of battery is 25 - 40 blocks, nominal voltage is 12V per block).

- Discharging: The battery converter will supply power to the inverter when the rectifier is shut down or in joint mode, and also the rectifier is current limiting.

Operation

- Under normal operation, the UPS load will be fed from the Inverter with the bypass switch inhibited. The rectifier, apart from providing DC power to the Inverter, also charges the battery under the float charge mode. The battery charge system shall have float charge, equalizing charge and recovery charge modes, to replenish the batteries self-discharging part while the battery is fully charged, equalizing the battery cell voltage to a constant value forcibly, and recharging the battery system to the required values when the batteries have been used, respectively.
- The Inverter shall constantly monitor the AC source frequency and shall be in synchronization with the AC input source till the frequency of the AC input source is within synchronizing limit and if the frequency of the standby source exceeds the synchronizing limit the Inverter will work on its own internal oscillator maintaining an output frequency of 50 Hz \pm 0.01% under all conditions of load. When the Inverter operates on its internal oscillator, it shall continuously monitor the frequency of the input source and when the input

- source frequency returns to within synchronization limit, the Inverter shall automatically synchronize itself with the input A/C source frequency and use it as a signal for Inverter output frequency control.
- When the A/C input voltage drops below specified limits or in case of a power failure the Inverter continues to supply AC power of constant voltage and constant frequency utilizing the battery system as a power source until the input voltage returns to normal requirement. When the power supply is resumed or the input voltage returns to limits, the Converter shall automatically start and the load fed for normal operation status.
 - If the power failure continues beyond battery backup time or the battery voltage drops to the final discharge voltage, the Inverter should automatically stop and at the same time transferring the load to the bypass circuit. On resumption of power supply, the Converter shall automatically re-start the operations and charge the batteries whereas the Inverter should inhibit automatic start and should be started manually.
 - When power is supplied from the Inverter in synchronization with the bypass, it shall accomplish the following:
 - a. When the UPS output current reaches overload status it shall automatically transfer the load to bypass circuit with no interruption and when the overload status is cleared it automatically re-transfers the load to Inverter.
 - b. When the battery final discharge condition is reached, the load shall automatically be transferred to the bypass circuit without interruption.
 - c. In case of failure of the UPS, the load shall be automatically transferred to the bypass circuit with no interruption and when the failure is cleared, re-transfer the load to the Inverter shall be done manually.
 - d. There should be provision made in the system to prevent, when necessary, asynchronous transfer.
 - e. When the UPS goes on bypass mode in any of the conditions described above and if at that time there is no bypass power supply available due to power failure, the UPS shall remain in standby mode and as soon as the bypass power supply is available will transfer the load to bypass.
 - f. A maintenance bypass transfer switch shall be provided with lock and key arrangement and should be manually done by authorized personnel only.
 - The entire UPS system, including all components like inverter, static switch, maintenance bypass, shall be housed in free-standing steel type factory-finished enclosures complying with the protection standards of IP20. The enclosure shall be open able using a special tool for internal access. The color shall be light grey.
 - Forced air-cooling shall be provided to allow components to operate within their rated temperature specified. The cooling fans shall have thermal relays protection using a latched cut fire re-setting, as a protection for the cooling fans.

Control and monitoring

- The UPS shall have Simple Network Management Protocol (SNMP) card with system (RS485 compatibility port) for interfacing to IBMS system or client's centralized computer network for Control and Monitoring System.
- It shall be provided with LED displays. The display system shall have, as minimum individual

- LEDs with different colors for the following:
 - a. Load on Inverter
 - b. Battery operation
 - c. Load on Bypass
 - d. UPS failure
 - e. LCD failure
 - f. Overload
- Statistical data Providing all statistical data like no. of days of UPS operation, no. of mains failures up to 1min, 2min etc., no. of overloads up to 110%, 125% etc, no. of hours operation on battery & on bypass etc., no. of hours battery temp exceeded 25 degree C.
- LCD touch panel
- The UPS shall be provided with a operator friendly large scale LCD touch panel.
- The LCD touch panel shall also include graphic measurement display, operational procedures of each activity, fault status display and also have capability to record at least 50 faults.
- The touch screen panel shall clearly define specified areas for operational function, execution and message display.
- It should be possible to operate the entire UPS system and its components and obtain all measurements and data through the touch screen operation. The measurement software should provide capability to measure phase voltage, current in each phase, frequency, power factor, available battery time etc.
- Under all operating conditions, the system software should have capability for displaying fault alarm automatically. The Firm should describe in detail the faults that would be displayed under this mode.

A.7.6 Installation, Testing & Commissioning

- Installation of UPS shall be carried out as per manufacturer's instructions and installation shall be verified by the manufacturer before energizing.
- Type testing shall be conducted from accredited Lab. Copies of the test certificates for same rating shall be submitted at the time of vendor approval. These shall not be more than **5 years old from the date of approval of drawing.**
- Testing at manufacturers' works shall be conducted before dispatch as per routine verification requirements.
- Physical check including checking damage/crack in any components, etc shall be done at site.
- Following test shall be performed, as a minimum, at site prior to handing over, to confirm the functional and the performance specification of the UPS as specified. All required test equipment like Digital Oscilloscope, Voltage Regulator and Measurement Meters etc. shall be the responsibility of the concerning vendor without any additional cost.
- Full load testing of UPS with required size load bank shall be done at site as per the approved QAP. All testing expenses including load bank and its arrangements shall be under the scope of vendor.

- The vendor shall demonstrate as a minimum the following features on site by providing all required test equipment, such as power factor improvement, input current THD, output voltage THD, output frequency and all other performance monitoring requirements detailed before as required by the Owner.

D.8 LT PANEL

A.8.1 Scope

The scope of work shall include :

1. Supplying, installation testing and commissioning of LT Panels for substation
2. Panel handling, loading unloading and storage.
3. Associated inter panel and intra panel wirings including both ac and dc wirings as well as control cabling, from panel to panel and from panel to DB.

A.8.2 Definitions

The definitions shall be as per IEC-61439 and other relevant IEC standards.

A.8.3 Codes & Standards

The contractor is required to follow all relevant IS and IEC codes as per latest amendments, however in particular following codes may be applied in addition.

1. IEC-61439 - Standard for low voltage switchgear and assemblies.
2. IEC-60044 - Standard for instrument transformer.
3. IEC-60099- Standard for surge arrester.
4. IEC: 60255- Measuring relays and protection equipment.
5. IEC -60947 - Low voltage switchgear and controlgear.
6. IS 2147 - Degrees of protection provided and enclosures for low voltage switchgear and control gear
7. IS 375 - Marking and arrangement of bus bars.
8. IS 13703-1993- HRC Fuse Links
9. IS 2705- Current Transformer
10. IS 3231- Relay
11. IS 1248- Indicating Instruments
12. IS 722- Integrating Instruments

- 13.IS 6875- Control Switches & Push Buttons.
14. NEC- 2008 - National electrical code.
15. NBC-2016 - National building code.
16. IER-1956 : Indian electricity rules.
17. IEA-2007 : Indian electricity act 2007
18. Any other local bye-law or supply company norm as applicable.

A.8.4 Service conditions

System particulars

- a. Nominal system voltage - 415V
- b. Rated system voltage - 1.1kV
- c. Frequency- 50Hz $\pm 3\%$
- d. No. of phases- 3
- e. System neutral- Solidly earthed
- f. Short circuit rating - 50kA for 1 sec
- g. Automation compatibility : SCADA compatible

Tropical conditions

- a. Ambient temperature : 50 degree celsius
- b. Relative humidity (avg.) : 60
- c. Isokeraunic level : 33
- d. Seismic Zone : Zone-4
- e. Climate type : hot and humid

The climatic conditions are prone to wide variations in ambient conditions and hence the equipment shall be of suitable design to work satisfactorily under these conditions.

Tolerances and creepage distance

Tolerances (on all the dimensions) and creepage distances shall be in accordance with provisions made in the relevant Indian/IEC/BIS standards and in these specifications. Otherwise the same will be governed by good engineering practice in conformity with required quality of the product.

A.8.5 Specifications

Panel Cubical Construction

- The complete panel assembly shall be a design verified assembly with design verification done as per IEC-61439.
- Panel fabricated out of 2mm CRCA sheet steel throughout and shall have undergone 7 tank process or better.
- Undrilled gland plates shall be 3mm thick. The gland plates shall have knock able type holes of suitable diameter of cable glands. Minimum 30% extra knock able holes shall be provided on each gland plate. Non-magnetic gland plates shall be used where single core cables are used for three-phase supply.
- The panel shall be self-supporting, free standing or wall mounted.
- The enclosure shall confirm to IP55 protection for outdoor panels and IP42 for indoor panels.
- The Panel shall be dust, vermin, corrosion proof and shall be mechanically stable to take the mechanical load of complete assembly with all fixed and moving components.
- The panel shall have appropriate protection against mechanical impact.
- The panel shall be extendable from both sides.
- The terminal blocks shall be provided at convenient location for cable termination. The distance between the terminal strip and gland plate shall be kept in such away that the cables can be properly dressed & no cable tension is transferred on the terminal strip/or equipment.
- Proper grouting arrangement shall be made in panel for installation of panel in accordance with seismic requirement.
- Complete panel assembly shall be fixed on ISMC-100.
- The design shall ensure generous availability of space for ease of installation and maintenance of cabling, and adequate safety for working in one vertical section without coming into accidental contact with live parts.
- Front and rear doors should be fitted with synthetic rubber or neoprene gaskets with fasteners designed to ensure proper compression of gaskets.
- All sheet steel work forming the exterior of switch boards shall be smoothly finished, leveled and free from flaws. The corners should be rounded. The apparatus and circuits in the panels shall be so arranged as to facilitate their operation and maintenance and at the same time to ensure the necessary degree of safety.
- Panel shall be constructed in form-3b methodology.
- All sheet steel work used in construction of panels shall be given for proper shot blasting/surface finish to make it free from all rusts/impurities/deposits.
- It shall be then provided with two primer coat and then/powder coated (electrostatically) with final paint shade RAL7032 as per IS - 5.
- It shall be the process of Powder Coating with suitable primer and having total coating thickness of 85-100 micron. The M.S Sheet Steel shall be given for proper shot blasting / surface finish to make it free from all impurities.
- All sheet steel work used in construction of panels should have undergone a rigorous metal treatment 7 tank process or better as mentioned below.
 - a. All sheet steel work shall be phosphate in accordance with the procedure

in accordance with relevant standards for phosphatizing iron and steel. Oil, grease and dirt shall be thoroughly removed by emulsion cleaning.

b. Rust and scale shall be removed by pickling with dilute acid followed by washing with running water, rinsing with slightly alkaline hot water and drying.

c. A recognized phosphate process to facilitate durable coating of the paint on the metal surface and also to prevent the spread of rusting in the event of the paint film being mechanically damaged. This again, shall be followed by hot water rinsing to remove traces of phosphate solution.

d. After phosphatizing through rinsing shall be carried out with clean water followed by final rinsing with dilute dichromate solution and oven drying.

e. Passivation in deoxalate solution to retain and augment the effects of phosphatizing.

Busbars and internal connections

- The selection, design and construction of bus bars shall conform to IS/IEC specifications and the latest amendments.
- Busbars shall be designed to carry rated currents during both steady state and transient conditions.
- The bus bars shall be air insulated and made of high conductivity, high strength electrolytic grade aluminium.
- Bus bars shall be located in air-insulated enclosures and segregated from all other compartments of the cubicle.
- Direct access or accidental contact with bus bars and primary connections shall not be possible.
- Bus bars shall be rated in accordance with service conditions and the rated for continuous and short time current ratings specified in SLD / data sheets.
- Busbars shall be design for a temperature rise of 40 degree celsius above the ambient temperature, while for all bolted connections of bus it shall be 45 degree celsius.
- The busbar shall be designed for a temperature of 190 degree during transient conditions.
- Bus bars shall be adequately supported on SMC/DMC insulator supports to withstand electro dynamic stresses due to short circuit currents.
- Bus bar support insulators shall be of non-hygroscopic material and shall conform to relevant IS standards.
- The current density of the bus bars shall not be less than 0.8 Amp / sq mm.
- Bus bars should be color coded for easy identification of individual phases and neutral.
- All the bus bars should be provided with color coded heat shrink sleeves.
- A main horizontal aluminum grounding bus, rated to carry maximum fault current, extending along the entire of the panel shall be provided.
- The ground bus shall be provided with two-bolt drilling with GI bolts and nuts at each end to receive the main Earthing grid.
- The size of the earth bus shall be as mentioned in drawings and schedules
- Important parameters for complete panel assembly shall be as follows :
 - a. Voltage - 415V \pm 6%

- b. Frequency - 50hz \pm 3%
 - c. No. of Phases - 3 + 100% Neutral + Earth bus
 - d. Peak Impulse Voltage - 12KV
 - e. Power frequency withstand capability – 2.5KV (power circuit) and 2KV (control circuit)
 - f. Short circuit withstand capacity - 50kA for 1 second
 - g. Type of discrimination required among switchgears - Total discrimination
 - h. Min clearance and creepage distance - As per IEC-61439
 - i. Dimensions : As per approved type tested design.
- Control wiring for all control circuit shall be done as follows :
 - a. Each control circuit shall be protected with the help of DP MCB .
 - b. Control wiring shall be done with 1.1kV grade FRLS type control cables tested for power frequency withstand of 2kV.
 - c. All voltage circuits shall be wired with 1.5sqmm cu control cables.
 - d. All current circuits shall be wired with 2.5sqmm cu control cables.
 - e. Control wiring shall be done neatly with proper dressing and ferruling done.
 - f. Control wiring shall be color coded appropriately.
 - g. Terminal links used for control wiring shall be of good quality and shall withstand the temperature.
 - h. All connections must be be tight.
 - Power wiring for main circuit shall be done as follows :
 - a. Switchgears of 100A rating and above shall be connected by the means of suitable busbars only.
 - b. Cable terminal blocks used for power cable termination shall be suitable to withstand the temperature rise due to steady state and transient currents.
 - c. All connections must be be tight.

Safety features and Interlocks

- The safety shutter shall be provided in breaker panels, which shall prevent in advertent contactwith isolating contacts when breaker is withdrawn from the Cradle.
- Door interlocking shall be provided in each switchgear compartment with a provision of defeat interlock .
- All panel doors shall have provision of padlocking.
- Insulating barriers shall be provided in all live sections of the panel.
- There shall be provision of positive earth connection between fixed and moving portion of theACB either through connector plug or sliding solid earth mechanism.
- Earthing bolts shall beprovided on the cradle or body of fixed ACB.
- Arc chute covers shall be provided wherevernecessary.
- In case of drawout type switchgears safety shutters shall be provided to fully cover the live section automatically once the switchgear is being draw out
- It shall be possible to bolt the draw-out frame not only in connected position but also in TESTand DISCONNECTED position to prevent dislocation due to vibration.

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- There shall be provision for locking the breaker in all three positions.
- The breaker shall be provided with interlock to prevent the breaker from being withdrawn or replaced except in the fully isolated position.
- Interlock shall also be provided to prevent the breaker from closing without in service position.
- Space heaters triggered by thermostat shall be provided in cable compartments to avoid moisture.
- Lamp operated with a door limit switch and a toggle switch shall also be provided in panel compartments along with 6/16A switch socket for ease of maintenance

Air Circuit Breaker (ACB)

- ACB shall be mechanically rugged and shall be designed to carry steady state current and also transient current up to the time arc gets quenched.
- The moving parts of 4 pole circuit breaker shall have operating mechanism, primary and secondary isolating devices, auxiliary switches, mechanical position indicators, all mounted on a rigid sturdy steel frame work.
- Primary and secondary disconnecting devices shall be self-aligning type of fully isolating.
- On/Off push buttons shall be provided in ACB in such a way that ACB can be switched ON or OFF without opening the switchgear compartment. Breaker shall also trip without opening switchgear compartment.
- ACB shall be mounted on a cradle and shall be withdrawable type.
- The cradle shall be so designed and constructed as to permit the smooth withdrawal and insertion of the breaker into it.
- The movement shall be free from jerks, easy to operate and shall be on steel balls/rollers and not on flat surfaces.
- There shall be 3 distinct and separate positions of the circuit breaker on the cradle.
 - a. Service : Both main and secondary isolating contacts in service.
 - b. Test : Main isolating contacts separate and secondary isolating contacts in service.
 - c. Isolated : Both main and secondary isolating contacts in isolated.
- Both mechanical and electrical indications shall be provided for TEST and SERVICE position.
- ACB maintenance trolley shall be provided by the contractor to rack out ACB
- ACB shall have following parameters / features :
 - a. Rated voltage – 415 +/-6% V
 - b. Rated frequency - 50Hz
 - c. P.I.V - 12kV
 - d. Rated short circuit capacity - 50kA for 1 sec.
 - e. Poles - Four pole
 - f. Temperature deration : No deration upto 50 degree celsius (In case deration is applicable, higher rating switchgear shall be provided)
 - g. Self watt loss : As per IEC-60947
 - h. Total breaking time : less than 70ms
 - i. Closing coil : suitable for 230V AC
 - j. Shunt coil : suitable for 230V AC

- k. Drawout type : Electrical
 - l. Spring charge operation : Through 230V AC motor as well as through handle.
 - m. Antipumping feature : Required and shall be inbuilt.
 - n. $I_{cs} = I_{cu} = I_{cw} = 100\%$
 - o. Spare contacts required : 4NO + 4NC
 - p. Indications : On, Off, Trip, Spring Charge, Ready to close
 - q. Undervoltage coil : As per design requirement.
 - r. Time delay (td) - 0-400 m sec
 - s. Inbuilt thermal memory
- Release of ACB shall have following parameters / features :
 - a. Protections : L,S,I,G
 - b. Setting options : L - 40%-100% I_n (nominal current rating) = I_r
 - S - $2 \times I_r$ to $10 \times I_r$
 - I - $6 \times I_n$ to $12 \times I_n$
 - G - 10% ,20% , 50% , 100%
 - c. Release type : microprocessor based.
 - d. Zone selective interlocking - required.
 - e. Communication : Fully communicable and shall be equipped with RS-485 port.
 - f. Memory : Non volatile memory to record 10 trip histories and 10 alarm history.
 - g. Alarm and indications : Visual indications for % loading in each phase, L,S,I,G fault, release failure
 - h. Release shall be capable to generate remote alarm in case of any internal fault and Spare contacts shall be provided with release to do so.

Moulded Case Circuit Breaker (MCCB)

- MCCB shall be mechanically rugged and shall be designed to carry steady state current and also transient current up to the time arc gets quenched.
- MCCB shall be provided with door operating mechanism having interlock, defeat and padlocking facility.
- MCCB should trip free, quick make and quick break type and should be equipped with a current limiting feature.
- MCCB shall have spreader links and terminal shroud as a feature for safety and proper heat dissipation.
- MCCBs shall have double break mechanism.
- MCCB shall have following parameters / features :
 - a. Rated voltage - 690V
 - b. Rated frequency - 50Hz
 - c. P.I.V - 12kV
 - d. Rated short circuit capacity - **50kA (minimum)**
 - e. Poles - Four pole
 - f. Temperature deration : No deration upto 50 degree celsius (In case deration is applicable, higher rating switchgear shall be provided)

- g. Self watt loss : As per IEC-60947
 - h. Total breaking time : less than 40ms
 - i. Shunt coil : suitable for 230V AC
 - j. Drawout type : Non withdrawable (fixed type)
 - k. $I_{cs} = I_{cu} = 100\%$
 - o. Spare contacts required : 2NO + 2NC
 - p. Indications : On, Off, Trip
 - q. Undervoltage coil : As per design requirement
- Release of MCCB shall have following parameters / features :
 - a. Overload setting (L) $0.4-1 \times I_n$
 - b. Short circuit setting (with time delay)(S) $2 - 10 \times I_r$
 - c. Time delay (td) 0-400 m sec
 - d. Short circuit setting (Instantaneous) (I) $11 \times I_n$
(Where I_n = nominal current of MCCB & I_r = rated current to which it is set.)
 - e. Ground Fault Setting with time delay (0-300ms) (G) : $0.1-1 \times I_n$
 - f. Neutral setting (N) (where ever required): $0.5-1 \times I_n$
 - g. Release type : microprocessor based
 - h. Communication : Fully communicable and shall be equipped with RS-485 port.
 - i. Memory : Inbuilt thermal memory.
 - g. Alarm and indications : Visual indications for L,S,I,G fault
 - h. Release shall be capable to generate remote alarm in case of any internal fault and Spare contacts shall be provided with release to do so.

Contactors

- All contactors and bi-metal relays should conform to IS - 13947 - 4/IEC - 947-4 standards.
- Contactors should be suitable for requisite duty and the contactor shall be designed to operate even in severe operating conditions.
- The Contactors shall be suitable for switching and controlling squirrel cage and slipping motors as well as other AC loads such as solenoids, capacitors, lighting loads, heating loads and transformer loads.
- The contactors shall be suitable for operation in service temperature up to 50 degree C without derating.
- The contactors and bimetal relays shall have been tested for type-2 co-ordination at 50KA, 415 V 50 Hz as per IS 13947 for both fuse protected as well as fuse-less motor feeders.
- The contactor shall have coil of 220/240 V AC or as may be specifically asked for.
- The design of the current carrying parts, contact system and the magnet system should be such that it should increase reliability of electrical and mechanical endurance.
- Auxiliary contact should have double break parallel bridge contact mechanism. For operator safety the contactors above 45 Amp should have arc-chamber. The construction of the arc chamber should be such that there is no emission of arc by-products on the surrounding equipment.

- The contactor shall have funnel shaped cable entries, cable end stops and predetermined insertion depths.
- Contactor below 63 Amp shall have captive screws preventing the screws from falling.
- Main contacts should be of silver alloy to have long contact life; it should withstand to keep the contact bounce to minimum and should be shrouded with an arc chute.
- Both moving and fix contacts should be accessible for inspection or replacement without disturbing terminal wiring.
- The magnet system should have laminated, construction to minimize the losses.
- Coils should withstand high temperature and ensure low power consumption. Coil should be resin cast/encapsulated. It should have inter layer insulation.
- Contactor should have facility to mount add-on auxiliary contact block. Mechanical interlocks should be provided for sequential operations if required.
- Contactor should be comfortably mounted in any position on a vertical plane. Contactor should be capable of handling high transient currents.
- It's Insulation voltage level should be - 1000 v. Contactor shall be designed to have mechanical endurance of the order of minimum 15 million operations or better.
- Contactor should operate without deration from - 30° C to +50° C

Current Transformer

- Current transformers shall comply with the requirements of IS. 2705.
- The current transformers shall be core type with cast resin/encapsulated secondary winding.
- CTs shall be mounted on the switchboard stationary part.
- The secondary CT leads from all panels should be terminated on the front of the board on easily accessible shorting type terminal connectors so that operation and maintenance can be carried out when the panels are in service.
- CT's shall be given heat run test.
- CT shall have following parameters / features :
 - a. Rated voltage - 415V
 - b. Rated frequency - 50Hz
 - c. Class : 0.5 (for metering) / 5P10 for protection / PS for unit protection
 - d. Rated short circuit capacity - As per fault level
 - e. Construction - Ring / wound type
 - f. Burden - As per SLD
 - g. Rated secondary current : 5A

Control switches

- Control Switches shall be of the heavy-duty rotary type with escutcheon plates clearly marked to show the operating position.
- They shall be semi-flush mounting with only the front plate and operating handle projecting.
- Circuit breaker control switches shall be of the spring return to neutral type, while instrument selector switches shall be of the stay-put type.

Push Buttons

- Push buttons should be of the momentary contact, push to actuate type.
- Push Buttons should be panel mounted, flush type having 22.5 mm Ø.
- Push Buttons should be spring returns type.
- Lock and key head with Push turn facility.
- Modular blocks should contain NO-NC contact.
- It should be snap-fit type for easy assembly.
- Double break self-cleaning contacts for prolong life.
- NO-NC contact block should be colour coded for easy identification.
- Push Buttons should have transparent shroud and rubber shroud to enhance protection against ingress as per IP- 67.
- It should withstand operating voltage as well as frequent operation.
- It should have finger proof shrouded terminals.

Terminal Blocks

- Insulating barriers shall be provided between adjacent terminals. CT Terminal blocks shall be shorting type.
- Terminal blocks shall have a minimum current rating of 10 Amps & 650 volt grade rating complete with insulated barriers. Provisions shall be made for label inscriptions.
- It should have snap fit action.
- It should have captive-screws and self-lifting washers.
- Withstand temp range from -30° C to 100° C.
- Terminal Connectors should have flame retardant property confirming to UL-94, V-2.
- Terminal Block should be suitable for commonly used DIN Rail - 35 X 7.5 mm and mounting channel 'C' shaped Std. 32 mm.
- Terminal Block should be suitable for commonly used DIN Rail - 35 X 7.5 mm and mounting channel 'C' shaped Std. 32 mm.
- The construction material should be of high quality like polyamide 6/6 and contacts of Nickel plated brass. Labels shall be of anodized aluminum, with white engraving on black background.
- They shall be properly secured with fasteners.

Digital Energy Meter

- The load manager shall be micro-controller based unit capable to measure a host of electrical parameters and display them on a 128 x 64 backlit LCD.
- It shall have load management feature and shall have six numbers of output relay contacts apart from CT/PT contacts.
- These outputs shall be individually field programmable for both the parameter on which to generate alarm as well as the values on which to activate alarm and deactivate it.
- In addition to this flexibility in terms of load management, the load manager shall also have RS485 port. RS485 supports MODBUS RTU protocol for connections to EMS/SCADA.

- The unit shall be made for threephase four wire system. The installation type, CT ratios and PT ratios shall be site selectable.
- The Load Manager with its six relay contacts shall be capable to be used as a DemandController. The method of Demand calculation i.e. sliding window, fixed window shall be selected at site. The device shall have all the features needed to implement a robust electrical load management system.
- It shall be programmable / configurable to suit most control and communication needs. The load manager shall be capable to measure following parameters:
 1. Voltage (Volts L-N & L-L) VL-N Accuracy: 0.5% of Reading VL-L Accuracy: 1.0% of Reading.
 2. Current (Amps IR, IY, IB) Accuracy: 0.25% of Reading.
 3. Line Frequency 45 to 55 Hz, Accuracy: 0.3% of Reading.
 4. Active Power (P) Accuracy: 0.5% of Reading (For IPFI>0.5).
 5. Reactive Power (Q) Accuracy: 1.5% of Reading (Between 0.5 Lag to 0.8 Lead).
 6. Apparent Power (S) Accuracy: 0.5% of Reading.
 7. Power Factor For Individual phases and System. Accuracy: 0.5% of Reading (IPFI≥0.5) Range of Reading: 0.05 to 1.000 Lag/Lead.
 8. Total Active Energy (KWh) Range of Reading: 0 to 9999999.9 KWh Accuracy: Class 0.5 as per IS14697.
 9. Total Apparent Energy (KVAh) Range of Reading: 0 to 9999999.9 KVAh Accuracy: Class 0.5 as per IS14697.
 10. Total Reactive Energy (KVARh) Range of Reading: 0 to 9999999.9 KVARh Accuracy: Class 0.5
 11. 3 rd to 15 th Harmonics (Odd) for all Voltages with THD.
 12. 3 rd to 15 th Harmonics (Odd) for all Currents with THD.
 13. Active Power (KW) Demand - Sliding & Fixed, Selectable.
 14. Apparent Power (KVA) Demand - Sliding & Fixed, Selectable
- The device shall also have following features:
 1. Display 128 X 64 Graphical LCD with Operating temp 10° C to 50° C.
 2. Data Logging Buffer 2 MB, Non-volatile memory, capable of holding 19691 records Logging Duration Site selectable.
 3. RS485 Modbus-RTU protocol
 4. Communication USB 8.0 Pen-drive For downloading logged data

D.8.6 Installation, Testing and Commissioning

- The complete Panel assembly shall be installed in accordance with the manufacturer's installation drawing duly approved by "The consultant "
- The panels need to be grouted considering the seismic zone requirement.
- Panels shall be properly aligned and leveled within tolerance of +/- 2mm and shall be ensured with a water level indicator or a laser gun whichever available. No shim shall be allowed to make a panel level suitably.
- All live sections and compartments shall be covered with insulation barriers.
- All the components of the panel shall be easily accessible.
- The location of installation shall be cleaned and co-ordination shall be made

with other disciplines.

- Grouting holes shall be provided from inside and the panel shall be suitably and tightly bolted. No tuck welding with base channel is allowed.
- Panels shall have peel-able poly layer on the cover for protection from cement, plaster, paint etc. during the construction period.
- The holes made in enclosure for cable termination or anything else shall be made only through drill machine or approved cutting tool with marking of dia done prior to cutting or drilling. Extra left out holes shall be filled neatly with fire retardant sealant.
- The Panel shall be tightly grouted. No spare nuts-bolts shall be left out un-tightened / open inside the DB enclosure in any case.
- Gland plates where ever used for cable termination shall be tightly fixed and shall be earthed.
- Size of Horizontal and vertical bus bars shall be equal.
- Switchgears above 63A shall be mounted on bus bars tightly and accurately.
- Termination lugs shall be tightly fixed and connected and there shall not be any bare wire strand jetting out of the lugs. Suitable crimping tool shall be used and terminal wires shall be covered with heat shrinkable sleeves whose color coding has to match with the color of the wire used.
- Color coding shall be followed for internal wiring also in a similar pattern as described. Bus bar shall be tagged for phase indication.
- Panel compartments shall be provided with space heaters and lights operated by door limit switches.
- The door of panel shall be aligned properly and there shall be no air gap left after closing the DB door. Gaskets shall be used to make DB free from moisture.
- Panel shall have Padlocking arrangement and shall be pad locked after complete installation.
- Panel board shall be fully tested (both type and routine test) for its components as per the specification laid under Indian standards. In particular following test shall be done :
 - (a) Continuity test (both earth continuity and loop continuity)
 - (b) Insulation resistance test.
 - (c) Contact resistance test.
 - (d) Primary injection test.
 - (e) Trip test and trip unit reset test with Test knob of breaker.
 - (f) CT testing (Polarity, Knee voltage)
 - (g) Phase rotation test.
 - (h) HV test on bus bar
 - (i) Space heater Testing
 - (j) Control wiring check

D.9 DYNAMIC VOLTAGE REGULATOR (DVR)

A.9.1 Scope

The scope of work shall include:

1. Supplying, installation testing and commissioning of dynamic voltage regulator
2. DVR handling, loading unloading and storage.
3. Associated wirings including both ac and dc wirings as well as control cabling within DVR and from DVR to other panels / DBs and 100kVA transformer.

A.9.2 Definitions

The definitions shall be as per IEC/IS.

A.9.3 Codes & Standards

The contractor is required to follow all relevant IS and IEC codes as per latest amendments, respective IS/IEC codes as mentioned in this document.

A.9.4 Service conditions

System particulars

- a. Nominal system voltage on LV side- 415V
- b. Rated system voltage on LV side- 1.1kV
- c. Frequency- 50Hz $\pm 3\%$
- d. No. of phases– 4 on LV side
- e. System neutral- Solidly earthed
- f. Short circuit rating - 50kA for 1sec on LV side.
- g. Automation compatibility : SCADA compatible.

Tropical conditions

- a. Ambient temperature : 50 degree celsius
- b. Relative humidity (avg.) : 60
- c. Isokeraunic level : 33
- d. Seismic Zone : Zone-4
- e. Climate type : hot and humid

The climatic conditions are prone to wide variations in ambient conditions and hence the equipment shall be of suitable design to work satisfactorily under these conditions.

Tolerances and creepage distance

Tolerances (on all the dimensions) and creepage distances shall be in accordance with provisions made in the relevant Indian/IEC/BIS standards and in these specifications. Otherwise the same will be governed by good engineering practice in conformity with required quality of the product.

A.9.5 Specifications

- PWM IGBT based dynamic voltage regulator (DVR) shall ensure stable voltage for critical loads.
- Voltage regulation shall be performed by IGBT driven PWM inverter operating at around 30kHz control frequency
- Typical voltage correction reaction time should be <300 micro seconds
- Voltage regulation shall be achieved by superimposition of PWM wave on incoming wave, without any brake in the power path.
- The control algorithm must work in closed loop; sensing both the input and output voltages as feedback for best regulation
- The control algorithm must sense the converter current at all times for better regulation and instantaneous over-load detection. The converter must detect overload and go to bypass mode and not rely solely on input/output MCCB and fuses for over load protection. Suitable audible and visible alarm shall be inbuilt for bypass mode.
- The converter must use semi conductor fuses at input to protect the IGBT converter.
- PWM Static Voltage regulator shall use static parts for real-time voltage correction. It shall not use any such moving part like relay or brush, which limit the rate of voltage regulation.
- The IGBT drivers must employ the following (minimum) protections to ensure long operational life of the IGBTs
 - a. Active clamping protection.
 - b. Output short circuit protection with soft turn off.
 - c. Vce saturation protection.
 - d. Must have isolated input and output power supplies for driving the IGBTs.
 - e. Isolated DC-DC supply for IGBTs
- Nominal input & output shall be 3 phase wye, 240V (P-N), 50Hz.
- There shall be no switching, current interruption, transitions or step changes during voltage regulation.
- The output voltage shall be duly free of harmful surges, spikes and EMI/RFI noises. Following are typical parameters for dynamic voltage regulator
 - a. Type- Three phase, Unbalanced load
 - b. Rating- 100 KVA Three Phase.
 - c. Full Regulation Range:
 - a. Input voltage range (for each phase)- 240V +/-20% P-N
 - b. Output Voltage (for each phase)- 240V + 1%
 - d. Losses at reference temperature
 - a.No-Load loss at minimum rated input voltage shall be less than 1%

- of rated KW
 - b. Full Load Loss at minimum rated input voltage shall be less than 1.5% of rated KW
 - e. Duty cycle- Continuous.
 - f. Waveform distortion- Nil
 - g. Overload capacity- 125% of rated current (instantaneous)
 - h. Efficiency - >98.5% from 20% to 100% load.
 - i. Cooling - Naturally Air cooled
 - j. Environmental Protection - IP 42 or better
 - k. Class of insulation - Class H
- The IGBT based DVR shall be ensured with following features/protections.
 - a. Switching deadband for complimentary IGBT devices to prevent short circuit.
 - b. MCCB at input and output for overload & short circuit protection.
 - c. Semiconductor fuses to protect IGBT stack.
 - d. Redundant internal bypass to ensure critical load is not interrupted by failure/overloading of the DVR
 - e. Heavy-duty, three-stage AC surge protection circuits shall be installed separately for each phase.
 - f. Noise filters shall be provided on input and output to protect against high frequency EMI/RFI noises.
 - g. Provision for input chokes at IGBT converter input and output for EMI/EMC reduction.
 - h. Provision to Raise/Lower output set voltage using easy to access/use regulator knobs.
 - i. Input and Output digital multifunction meters must be provided for input/output current, voltage, power etc
 - j. Input and Output digital multifunction meters must have RS485 compatibility.
 - k. The DVR shall have self supervision feature
 - The IGBT based DVR shall be ensured with following indications/alarms.
 - a. LED for output healthy (Green)
 - b. LED for bypass (Red with hooter)
 - c. R,Y,B LEDs for three phases.
 - d. DC side faults (in annunciation window and hooter)
 - e. AC side faults (in annunciation window and hooter)
 - f. Phase reversal (in annunciation window and hooter)

Installation testing and commissioning

- Each PWM DVR unit shall be provided with a detailed operating manual with Installation, connection, turn-on, normal operation, maintenance & trouble-shooting instructions.
- The system should be repairable at site. The components must be functionally segregated. In the rare event of a failure, only the affected part must be replaced without the need to replace healthy/undamaged components/parts e.g: If there is a failure in IGBTs, then there must not be any need to replace control circuit elements like micro processor board, sensors etc. This is to ensure that

- maintenance cost is kept low for the end user.
- Maintenance by-pass shall be provided.

Testing

- Regulation test
- Heat run test
- No load efficiency test

A.10 EARTHING

A.10.1 Scope

The scope of work shall include :

1. Supplying, laying testing and commissioning of earth mat
2. Civil works associated with earthing
3. Interconnections to earth grid.

A.10.2 Definitions

The definitions shall be as per IEEE-80-200 and other relevant IS/IEC standards.

A.10.3 Codes & Standards

The contractor is required to follow all relevant IS and IEC codes as per latest amendments, however in particular following codes may be applied in addition.

1. IEEE-80-2000 - Code of practice for AC substation grounding.
2. IS-3043 - Code of practice for earthing
3. NEC- 2008 - National electrical code.
4. NBC-2016 - National building code.
5. IER-1956 : Indian electricity rules.
6. IEA-2007 : Indian electricity act 2007
7. Any other local bye-law or supply company norm as applicable.

A.10.4 Service conditions

System particulars

- a. Nominal system voltage - 11kV / 415V
- b. Rated system voltage - 12kV / 1.1kV
- c. Frequency - 50Hz \pm 3%

- d. No. of phases - 3
- e. System neutral - Solidly earthed
- f. Short circuit rating - 25kA for 3sec and 50kA for 1 sec.

Tropical conditions

- a. Ambient temperature : 50 degree celsius
- b. Relative humidity (avg.) : 60
- c. Isokeraunic level : 33
- d. Seismic Zone : Zone-4
- e. Climate type : hot and humid

The climatic conditions are prone to wide variations in ambient conditions and hence the equipment shall be of suitable design to work satisfactorily under these conditions.

Tolerances and creepage distance

Tolerances (on all the dimensions) and creepage distances shall be in accordance with provisions made in the relevant Indian/IEC/BIS standards and in these specifications. Otherwise the same will be governed by good engineering practice in conformity with required quality of the product.

A.10.5 Specifications

Earth Electrode

- The earth electrode is the main component of the earthing system which is in direct contact with the ground and thus provides a means of releasing or collecting earth leakage currents. The material should have good electrical conductivity & should not corrode in a wide range of soil conditions.
- The earth electrode shall be maintenance free type copper bonded rod of suitable length and dia as per calculations / schedules .
- The copper bonded rod shall have a cu coating thickness of 250 microns.
- These electrodes shall be buried underground at a suitable depth (preferably along the corners of earth grid) to form a bonded mesh / grid of earth electrodes.
- Earth enhancement material (Back fill compound) shall be a superior conductive material that improves earthing effectiveness especially in areas of poor conductivity such as rocky ground, sandy soil & areas of moisture variation.
- It shall be placed around earth electrode to improve the conductivity of earth electrode & ground contact area.
- The material shall be supplied in sealed moisture proof bags. These bags shall be marked with the name of the manufacturer or trade name, quantity, batch no., date of manufacture etc.

- It shall have following characteristics.
 - i) It should have low resistivity preferably below 0.2 ohm-meter (Resistivity shall be tested by making a 20cm cube of the material & checking the resistance across the opposite faces of the cube.).
 - ii) It shall not depend on the continuous presence of water to maintain its conductivity.
 - iii) It should be a little alkaline in nature with pH value of > 7 & < 9 . Test certificate from NABL approved laboratory to be provided for the compound so designed.
 - iv) It should have better hygroscopic properties to absorb moisture. It should absorb & release the moisture in the dry weather condition and help in maintaining the moisture around the earth electrode.
 - v) It should have capacity to retain more than 10% moisture at 105°C. Test certificate for the same from NABL approved laboratory shall be submitted.
 - vi) Material shall be in granular form of size 0.1mm to 3mm and shall absorb water to the extent of @ 51%. Specific gravity of BFC material shall be between 2.5 to 2.7.
 - vii) Material shall be nontoxic, nonreactive, nonexplosive & noncorrosive.
 - viii) Material shall be thermally stable between temperature range of -10°C to 60°C.
 - ix) Material shall not decompose or leach out with time.
 - x) It shall not pollute the soil or local water table & shall meet environmental friendly requirement for landfill.
 - xi) It should expand & swell considerably & remove entrapped air to create strong connection between earth electrode & soil.
 - xii) It should diffuse in to the soil pores & create conductive roots enlarging conductive zone of the earth pit.
 - xiii) It shall not require periodic charging treatment or replacement. It shall not cause burns, irritation to eye, skin etc. Minimum quantity requirement per pit of size 5'x5'x10' shall be 75Kg. and for 300mm bore type pit shall be 50 Kg.

A.10.6 Installation, testing and commissioning of earth mat

- Make 5ft x 5ft x 10ft. earth pit. If it is not possible to make such a pit due to hard rocky soil or any other reasons, 300mm bore up to 10 ft. deep shall be made using earth auger or any other method.
- Sleeve the soil and remove the gravels and stones. If soil quality is good (without murum & rocks) then add some quantity of earth enhancement material in the soil for using as backfill.
- If the soil seems unusable (Containing large quantity of gravel, stones, murum, sand etc.) the replace the soil with black cotton soil.
- Insert the electrode at the centre of the earth pit and arrange to keep it vertical in the pit.
- Arrange for adequate quantity of water supply for the pit. (Approx. 600 litres).
- Fill the pit with the backfill material and keep on adding the earth enhancement material surrounding the electrode and simultaneously watering the pit.
- With a steel bar or pipe keep on peking the soil and stirring intermittently for

- removing the air pockets and proper settlement of the pit
- .Procedure to be repeated till completion of the filling of the earth pit along with the packing materials and sufficient watering & adequate ramming.
- The pit shall be very compactly rammed and watering for 2-3 days and addition of soil if required be done.
- Make trench of 600mm (Depth) x 300mm wide for connecting the earth pit to nearest point of connection.
- Construct inspection chamber with cover for the installation.
- Measure the earth resistance as per IS-3043-1987 code of practice. Earth resistance value shall be less than 1 ohm in nonrocky/non-sandy surface by single electrode installation.
- The bidder shall install earthing material required for the system and individual equipment earthing. All work such as cutting, bending, supporting, soldering, coating, drilling, brazing, clamping, bolting and connecting into structures, pipes, equipment frames terminals, rails or other devices shall be in the bidder's scope of work. The bidder shall also carryout the excavation and trenching work involved. The bidder shall also back-fill and reinstates the trenches after installation of earthing conductors.
- Metallic frames of all electrical equipments shall be earthed by two separate and distinct connections with earthing system.
- Neutral connection shall never be used for the equipments earthing.
- A separate earth electrode pit shall be provided adjacent to structures supporting lightning arrester. Earth connections shall be as short and as straight as practicable.
- On completion of the installation, continuity of all conductors and joint shall be tested. In case of contract for complete earthing, the supplier/licensed electrical contractor shall quote his rates for erection of complete earth mat with earth electrodes separately

1. Conventional lighting protection rod:

- Air terminal shall be made up of Copper tube thoroughly protected against corrosion by a zinc coating. The size of the air terminal shall be 20 mm x 3mm. Air termination networks may consist of vertical or horizontal conductors, or combinations of both. For the purpose of lightning protection, the vertical and horizontal conductors are considered equivalent and the use of pointed air terminations, or vertical finial is, therefore, not regarded as essential. A vertical air termination, where provided, need not have more than one point, and shall project at least 30 cm, above the object, salient point or network on which it is fixed. For a flat roof, horizontal air termination along the outer perimeter of the roof shall be used. For a roof of larger area a network of parallel horizontal conductors shall be installed. No part of the roof should be more than 9 m from the nearest horizontal protective conductor horizontal air terminations should be carried along the contours such as ridges, parapets and edges of flat roofs, and, where necessary, over flat surfaces, in such a way as to join each air termination to the rest, and should themselves form a closed network. All metallic projections including reinforcement, on or above the main surface of the roof which are connected to the general mass of the earth, should be bonded and form a part of the air termination network. If portions of a structure vary considerably in height, any necessary air

terminations or air termination network for the lower portions should be bonded to the down conductors of the taller portions, in addition to their own down conductors.

- Protective earthing conductor may be site fabricated or factory fabricated made up of Copper of required dimensions as mentioned in the tender document. The earth conductor shall be rust free and shall be painted with silver paint to prevent rusting in due course of time. Bare copper conductors shall not be used as a protective conductor wherever required, a copper cable with insulation shall be used and as specified. The protective earth conductor shall be neatly fabricated with smooth surface.

A.11 Battery charger cum DCDB

A.11.1 Scope

The scope of work shall include:

1. Supplying, installation testing and commissioning of battery charger cum DCDB for HT panels.
2. Handling, loading unloading and storage.
3. Associated wiring and internal cabling works.

A.11.2 Definitions

The definitions shall be as per relevant IEC/IEEE standards.

A.11.3 Codes & Standards

The contractor is required to follow all relevant IS and IEC codes as per latest amendments, following codes shall be followed in particular:

1. IEC- 60335-2-29 - Particular requirement for battery charger.
2. NEC- 2008 - National electrical code.
3. NBC-2016 - National building code.
4. IER-1956 : Indian electricity rules.
5. IEA-2007: Indian electricity act 2007.
6. Any other local bye-law or supply company norm as applicable.

A.11.4 Service conditions

System particulars

- a. Nominal system voltage - 110V bipolar DC

- b. Rated system voltage - 1.8kV
- c. Frequency - 50Hz \pm 3%
- d. No. of phases – 2pole + earth
- e. System neutral - Solidly earthed

Tropical conditions

- a. Ambient temperature : 50 degree celsius
- b. Relative humidity (avg.) : 60
- c. Isokeraunic level : 33
- d. Seismic Zone : Zone-4
- e. Climate type : hot and humid

The climatic conditions are prone to wide variations in ambient conditions and hence the equipment shall be of suitable design to work satisfactorily under these conditions.

Tolerances and creepage distance

Tolerances (on all the dimensions) and creepage distances shall be in accordance with provisions made in the relevant Indian/IEC/BIS standards and in these specifications. Otherwise the same will be governed by good engineering practice in conformity with required quality of the product.

A.11.5 Specifications

- The Sealed Maintenance Free Batteries or Lead Batteries are placed outside the Charger. The Batteries are supplied in Modular Form, suitable for Floor standing.
- The Battery Charger & DC Distribution Board shall be a composite unit.
- The Battery Charger shall be Float cum Boost type, Thyristor controlled .The charger shall have selector switch for Auto Float - Boost / Manual Float / Manual Boost Mode of Operation. During Auto Float – Boost Mode, Automatic Changeover shall takes place from Float Mode to Boost Mode and vice – versa. This mean that when the Batteries are fully charged the charging shall automatically change from Boost charge to Trickle charge.
- The Float cum Boost Charger and DC Distribution Board shall be housed in Sheet Steel Cubicle Sheet Steel Panels of 1.6 mm thickness. Louvers shall be provided in the cabinet for the ventilation. The Cubicle shall be painted in Siemens Grey shade. Channels shall be provided at the base.
- The D.C Output voltage of Float / Boost Charger shall be stabilized within +/- 2% for A.C. Input variation of 230V +/- 10%, Frequency variation of 50 Hz +/- 50% and D.C load variation of 0-100%. The voltage & regulation shall be achieved by a constant voltage regulator having fast response SCR Controlled. The ripple content in output will be within 3% of D.C. Output

Nominal Voltage.

- There shall be provision to select Auto Float / Manual Float / Manual Boost Modes. During Auto Float mode the Battery charging shall automatically changeover from Boost Mode to Float Mode and vice – versa. During Manual Float / Boost modes it shall be possible to set the Output Volts by separate potentiometers.
- The Battery Charger shall have automatic output current limiting feature.
- Battery charger shall constitute of following :
 - a. 1 No. Double Pole ON / OFF MCB at A.C. Input.
 - b. 1 No. Pilot lamp to indicate Charger Mains ON.
 - c. 1 No. MAIN TRANSFORMER: Double wound, naturally air-cooled, having copper winding.
 - d. 1 Set single phase full wave bridge rectifier consisting of 2 nos. Diodes and 2 nos. SCRs, liberally rated, mounted on heat sinks and complete with resistor / condenser network for surge suppression.
 - e. 1 No. Rotary Switch to selected AUTO FLOAT / MANUAL FLOAT / MANUAL BOOST. During Auto Float Mode Automatic Changeover shall take place from Float Mode to Boost Mode and vice-versa.
 - f. 1 Set solid state constant potential controller to stabilize the DC output voltage of the Float cum Boost Charger at $\pm 2\%$ of the set value for AC Input Voltage variation of 230V $\pm 10\%$, Frequency variation of $\pm 5\%$ from 50 Hz and simultaneous load variation of 0-100% .
 - g. 1 No. Electronic controller to Automatically Changeover Battery charging from Boost to Float and vice – versa.
 - h. 1 No. DC Ammeter and Toggle switch to read charger output current and Battery Charge / Discharge Current.
 - i. 1 No. Moving coil DC Voltmeter with selector switch to read the Charger Output / Load Volts.
 - j. 2 Set Potentiometer to adjust the output voltage during Manual / Auto Float and Boost Modes.
 - k. 1 No. Double Pole ON / OFF M.C.B at Charger Output.
 - l. 1 set Dropper Diode to Automatically maintain Load Voltage constant within 110-125V (Relays) with electronic controller.
 - m. 1 set D.C. Overvoltage Trip circuit with Indication.
 - n. 1 no. Series Diode to prevent reverse current flow Battery to Charger.
- The Battery Charger shall have following alarm and annunciation feature.
 - a. A.C Mains Fail.
 - b. DC Output/ Battery Under Volt.
 - c. Charger Fail.
 - e. Battery on Boost Charge.
 - f. D.C. Output Over volt.
 - g. Battery on Boost Charge.
- DCDB shall be as per SLD
- The Battery Charger shall have following ratings :
 - a.AC INPUT - 230V $\pm 10\%$ AC 50 Hz Single Phase.
 - b.DC OUTPUT - To Float / Boost Charge 110V – 100AH Batteries and also supply a continuous Load.

- c. CURRENT RATING - As per schedule : Battery – 10.0A
- d. FLOAT MODE - Nominal 122.5V (Adj between 110.0V- 125.0V)
- e. BOOST MODE - Nominal 126.5V (Adj between 110.0 V - 135.0V)
- f. VOLTAGE REGULATION: +/- 2% of the set value.
- g. RIPPLE - Less than 3%.

A.11.6 Installation, Testing & Commissioning

- Installation of Inverter shall be carried out as per manufacturer's instructions and installation shall be verified by the manufacturer before energizing.
- Type testing shall be conducted from accredited Lab. Copies of the test certificates for same rating shall be submitted at the time of vendor approval. These shall not be more than **5 years old from the date of approval of drawing.**
- Testing at manufacturers' works shall be conducted before dispatch as per routine verification requirements.
- Physical check including checking damage/crack in any components, etc shall be done at site.
- Following test shall be performed, as a minimum, at site prior to handing over, to confirm the functional and the performance specification of the inverter as specified. All required test equipment like Digital Oscilloscope, Voltage Regulator and Measurement Meters etc. shall be the responsibility of the concerning vendor without any additional cost.
- Full load testing of battery charger with both float and boost charge testing shall be done at site as per the approved QAP. All testing expenses shall be under the scope of vendor.