BIDDING DOCUMENT
FOR

"Supply, dismantling, construction, erection and commissioning of 2 Nos 220 kV Bays at 400/220 kV Misa S/s (POWERGRID) and associated works etc.".

FUND: "AIIB State Share"

(E-Tender)

VOLUME -2

https://assamtenders.gov.in

BID IDENTIFICATION NO:
AEGCL/MD/AIIB/PKG-E/Main/2021-22/Part 2/BID

ASSAM ELECTRICITY GRID CORPORATION LIMITED

VOLUME-2 TECHNICAL SPECIFICATION

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Section-1
SCOPE AND GENERAL TECHNICAL CONDITIONS

1.1.0 INTENT OF THE SPECIFICATION

1.1.1 This volume of the specification deals with the general technical information & criteria for design, manufacture, supply & delivery of equipment/material at site, erection, testing & commissioning and setting to work of construction/renovation of new/existing 220 kV Bays (2nos.), dismantling of existing equipment/structure and storing at required on "Design, Supply and Install" basis as defined in Volume-1.

1.1.2 The provisions of this section shall supplement all the detailed Technical Specifications and requirements brought out herein. The CONTRACTOR's proposal shall be based on the use of materials complying fully with the requirements specified herein.

1.2.0 SCOPE

1.2.1 The work involves design, engineering, manufacture, assembly, inspection, testing at manufacturer's works before dispatch, packing, supply, including insurance during transit, delivery at site subsequent storage and erection & commissioning at site of various equipment and materials including substation steel structures and civil foundations for equipment, dismantling and shifting of material to PGCIL specified store etc. as specified in subsequent Clauses and Sections and all necessary works required for completion of the job.

1.2.2 It is not the intent to specify completely herein all details of design and construction of the equipment and accessories. However, the equipment and accessories shall conform in all respects to high standards of engineering, design and workmanship and be capable of performing in continuous operation up to the bidder's guarantees in a manner acceptable to the Purchaser. The Purchaser will interpret the meaning of drawings and specifications and shall be entitled to reject any work or material, which in his judgement is not in full accordance therewith.

1.2.3 The major items of works included in the scope of this specification are listed below: -

i) Design & supply of all substation switchgears, control gears and protection equipment as per this bidding document.
ii) Erection, testing and commissioning of all switch & control gears such as circuit breakers, isolators, current transformers, relay & control panels, Lightning Arresters etc. as specified in Bill of Materials.
iii) Supply and erection of substation/ equipment mounting steel structure.
iv) Construction of Kiosk, cable trenches and earth mat including supply of all materials.
v) Other works includes site development, construction/modification of existing foundation, dismantling of existing equipment and structure and construction of new structure foundations, Design and installation of illumination system for switchyard (for the 220 kV bay under construction vide this BID) etc. as brought out in the Specification and Schedule of Requirements.
vi) Integration of all switch & control gears of the bay including control and relay panel along with the ABT metering module into the existing Substation Automation System at Misa S/s (POWERGRID).

1.2.4 The various items of supply are described very briefly in the schedule of Bid Form, Prices & Other Schedules and annexure. The various items as defined in these schedules shall be read in conjunction with the corresponding section in the technical specifications including amendments and, additions if any.

1.2.5 The tentative Bill of Quantities is furnished in Section 2: BIDDING FORMS of Vol-1 of this Bidding Document.

1.3.0 CONTRACTOR TO INFORM HIMSELF FULLY

1.3.1 The Contractor should ensure that he has examined the General Conditions, qualifying criteria, Specifications and Schedules as brought out in Volume-I and this Volume and has satisfied himself as to all the conditions and circumstances affecting the contract price and fixed his price according to his own views on these matters and acknowledge that no additional allowances except as otherwise provided therein will be levied.

1.3.2 The Purchaser shall not be responsible for any misunderstanding or incorrect information obtained by the CONTRACTOR other than information given to the CONTRACTOR in writing by the Purchaser

1.4.0 SERVICE CONDITIONS

1.4.1 The plant and materials supplied shall be suitable for operation under the following climatic and other conditions:

a)	Peak ambient day temperature in still air		50^0C
b)	Minimum night temperatures		15^0C
c)	Reference ambient day temperature		50^0C
d)	Relative Humidity	(a)Maximum	100 %
		(b)Minimum	10 %
e)	Altitude		Below 1000 M above MSL
f)	Maximum wind pressure:		As per IS: 802 latest code
g)	Other Data		Refer Meteorological data pertaining to the locations
h)	Seismic Intensity		ZONE-V as per IS 1893.

1.5.0 CONFORMITY WITH INDIAN ELECTRICITY RULES & OTHER LOCAL REGULATIONS:

1.5.1 The CONTRACTOR shall note that all substation works shall comply with the latest provisions of Indian Electricity Rules and with any other regulations. Local authorities concerned in the administration of the rules and regulation relating to such works shall be consulted, if necessary, in regard to the rules and regulations that may be applicable.

1.6.0 STANDARDS

1.6.1 The equipment covered by this specification shall, unless otherwise stated be designed, constructed and tested in accordance with the latest revisions of relevant Indian Standards and shall conform to the regulations of local statutory authorities.

1.6.2 In case of any conflict between the standards and this specification, this specification shall govern.

1.6.3 Equipment conforming to other international or authoritative Standards which ensure equivalent or better performance than that specified under Clause 1.6.1 above shall also be accepted. In that case relevant extracts of the same shall be forwarded with the bid.

1.7.0 CONTRACTOR'S REQUIREMENT

1.7.1 The Contractor should be in possession of a valid E.H.V. Electrical Licence issued by the Chief Electrical Inspector, Govt. of Assam, as per the provision of Law. An attested copy of the aforementioned Licence must be handed over to the Employer for his record prior to handing/ taking over of sites.

1.7.2 All the works shall also be inspected by the Chief Electrical Inspector, Govt. of Assam or his authorised representatives. It is the responsibility of the Contractor to obtain pre-requisite commissioning clearance of any equipment from the said Inspectorate. The Contractor will pay necessary fees to the Inspectorate, which it may levy.

1.8.0 ENGINEERING DATA

1.8.1 The furnishing of engineering data by the CONTRACTOR shall be in. accordance with the Bidding Document. The review of these data by the Purchaser will cover only general conformance of the data to the specifications and not a thorough review of all dimensions, quantities and details of the materials, or items indicated or the accuracy of the information submitted. This review by the Purchaser shall not be considered by the CONTRACTOR, as limiting any of his responsibilities and liabilities for mistakes and deviations from the requirements, specified under these specifications.

1.8.2 All engineering data submitted by the CONTRACTOR after review by the Purchaser shall or part of the contract document.

1.9.0 DRAWINGS AND DOCUMENTS FOR APPROVAL

1.9.1 In addition to those stipulated in clause regarding drawings in GENERAL CONDITIONS OF CONTRACT (Vol-1), the following sub clauses shall also apply in respect of Contract Drawings.

1.9.2 All drawings submitted by the CONTRACTOR including those submitted at the time of Bid shall be with sufficient detail to indicate the type, size, arrangement, dimensions, material description, Bill of Materials, weight of each component break-up for packing and shipment, fixing arrangement required, the dimensions required for installation and any other information specifically requested in these specifications.

1.9.3 Each drawing submitted by the CONTRACTOR shall be clearly marked with the name of the Purchaser, the specification title, the specification number and the name of the Project. All titles, noting, markings and writings on the drawing shall be in English. All the dimensions should be to the scale and in S.I. units.

1.9.4 The drawings submitted for approval to the Purchaser shall be in quadruplicate. One print of such drawings shall be returned to the CONTRACTOR by the Purchaser marked "approved/approved with corrections", if found generally in accordance with the specifications.

1.9.5 Initial submitted drawings may be in soft copies forwarded through emails. However, in this case drawings must be in Auto-CAD.

The CONTRACTOR shall there upon furnish the Purchaser additional prints as may be required along with one reproducible in original of the drawings after incorporating all corrections.

The Contractor shall perform the work strictly in accordance with these drawings and no deviation shall be permitted without the written approval of the Employer, if so required.

1.9.6 All manufacturing, fabrication and erection work under the scope of Contractor prior to the

approval of the drawings shall be at the Contractor's risk. The contractor may make any changes in the design which are necessary to conform to the provisions and intent of the contractor and such changes will again be subject to approval by the Employer.

1.9.7 The approval of the documents and drawings by the Employer shall mean that the Employer is satisfied that:

a) The Contractor has completed the part of the Works covered by the subject document (i.e., confirmation of progress of work).
b) The Works appear to comply with requirements of Specifications.

In no case the approval by the Employer of any document does imply compliance with neither all technical requirements nor the absence of errors in such documents. If errors are discovered any time during the validity of the contract, then the Contractor shall be responsible of their consequences.

1.9.8 All drawings shall be prepared using AutoCAD software version 2000 or later only. Drawings, which are not compatible to AutoCAD software version 2000 or later, shall not be acceptable. After final approval all the drawings shall be submitted to the Employer in readable CD's.

1.9.9 Selected drawing are subjected to approval by PGCIL.

1.9.10 All Designs / Drawings / Calculations/ Data submitted by the contractor, from time to time shall become the property of the Employer and Employer has the right to use or replicate such designs for future contracts / works without the permission of the Contractor. The Employer has all rights to use/ offer above designs/drawings/data sheets to any other authority without prior Permission of the Contractor.

1.10.0 FINAL DRAWINGS AND DOCUMENTS

1.10.1 The successful Contractor shall require to provide following drawings and documents for each substation in printed form and as well as in soft copies. All soft copies of drawings must be in 'AutoCAD' file format.

(a) All approved drawings (AS BUILD) of equipment and works related to a particular substation in three (3) copies.
(b) Instruction manuals of all equipment related to a particular substation in three (3) copies. These instruction manuals shall generally consist of
  (i) Operation Manuals,
  (ii) Maintenance Manuals and
  (iii) Spare Parts Bulletins.
(c) Copies of routine test reports (in triplicate) of relevant equipment.
(d) Final Guaranteed and Other technical particulars of relevant equipment (in triplicate).

1.10.2 In addition to the above, the Contractor shall provide five (5) sets of all the printed drawings and documents including the soft copies to Employer for his reference and record.

1.11.0 APPLICATION AND SYSTEM SOFTWARE

1.11.1 Contractor shall provide copies of licensed copies application software / configuration & system software in the form of CD (in duplicate) for all IEDs, meters, SAS etc.

1.12.0 DESIGN IMPROVEMENTS

1.12.1 The Employer or the Contractor may propose changes in the specification and if the parties

agree upon any such changes and the cost implication, the specification shall be modified accordingly.

1.13.0 DESIGN CO-ORDINATION

1.13.1 Wherever, the design is in the scope of Contractor, the Contractor shall be responsible for the selection and design of appropriate material/item to provide the best coordinated performance of the entire system. The basic design requirements are detailed out in this Specification. The design of various components, sub-assemblies and assemblies shall be so done that it facilitates easy field assembly and maintenance.

1.14.0 DESIGN REVIEW MEETING

1.14.1 The contractor will be called upon to attend design review meetings with the Employer, and the consultants of the Employer during the period of Contract. The contractor shall attend such meetings at his own cost at Assam or at mutually agreed venue as and when required. Such review meeting will be held generally minimum once a month or the frequency of these meeting shall be mutually agreed between the Employer and the Contractor. Frequency of Design Review Meetings shall depend upon the project requirement to ensure project implementation as per the Master Programme.

1.15.0 QUALITY ASSURANCE, INSPECTION & TESTING

1.15.1 Quality Assurance

To ensure that the supply and services under the scope of this Contract whether manufactured or performed within the Contractor's works or at his Sub Contractor's premises or at site or at any other place of work are in, accordance with the specifications, the Contractor shall adopt suitable quality assurance programme to control such activities at all points necessary. Such programme shall be outlined by the Contractor and shall be finally accepted by the Employer after discussions before the award of Contract. A quality assurance programme of the Contractor shall generally cover but not limited to the following:

a) His organization structure for the management and implementation of the proposed quality assurance programme
b) Documentation control System.
c) Qualification data for Contractors key personnel.
d) The procedure for purchases of materials, parts components and selection of sub-contractors services including vendor analysis, source inspection, incoming raw material inspection, verification of material purchases etc.
e) System for shop manufacturing including process controls and fabrication and assembly controls.
f) Control of non-conforming items and system for corrective action.
g) Control of calibration and testing of measuring and testing equipment.
h) Inspection and test procedure for manufacture.
i) System for indication and appraisal of inspection status.
j) System for quality audits.
k) System for authorizing release of manufactured product to the Employer.
l) System for maintenance of records.
m) System for handling storage and delivery and
n) A quality plan detailing out the specific quality control procedure adopted for controlling the quality characteristics relevant to each item of supply.

The Quality plan shall be mutually discussed and approved by the Employer after incorporating necessary corrections by the Contractor as may be required.

1.15.2 Quality Assurance Documents

The Contractor shall be required to submit all the Quality Assurance Documents as stipulated in the Quality Plan at the time of Employers inspection of equipment/material.

The Employer or his duly authorized representatives reserves the right to carry out Quality Audit and quality surveillance of the systems and procedures of the Contractors/his vendors Quality Management and Control Activities.

1.16.0 EMPLOYER'S SUPERVISION

1.16.1 To eliminate delays and avoid disputes and litigation it is agreed between the parties to the Contract that all matters and questions shall be resolved in accordance with the provisions of this document.

1.16.2 The manufacturing of the product shall be carried out in accordance with the specifications. The scope of the duties of the Employer, pursuant to the contract, will include but not be limited to the following.

(a) Interpretation of all the terms and conditions of these Documents and Specifications.
(b) Review and interpretation of all the Contractors drawings, engineering data etc.
(c) Witness or authorize his representative to witness tests at the manufacturer's works or at site, or at any place where work is performed under the contract.
(d) Inspect, accept or reject any equipment, material and work under the Contract, in accordance with the Specifications.
(e) Issue certificate of acceptance and/or progressive payment and final payment certificate.
(f) Review and suggest modification and improvement in completion schedules from time to time, and
(g) Supervise the Quality Assurance Programme implementation at all stages of the works.

1.17.0 INSPECTION & INSPECTION CERTIFICATE

1.17.1 The Purchaser, his duly authorized representative and/or outside inspection agency acting on behalf of the Purchaser shall have, at all reasonable times, access to the premises and works of the CONTRACTOR and their sub-CONTRACTOR(s)/sub-vendors and shall have the right, at the reasonable times, to inspect and examine the materials and workmanship of the product during its manufacture.

1.17.2 All routine and acceptance tests whether at the premises or works of, the CONTRACTOR or of any Sub-CONTRACTOR, the CONTRACTOR except where otherwise specified shall carry out such tests free of charge. Items such as labour, materials, electricity, fuel, water, stores apparatus and instruments as may be reasonably demanded by the Purchaser/inspector or his authorized representative to carry out effectively such tests in accordance with the Contract shall be provided by the CONTRACTOR free of charge.

1.17.3 If desired by the Purchaser, the CONTRACTOR shall also carry out type tests as per applicable Standards for which Purchaser shall bear the expenses except in cases where such tests have to be carried out in pursuance to ***Clause 1.18.3***. The CONTRACTOR is required to quote unit rates of type test charges in a separate Schedule (if such schedule is provided in the Bidding Document) in pursuance to this Clause. However, these type test charges shall not be taken into account in comparing Price Bid.

1.17.4 The inspection by Purchaser and issue of Inspection Certificate thereon shall in no way limit the liabilities and responsibilities of the CONTRACTOR in respect of the agreed Quality Assurance

Programme forming a part of the Contract.

1.17.5 The inspection by Employer and issue of Inspection Certificate thereon shall in no way limit the liabilities and responsibilities of the Contractor in respect of the agreed Quality Assurance Programme forming a part of the Contract.

1.18.0 Tests

The type, acceptance and routine tests and tests during manufacture to be carried-out on the material and equipment shall mean as follows:

i) Type Tests shall mean those tests, which are to be carried out to prove the process of manufacture and general conformity of the material to this Specification. These tests shall be carried out on samples prior to Commencement of commercial production against the order. The Bidder shall indicate his schedule for carrying out these tests.

ii) Acceptance Tests shall mean those tests, which are to be carried out on samples taken from each lot offered for pre-dispatch inspection, for the purposes of acceptance of that lot.

iii) Routine Tests shall mean those tests, which are to be carried out on the material to check requirements, which are likely to vary during production.

iv) Tests during Manufacture shall mean those tests, which are to be carried out during the process of manufacture and end inspection by the CONTRACTOR to ensure the desired quality of the end product to be supplied by him.

v) The norms and procedure of sampling for these tests will be as per the Quality Assurance Programme to be mutually agreed to by the CONTRACTOR and the Purchaser.

1.18.1 The standards and norms to which these tests will be carried out are specified in subsequent Sections of this Specification. Where a particular test is a specific requirement of this Specification, the norms and procedure of the test shall be as specified or as mutually agreed to between the CONTRACTOR and the Purchaser in the Quality Assurance Programme.

1.18.2 For all type and acceptance tests, the acceptance values shall be the values specified in this Specification or guaranteed by the Bidder or applicable Standards, as applicable.

1.19.0 GUARANTEED TECHNICAL PARTICULARS

1.19.1 The Guaranteed Technical Particulars of the various items shall be furnished by the Bidders in the prescribed schedules of this Specification with the Technical Bid. The Bidder shall also furnish any other information's as in their opinion is needed to give full description and details to judge the item(s) offered by them.

1.19.2 The data furnished in Guaranteed Technical Particulars should be the minimum or maximum value (as per the requirement of the specification) required. A Bidder may guarantee a value more stringent than the specification requirement. However, for testing purpose or from performance point of view, the material shall be considered performed successfully if it achieves the minimum/maximum value required as per the technical specification. No preference what *so* ever shall be given to the bidder offering better/more stringent values than those required as per specification except where stated otherwise.

1.20.0 PACKING

1.20.1 All the materials shall be suitably protected, coated, covered or boxed and crated to prevent

damage or deterioration during transit, handling and storage at Site till the time of erection. The CONTRACTOR shall be responsible for any loss or damage during transportation, handling and storage due to improper packing.

1.20.2 The CONTRACTOR shall include and provide for securely protecting and packing the materials so as to avoid loss or damage during transport by air, sea, rail and road.

1.20.3 All packing shall allow for easy removal and checking at site. Wherever necessary, proper arrangement for attaching slings for lifting shall be provided. All packages shall be clearly marked for with signs showing 'up' and 'down' on the sides of boxes, and handling and unpacking instructions as considered necessary. Special precaution shall be taken to prevent rusting of steel and iron parts during transit by sea.

1.20.4 The cases containing easily damageable material shall be very carefully packed and marked with appropriate caution symbols, i.e., fragile, handle with care, use no hook etc. wherever applicable.

1.20.5 Each package shall be legibly marked by the-CONTRACTOR at his expenses showing the details such as description and quantity of contents, the name of the consignee and address, the gross and net weights of the package, the name of the CONTRACTOR etc.

1.21.0 CONSTRUCTION TOOLS, EQUIPMENTS ETC.

1.21.1 The Contractor shall provide all the construction equipment, tools, tackle and scaffoldings required for construction, erection, testing and commissioning of the works covered under the Contract including construction power water supply etc. He shall submit a list of all such materials to the Employer before the commencement of work at site. These tools and tackle shall not be removed from the site without the written permission of the Employer.

1.22.0 MATERIALS HANDLING AND STORAGE

1.22.1 All the supplies under the Contract as well as Employer supplied items (if any) arriving at site shall be promptly received, unloaded and transported and stored in the stores by the Contractor.

1.22.2 Contractor shall be responsible for examining all the shipment and notify the Employer immediately of any damage, shortage, discrepancy etc. for the purpose of Employer's information only. The Contractor shall submit to the Employer every week a report detailing all the receipts during the week. However, the Contractor shall be solely responsible for any shortages or damages in transit, handling and/or in storage and erection at site. Any demurrage, and other such charges claimed by the transporters, railways etc., shall be to the account of the Contractor.

1.22.3 The Contractor shall maintain an accurate and exhaustive record-detailing out the list of all items received by him for the purpose of erection and keep such record open for the inspection of the Employer.

1.22.4 All items shall be handled very carefully to prevent any damage or loss. The materials stored shall be properly protected to prevent damage. The materials from the store shall be moved to the actual location at the appropriate time to avoid damage of such materials at Site.

1.22.5 All the materials stored in the open or dusty location must be covered with suitable weatherproof and flameproof covering material wherever applicable.

1.22.6 The Contractor shall be responsible for making suitable indoor storage facilities, to store all

items/materials, which require indoor storage.

1.22.7 The Contractor shall have total responsibility for all equipment and materials in his custody stored, loose, semi-assembled and/or erected by him at site. The contractor shall make suitable security arrangements including employment of security personnel to ensure the protection of all materials, equipment and works from theft, fire, pilferage and any other damages and loss.

1.22.8 The Employer will verify the storage facilities arranged by the contractor and dispatch clearance will be provided only after Employer is satisfied.

1.23.0 CONTRACTOR'S MATERIALS BROUGHT ON TO SITE

1.23.1 The Contractor shall bring to Site all equipment, components, parts, materials, including construction equipment, tools and tackles for the purpose of the work under intimation to the Engineer. All such goods shall, from the time of their being brought vest in the Employer, but may be used for the purpose of the Works only and shall not on any account be removed or taken away by the Contractor without the written permission of the Engineer. The Contractor shall nevertheless be solely liable and responsible for any loss or destruction thereof and damage thereto.

1.23.2 The Employers shall have a lien on such goods for any sum or sums, which may at any time, be due or owing to him by the Contractor, under in respect of or by reasons of the Contract. After giving a fifteen (15) days' notice in writing of his intention to do so, the Employer shall be at liberty to sell and dispose of any such goods, in such manner, as he shall think fit including public auction or private treaty.

1.23.3 After the completion of the Works, the Contractor shall remove from the Site under the direction of the Engineer the materials such as construction equipment, erection tools and tackles, scaffolding etc. with the written permission of the Engineer. If the Contractor fails to remove such materials within fifteen (15) days of issue of a notice by the Engineer, the Engineer shall have the liberty to dispose of such materials as detailed under clause 1.24.2 above and credit the proceeds thereto to the account of the Contractor.

1.24.0 COMMISSIONING SPARES

1.24.1 It will be the responsibility of the Contractor to provide all commissioning spares required for initial operation till the Employer declares the equipment as ready for commissioning. All commissioning spares shall be deemed to be included in the scope of the Contract at no extra cost to the Employer.

1.24.2 These spares shall be received and stored by the Contractor at least 3 months prior to the schedule date of commencement of commissioning of the respective equipment and utilized as and when required. The unutilized spares and replaced parts, if any, at the end of successful completion of performance and guarantee test shall be the property of the Contractor and he will be allowed to take these parts back at his own cost with the permission of Employer's Representative.

SECTION-2

TECHNICAL SPECIFICATION ACSR CONDUCTORS AND ACCESSORIES FOR CONDUCTORS

2.1.0 SCOPE

2.1.1 This Section of the Specification covers the technical parameters for design, manufacture, testing at manufacturer's works and supply of Conductor, and accessories for Power Conductors.

2.1.2 POWER CONDUCTOR

2.1.3 TYPE OF CONDUCTOR

The ACSR Conductor shall generally conform to IEC: 61089/ IS: 398 (relevant part)/ ASTM:B-232 / CEA guidelines for rationalized use of high performance conductors except where otherwise specified herein.

Conductor conforming to a standard other than the Indian Standard specification then an English version of the Standard in addition to the original standard if written in a language other than English should be submitted indicating clearly the advantage, if any, that would be obtained by the Employer for adopting this standard instead of the said India Standard.

2.1.4 STANDARD TECHNICAL PARTICULARS

All ACSR Conductor shall satisfy all the parameters as furnished in Technical Data Sheet.

All the aluminium and steel strands shall be smooth, uniform and free from all imperfections, such as spills and splits, die marks, scratches, abrasions, etc., after drawing and also after stranding.

The steel strands shall be hot dip galvanised and shall have a minimum zinc coating.

2.1.5 MATERIAL

The aluminum strands shall be hard drawn from electrolytic aluminum rods having purity and copper content as per the values indicated in the STP. They shall have the same properties and characteristics as prescribed in IEC: 60889.

The steel wire strands shall be drawn from high carbon steel wire rods produced by either the acid or the basic open-hearth process, the electric furnace process, or the basic oxygen process and shall conform to the chemical composition indicated in the STP.
The Steel wire strands shall have the same properties and characteristics as prescribed for regular strength steel wire in IEC : 60888.

The zinc used for galvanizing shall be electrolytic High Grade Zinc of purity. It shall conform to and satisfy all the requirements of IS:209.

2.1.6 JOINTS IN WIRE

In the Aluminium wires no joints shall be permitted in the individual wires in the outer most layer of the finished conductor. However, joints are permitted in the inner layer of the conductor unavoidably broken during stranding provided such breaks are not associated with either inherently defective wire or with the use of short lengths of aluminium wires. Such joints shall not be more than four (4) per conductor length and shall not be closer than 15 meters from joint in the same wire or in any other aluminium wire of the completed conductor.

Joints shall be made by cold pressure butt welding and shall withstand a stress of not less than the breaking strength of individual strand as per STP.

In the Steel wires there shall be no joint of any kind in the finished wire entering into the manufacture of the strand. There shall also be no strand joints or strand splices in any length of the completed stranded steel core of the conductor.

2.1.7 STRANDING

The wires used in construction of a ACSR conductor shall, before and after stranding, satisfy all requirements of IS 398 with latest amendments thereof.

The lay ratio of the different layers shall be within the limits as per the said Standard. In all constructions, the successive layers shall have opposite directions of lay, the outer most layer being right-handed. The wires in each layer shall be evenly and closely stranded. In aluminium alloy stranded conductors having multiple layers of wires, the lay ratio of any layer shall not be greater than the lay ratio of the layer immediately beneath it.

2.1.8 TYPE/ROUTINE/ACCEPTANCE TESTS

Type Test:
The following tests shall be conducted on a sample/samples of the conductor(s) required under the package from each stranding machine from which the conductor is to be manufactured & supplied:

a) DC resistance test on stranded conductor
b) UTS test on stranded conductor
c) Corona extinction voltage test (dry)
d) Radio interference voltage test (dry)

Acceptance Test:

a) Visual and dimensional check on drum
b) Visual check for joints, scratches etc. and length measurement of conductor by rewinding
c) Measurement of diameters of individual Steel and Aluminium strands
d) Galvanizing test on steel strands
e) Check for lay Ratios of various layers
f) Torsion and Elongation tests on steel strands
g) Breaking load test on steel and Aluminium strands
h) Wrap test on Steel & Aluminium strands
i) DC resistance test on Aluminium strands
j) Procedure qualification test on welded joint of Aluminium strands
k) Drum strength test (steel drum)
l) Barrel Batten strength test (wooden drum)

The above acceptance tests shall be repeated on one conductor sample taken from site in presence of AEGCL's representative for each 500km progressive supply. The tests shall be carried out by the supplier at his cost at its own premises or any other tests centre having required facilities. The sample shall be selected by AEGCL's site representative and the tests

shall be witnessed by AEGCL's representative.

Routine Tests:

a) Check to ensure that the joints are as per Specification
b) Check that there are no cuts, fins etc. on the strands
c) Check that drums are as per Specification
d) All acceptance test as mentioned above to be carried out on aluminium and steel strands of 20% of drums

Tests During manufacture:

a) Chemical Analysis of Zinc used for galvanising
b) Chemical Analysis of Aluminium used for making Aluminium Strands
c) Chemical Analysis of Steel used for making Steel Strands.

2.1.9 REJECTION AND RETESTS

Stipulations made in the IS 398 (Part-IV) on Rejection and Retests shall be followed.

2.1.10 PACKING

All conductor reels shall conform to latest edition of IS : 1778 and be of dimensions approved by the Employer and made of seasoned wood sufficiently strong to ensure arrival at site, intact withstanding normal handling and hazards inland and ocean transit. The reels shall be of such size as to provide at least 12.5 mm clearance at all points from the conductor to the inner surface of the laggings.

All reels shall have two coats of aluminium paint on both inside and outside surface and shall be fitted with malleable iron Hub-bushings.

All reels shall be a layer of waterproof paper around the hub under the cable and another layer over the outermost layer of the cable, that is next to the lagging.

The reels shall be properly reinforced with galvanized steel wires or iron straps over the lagging in two places in an approved manner.

The wooden drums shall preferably be given protective coating of a reliable organic wood preservative before painting with Aluminium paint and the laggings shall also be given a similar treatment before being fixed on the drum. There shall be one standard length of Conductor in each drum.

2.1.11 The details of the ACSR Moose, ACSR Zebra and ACSR Panther conductors are tabulated below:

ACSR MOOSE

Sl. No	DESCRIPTION	PARTICULARS
1	Type of Conductor	Aluminium Conductor Steel

Sl. No	DESCRIPTION	PARTICULARS
		Reinforced (ACSR)
2	No of Strand x size	54 x 3.53 mm
3	Conductor over all diameter	31.77 mm
4	Total sectional area	597 mm^2
5	Approx. weight	2004 kg/km
6	Minimum UTS	161.2 kN
7	Modulus of Elasticity (Final)	0.7034 kg/cm^2
8	Coefficient of linear expansion	19.3 x 10^{-6} /^{0}C
9	Calculated maximum resistance/Km of Conductor at 20°C	0.05552 ohms/km
10	Layer and No of Wire	
	Steel core	1
	1st steel layer	6
	1st Aluminium layer	12
	2nd Aluminium layer	18
	3rd Aluminium layer	24
11	Aluminum strands after stranding	
(a)	Diameter	
	Nominal	3.53
	Maximum	3.55
	Minimum	3.51
(b)	Minimum breaking load of strand	
	Before stranding	1.57
	After stranding	1.49
12	Steel strand after stranding	
(a)	Diameter	
	Nominal	3.53
	Maximum	3.59
	Minimum	3.47
(b)	Minimum breaking load of strand	
	Before stranding	12.86
	After stranding	12.22
13	DC resistance of the conductor at 20°C	0.05552
15	Linear mass of the conductor	
	Standard	2004
	Minimum	1969
	Maximum	2040

ACSR ZEBRA

Sl. No	DESCRIPTION	PARTICULARS
1.	Code Name	ZEBRA
2.	Equivalent area of Aluminium (sq.mm.)	418.6
3.	Wire Strand (Al./Steel)	54/7
4.	Nominal diameter of strand (Al./Steel)(mm.)	3.18/3.18
5.	Weight (Kg/Km)	1621

6.	Co-eff. of linear expansion per oC	19.30x10 -6
7.	Ultimate Tensile Strength (kgf.)	13316
8.	Maxm. DC resistance at 20oC (/Km) (Calculated from maxm. Value of resistivity and min. Cross-sectional area)	0.0680
9.	Zinc coating of steel :	
	No. of one minute dip	3
	Min. wt. of zinc.(gm.m2)	260
	Purity of zinc (%)	99.95
10.	Diameter of conductor (mm)	28.62
11.	Standard Length (meter)	1100

ACSR PANTHER

Sl. No.	DESCRIPTION	PARTICULARS
1	Code name	PANTHER
2	Number of strands & size	Al: 30/ 3.00 mm St: 7/ 3.00 mm
3	Overall diameter	21.00 mm
4	Breaking load	130.32 kN
5	Weight of conductor	974 kg / km
6	Co-efficient of linear expansion	$19.35x10^{-6}/^{0}C$
7	Number of strand	
	Steel centre	1
	1st Steel Layer	6
	1st Aluminium Layer	12
	2nd Aluminium Layer	18
	3rd Aluminium Layer	-
8	Sectional area of Aluminium	212.10 mm^2
9	Total sectional area	261.50 mm^2
10	Calculated d.c. resistance at 20^0 C	0.1400 ohm/km
11	Ultimate tensile strength	89.67

2.8.0 ELECTRICAL CLEARANCES

2.8.1 Following minimum electrical clearances (outdoor) shall be maintained in the switchyard:

Sl. No.	Clearance	220 KV	132 KV	33 KV
1	Phase to Phase	2400 mm	1300 mm	320 mm
2	Phase to Earth	2400 mm	1300 mm	320 mm
3	Sectional Clearance	5000 mm	4000 mm	2800 mm
4	Live part to ground	5500 mm	4600 mm	3700 mm
5	Base of insulator (supporting live part) to ground	2500 mm	2500 mm	2500 mm

SECTION 3

TECHNICAL SPECIFICATION FOR SURGE ARRESTORS

3.1.0 SCOPE

3.1.1 This Section covers the specifications for design, manufacture, testing at manufacturers works before dispatch, subsequent dispatch of 220kV, 10 kA, Station class heavy duty, gapless metal (zinc) oxide Surge Arrestors complete with fittings & accessories such as surge monitor, terminal connectors etc.. including mounting structures as applicable.

3.1.2 Loading at manufacturer's works, transportation and delivery at respective substation site including unloading at destination site.

3.1.3 Erection, Testing and Commissioning of Surge Arresters.

3.2.0 STANDARDS

3.2.0 The design, manufacture and performance of Surge Arrestors shall comply with IS: 3070 Part-3 unless otherwise specifically specified in this Specification

3.3.0 GENERAL REQUIREMENT

The Surge arresters shall conform to **IS 15086 part 4/IEC: 60099-4 (latest edition)** except to the extent modified in the specification and shall also be in accordance with requirements under Section-GTR.

The Surge Arrestors shall be designed for use in the geographic and meteorological conditions as given in Section-GTR and Section-Project.

3.3.1 DUTY REQUIREMENTS

The surge arresters shall be of Station High Duty (SH) / Station Medium Duty (SM) / Station Low Duty (SL) as per requirement and gapless type without any series or shuntgaps.

The surge arrestor shall draw negligible current at operating voltage and at the same time offer least resistance during the flow of surge current.

420 kV class Surge arresters shall be capable of discharging of severe re- energisation switching surges on a 400kV, 450km long line with Surge impedance of 300 ohms and capacitance of 11.986nF/km and over voltage factor of 2.3 p.u. Similarly, 800kV class Surge arresters shall be capable of discharging of severe re- energisation switching surges on a 765kV, 450km line with Surge impedance of 270 ohms and capacitance of 13nF/km.

420kV class arrester shall be capable of discharging energy equivalent to **Station High Duty (SH) class of IEC with thermal energy (Wth) of 12 kJ/kV for a 420kV system** followed immediately by 50 Hz energisation with a sequential voltage profile as specified below:

650 kVp for 3 peaks
575 kVp for 0.1 second
550 kVp for 1 second
475 kVp for 10 seconds

800kV class arrester shall be capable of discharging energy equivalent to **Station High Duty (SH) class of IEC with thermal energy (Wth) of 13 kJ/kV for an 800kV system** followed

immediately by 50 Hz energisation with a sequential voltage profile as specified below:

1000 kVp for 3 peaks

Outer insulator of surge arrester shall be porcelain/polymer conforming to requirements stipulated in Section-GTR. Terminal connectors shall conform to requirements stipulated under Section- GTR. The outer insulator housing shall be so coordinated that external flashover will not occur due to application of any impulse or switching surge voltage upto the maximum design value for arrester.

885 kVp for 1 second
866 kVp for 10 seconds

245/145 kV class arrester shall be capable for discharging energy equivalent **to Station Medium Duty (SM) class of IEC with thermal energy (Wth) of minimum 7 kJ/kV for 245/145 kV system** followed by procedure as perIEC.

The surge arresters shall be suitable for withstanding forces as defined in Section- GTR.
The reference current of the arresters shall be high enough to eliminate the influence of grading and stray capacitance on the measured reference voltage.

The surge arresters are being provided to protect the following equipment whose insulation levels are indicated in the table given below:-

Equipment to be protected	Lightning Impulse (kVp) for 800 kV system	Switching surge(kV) for 800 kV system	Lightning impulse(kVp) for 420 kV system	Switching surge(kV) for 420 kV system	Lightning impulse (kVp) for 245 kV system	Lightning Surge (kVp) for 145 kV system
Power transformer	± 1950	± 1550	±1300	±1050	±950	± 550
Reactor	± 1950	± 1550	± 1300	±1050	± 950	± 550
Instrument Transformer	± 2100	±1550	±1425	±1050	± 1050	±650
CB/Isolator Phase to ground	± 2100	± 1550	±1425	±1050	± 1050	± 650
CB/Isolator Across open contacts	± 2100 (-/+457)	± 1140 (-/+653)	±1425 (-/+240)	± 900 (-/+345)	±1050 (for CB) ± 1200 (for Isolator)	± 750 (for Isolator)

The duty cycle of CB installed in 800/420/245/145 kV System of the Employer shall be O-0.3 sec-CO-3 min-CO. The Surge Arrester shall be suitable for such circuit breaker duties in the system.

3.4.0 CONSTRUCTIONALFEATURES

The features and constructional details of surge arresters shall be in accordance with

requirement stipulated here under:

The non-linear blocks shall be of sintered metal oxide material. These shall be provided in such a way as to obtain robust construction, with excellent mechanical and electrical properties even after repeated operations.

The surge arrester offered shall be of Design A (for 336kV and above SA) and Design A/Design B for <336kVSA.

a. Design A type arresters must be fitted with pressure relief devices suitable for preventing violent failure of insulator housing and providing path for flow of rated fault currents in the event of arrester failure.

b. Design B arrester should be embedded, all the components free of bubbles and gaps thus preventing partial discharge and moisture ingress. This type of design must have ability to control the cracking or tearing open of housing due to arc action and thereby avoiding violent shattering**.**

Outer insulator of surge arrester shall be porcelain/polymer conforming to requirements stipulated in Section-GTR. Terminal connectors shall conform to requirements stipulated under Section- GTR. The outer insulator housing shall be so coordinated that external flashover will not occur due to application of any impulse or switching surge voltage upto the maximum design value for arrester.

Arresters shall not fail due to arrester insulator contamination.

Seals **(for design A arresters)** shall be provided in such a way that these are always effectively maintained even when discharging rated lightning current.

The end fittings shall be made of corrosion proof material and preferably be nonmagnetic.

The name plate shall conform to the requirements of IEC incorporating the year of manufacture. The following details shall be furnished for quality checks:

a. The heat treatment cycle details along with necessary quality checks used for individual blocks and insulation layer formed across each block.

b. Metalizing coating thickness for reduced resistance between adjacent discs.

The manufacturer will submit Data for rejection rate of ZnO blocks during manufacturing/operation for the past three years.

The sealing arrangement **(for design A arresters)** of the Surge Arrester stacks shall be done incorporating grooved flanges with the O-rings/elliptical cross-section gaskets of Neoprene or Butyl rubber.

Arresters shall be of hermetically sealed units, self-supporting construction, suitable for mounting on tubular support structures. However, 765 kV Surge Arrester shall be suitable for mounting on lattice type support structures.

For 624kVSurgearresters,number of stac shall be three(3).The FRP tube outer diameter shall be

300mm (min) and FRP tube thickness shall be 25mm(min).

3.5.0 FITTINGS & ACCESSORIES

Arresters shall be complete with insulating base having provision for bolting to flat surface of structure

Self-contained discharge counters, suitably enclosed for outdoor use and requiring no auxiliary or battery supply for operation shall be provided for each single pole unit along with necessary connection arrangement. Suitable leakage current meters should also be provided. The reading of milli ammeter and counters shall be visible through an inspection glass panel. The terminals shall be robust and of adequate size and shall be so located that incoming and outgoing connections are made with minimum possible bends. The surge counter shall be provided with a potential free contact rated for 220 Volt (DC) which shall close whenever a surge is recorded by the surge monitor. Necessary arrangement shall be provided for extending the contact information to Substation Automation System/RTU.

Surge monitor consisting of discharge counters and milli ammeters should be suitable to be mounted on support structure of the arrester and should be tested for IP66 degree of protection. The standard supporting structure for surge arrester should be provided with a mounting pad, for fixing the surge monitor. The surge monitor should be suitable for mounting on this standard insulating mounting pad. Also all nuts, bolts, washers etc. required for fixing the surge monitor shall be supplied by the Contractor. The arrangement for Surge Monitor enclosure fixing to the structure shall be at its rear/bottom. Connection between the Surge Arrester base and Surge Monitor shall be through a 2.0 m (minimum) long insulated copper rod/strip of at least 75 sq.mm cross sectional area or **PVC insulated flexible copper cable of at least 70 Sqmm.** The cable shall be terminated at rear/bottom side of the Surge Monitor. The gaskets of the surge monitors shall be of Neoprene, Butyl or equivalent material.

Grading/corona rings shall be provided on each complete arrester unit, as required. Suitable terminal connectors shall be supplied by the Contractor.

3.6.0 TESTS

In accordance with the requirements stipulated under Section-GTR, the surge arresters should have been type tested as per latest IEC/IS and shall be subjected to routine and acceptance tests in accordance with latest IEC/IS

Test reports for all type tests as per latest IS 15086 part4/IEC-60099-4 including following additional type tests shall also be submitted for the Employer's review:

a. Seismic withstand test as per Annexure-B of Section-GTR.
b. Corona Extinction Voltage test as per Annexure-A of Section-GTR.
c. **Cantilever test on complete arrester as per requirement of Annexure-I.**

(a) **Acceptance Tests:**

a. Measurement of power frequency reference voltage of the arrester units.
b. Lightning Impulse Residual voltage on arrester units as per IEC.
c. Internal Ionisation or partial Discharge test.

(b) **Special Acceptance Test:**

a. Thermal stability test on three sections as per IEC Clause9.2.2.

b. Aging test for Zinc oxide blocks is to be carried out on 3 samples for 72 hours at maximum continuous over voltage (MCOV) and at a temperature of 115°C. Acceptance norm being Ir (resistive current)/watt loss shall remain or decrease at the end of 72 hrs from the value taken after 1 hour of start of test.

c. Watt loss test.

(c) Routine Tests:

a. Sealing test: Water dip test at 1.5m depth from top of Surge Arrestor for 30 minutes shall be performed during assembly of Surge Arrester stacks (followed by other routine tests, i.e. P.D. Measurement, Reference Voltage, Residual Voltage & IR measurement).

b. Measurement of reference voltage.

c. Residual voltage test of arrester unit.

d. Internal Ionisation test or partial discharge test.

e. Verticality check on completely assembled Surge arresters as a sample test on each lot.

(d) Routine Tests on Surge Monitors:

a. The Surge monitors shall be connected in series with the test specimens during residual voltage and current impulse withstand tests to verify efficacy of the same. Additional routine/functional tests with one 100A and 10kA current impulse (8/20 micro sec.) shall also be performed on the Surge monitor.

b. Surge monitors shall be routinely tested for water dip test at 1.5m depth for 30 minutes. Nowater vapours shall be visible on the monitor glass.

(e) Routine Tests on insulators

All routine tests shall be conducted on the hollow column insulators as per IEC 62155. Polymer housing shall be tested in accordance to IEC-61462.

3.7.0 MANDATORYSPARES

Bidder shall include in his proposal mandatory spares as mentioned in the Bidding Documents.

3.8.0 TECHNICAL PARAMETERS

The technical parameters shall be as per enclosed Annexure-I.

3.9.0 PRE-COMMISSIONING TESTS

An indicative list of tests is given below:

a. Operation check of LA counters.
b. Insulation resistance measurement
c. Capacitance and Tan delta measurement of individual stacks.
d. Third harmonic resistive current measurement (to be conducted after energisation.)

Contractor shall perform any additional test based on specialties of the items as per the field Q.P./Instructions of the equipment manufacturer or Employer without any extra cost to the Employer. The Contractor shall arrange all

instruments required for conducting these tests along with calibration certificates at his own cost.

ANNEXURE-I

Technical Parameters for 765kV, 400kV, 220kV and 132kV Surge Arresters (withPolymer/Porcelain Housing)

Sl. No.	Description	Unit	800kV SA	420kV SA	245kV SA	145kV SA
1	Nominal System Operating voltage	kV, rms	765	400	220	132
2	Rated frequency	Hz	50	50	50	50
3	No. of Poles	No.	1	1	1	1
4	Design ambient temperature	°C	50	50	50	50
5	Rated arrestervoltage	kV	624	336	216	120
6	Continuous operating voltage at 50 deg.C	kV	490	267	168	102
7	Nominal discharge current		20 kA of 8/20 microsecond wave	20 kA of 8/20 microsecond wave	10 kA of 8/20 microsecond wave	10 kA of 8/20 microsecond wave
8	Discharge current at which insulation co-ordination willbe done		20 kA of 8/20 microsecond wave	20 kA of 8/20 microsecondwave	10 kA of 8/20 microsecond wave	10 kA of 8/20 microsecondwave
9	Rated thermalenergy rating Wth	kJ/kV of ratedarrester voltage	13kJ/kV	12kJ/kV	7kJ/kV	7kJ/kV
10	Repetitive charge transfer rating Qrs in coulombs	C	3.6C	2.4C	1.6C	1.6C
11	Max. switching surge residualvoltage	kVp	1180 (at 1kA) 1220 (at 2kA)	670 (at 2kA) 650 (at500A)	500 (at 1kA)	280 (at 1kA)
12	Max. residual voltage at					
i)	5kA	kVp	-	-	560	310
ii)	10 kA nominal discharge current	kVp	-	800	600	330
iii)	20 kA nominal discharge current	kVp	1480	850	-	-
iv)	Steep fronted wave residual voltage at 20 kA	kVp	**1650**	925	-	-
13	Arrester classification		Station High duty(SH)	Station High duty(SH)	Station Medium duty (SM)	Station Mediumduty (SM)
14	High current short duration test value(4/10 micro second wave)	kAp	100	100	100	100

15	Current for pressure relief test	kA rms	63	40 / 50 / 63 (As Applicable)	40 / 50 (As Applicable)	40
16	Low current long duration test value	As per IEC				
17	Insulation Level					
a)	Full wave impulse withstand voltage (1.2/50 microsec.)					
i)	ArresterHousing	kV peak	As per latest IEC:60099- 4/IS 15086 part 4	As per latest IEC:60099-4/IS 15086 part 4	As per latest IEC:60099-4/IS 15086 part 4	As per latest IEC:60099-4/IS 15086 part 4
b)	Switching impulse withstand voltage (250/2500 micro-second) dry/wet					
i)	ArresterHousing	kVpeak	As per latest IEC:60099- 4/IS 15086 part 4	As per latest IEC:60099-4/IS 15086 part 4	-NA-	-NA-
c)	One minute power frequency dry/wet withstand voltage					
i)	ArresterHousing	kV rms	-N/A-	-NA-	As per latest IEC:60099-4/IS 15086 part 4	As per latest IEC:60099-4/IS 15086 part 4
18	Max. radio interference voltage for frequency between 0.5 MHz and 2 MHz. in allpositions	microvolts	2500 at 508 kVrms	500 at 266 kVrms	500 at 156 kVrms	500 at 92 kVrms
19	Minimum Creepage distance (31mm/kV)	mm	As per Section-GTR	As per Section-GTR	As per Section-GTR	As per Section-GTR
20	Cantilever Strength (for 1 minute withstand test)	kg	500	350	150	150
21	Maximum deflection at abovecantilever load	mm	200	200	125	50
22	Seismic acceleration		As per IS:1893	As per IS:1893	**---**	**---**
23	Partial Discharge at 1.05 COV		≤ 10pC	≤ 10pC	≤ 10pC	≤ 10pC
24	System neutralearthing		EffectivelyEarthed	EffectivelyEarthed	EffectivelyEarthed	EffectivelyEarthed

Note: The above insulation levels are applicable for altitude up to 1000 meters above M.S.L. For higher altitudes, suitable correction factor as per relevant IEC shall be applied.

Technical parameters for 72.5kV, 36 kV and 11 kV Surge Arresters (with Porcelain /Polymer Housing)

Sl. No.	Description	Unit	72.5kV SA	36kV SA	12kV SA
1	Nominal System Operating voltage	kV, rms	66kV	33kV	11kV
2	Rated frequency	Hz	50	50	50
3	No. of Poles	No.	1	1	1
4	Design ambient temperature	°C	50	50	50
5	Rated arrester voltage	kV	60	30	9
6	Continuous operatingvoltage at 50 deg.C	kV rms	51	25	7.2
7	Nominal discharge current	kA	10 kA of 8/20 microsecond wave		
8	Discharge current atwhich insulation co- ordination will be done	kA	10 kA of 8/20 microsecond wave		
9	Rated thermal energyrating Wth	kJ/kV of rated arrestervoltage	7	4	4
10	Repetitive charge transferrating Qrs in coulombs	C	1.6	1	1
11	Max. switching surgeresidual voltage	kVp	136 (at 1kA)	72 (at 1kA)	22.4 (at 1kA)
12	Max. residual voltage at				
i)	5kA	kVp	160	85	26
ii)	10 kA nominal dischargecurrent	kVp	170	90	28
iii)	20 kA nominal discharge current	kVp	190	- -	--
iv)	Steep fronted wave residualvoltage at 10 kA	kVp	190	- -	--
13	Arrester designation		Station Mediumduty (SM)	Station Low duty(SL)	Station Low duty(SL)
14	High current short duration test value(4/10 micro second wave)	kArms	100	100	100
15	Current for pressure relieftest	kAp	40	25	25
16	Low current long duration test value		As per IEC		
17	Insulation Level				
a)	Full wave impulse withstand voltage (1.2/50 microsec.)				
b)	One minute power frequency dry/wet withstand voltage				
i)	Arrester Housing	**kV rms**	**As per latest**	**As per latest**	**As per latest**

			IEC:60099-4/IS 15086 part 4	**IEC:60099- 4/IS 15086 part 4**	**IEC:60099-4/IS 15086 part 4**
18	Minimum Creepage distance	mm	As per Section-GTR	As per Section-GTR	As per Section-GTR
19	Cantilever Strength(for 1 minute withstand test)	kg	150	150	150
20	Maximum deflection at above cantilever load	mm	20	20	20

Note: The above insulation levels are applicable for altitude up to 1000 meters above M.S.L. For higher altitudes, suitable correction factor as per relevant IEC shall be applied.

SECTION: 4

TECHNICAL SPECIFICATIONS OF EARTHING SYSTEM AND DSLP

4.1.0 General

(a) Earthing system shall installed as per drawings provided with this bidding document. The main earthing system for the switch yard shall consist of a mesh made out of Galvanised MS flats of size not less than 65 mm in width and12 mm thick covering the entire switchyard area and earth electrodes distributed all over the mesh. The earth electrodes shall also be placed all around the periphery of the mesh at regular intervals.

(b) The earth mat shall be created by laying the earthing conductor (Galvanised MS flats) in both directions perpendicularly. The mesh points so created and all other joints shall be welded and painted and painted with rust proof paint after welding.

(c) Minimum depth of burial of main earthing conductors shall be 600 mm from FGL.

(d) Wherever earthing conductor crosses cable trenches, underground service ducts, pipes, tunnels, railway tracks etc., it shall be laid minimum 300 mm below them and shall be circumvented in case it fouls with equipment/structure foundations.

(e) The earthing system must conform to requirements of the Indian Electricity Rules and the provisions of IS: 3043.

(f) All earth electrodes and risers for equipment and other earthing must be connected at mesh points of the earth mat. All such connections shall be welded.

(g) All metallic supporting structures and non-current carrying metallic parts of all equipment shall be provided with double earthing.

(h) All LAs, VTs, CVTs and all transformer neutrals must be earthed through separate earth electrodes and in turn these electrodes shall be connected to the main earth grid.

(i) One number 40mm dia, 3000 mm long MS earth electrode with test link, CI frame and cover shall be provided to connect each down conductor of surge arresters, capacitive &inductive voltage transformers, lightning masts and towers with peak.

(j) 50mm x 6mm MS flat shall run on the top tier and all along the cable trenches and the same shall be welded to each of the racks. Further this flat shall be earthed at both end sand at an interval of 30 mtrs. The M.S. flat shall be finally painted with two coats of Red oxide primer and two coats of Post Office red enamel paint.

(k) The earthing system in the Control Room must also be connected to the main station grid. For this purpose earthing conductor around the building shall be buried in earth at a minimum distance of 1500 mm from the outer boundary of the building which in turn shall be connected to the main earth grid by two runs of 65mm x 12mm GI flats.

(l) Each earthing lead from the neutral of the power transformers shall be directly connected to two pipe electrodes in treated earth pit (as per IS) which in turn, shall be buried in Cement Concrete pit with a cast iron cover hinged to a cast iron frame to have an access to the joints. All accessories associated with transformer like cooling banks, radiators etc. shall be connected to the earthing grid at minimum two points. These electrodes must also be connected to the Main Earth Mat of the substation.

4.1.1 Summary of Earthing System

Sl. No.	Item	Size	Materials
1	Main Earthing Conductor to be buried in ground	65mm x 12 mm	GI Flat

2	Conductor above ground & earthing leads (for equipment)	65mm x 12 mm	GI Flat
3	Conductor above ground & earthing leads (for columns & aux. structures)	65mm x 12 mm	GI Flat
4	Earthing of indoor LT panels, Control panels and outdoor marshalling boxes, MOM boxes, Junction boxes & Lighting Panels etc.	50mm x 6 mm	GI Flat
5	Rod Earth Electrode	40mm dia, 3000 mmlong	Mild Steel
6	Pipe Earth Electrode (in treated earth pit) as per IS 3043	40mm dia, 3000 mm long	Galvanised Steel

4.1.2 PROTECTION AGAINST DIRECT LIGHTNING

Protection against direct lightning shall be provided by stringing GI shield wires and/or by lightning masts (SPIKES) as per layout drawings attached.

Conductors of the lightning protection system shall not be connected with the conductors of the safety earthing system above ground level.

Down conductors shall be cleated on the structures at 2000 mm interval. For grounding of lightning spikes and shield wires, 7/3.66 mm GI steel wires shall be used.

Connection between each down conductor and rod electrodes shall be made via test joint (pad type compression clamp) located approximately 1500 mm above ground level. The rod electrode shall be further joined with the main earth-mat.

Two runs of down conductors shall be used for grounding of each Lightning Spikes. For that, lugs with bolts shall be provided at base of spikes.

G.I. wires for shielding shall conforming to IS 2141.Parameters of galvanised steel wires shall be as follows:

a) No of Strand: 7
b) Diameter of single strand: 3.66 mm
c) Minimum Breaking Load: 6970 KG
d) Overall Diameter: 10.98 mm
e) Area: 72.25 mm2

SECTION 5

TECHNICAL SPECIFICATIONS OF INSULATOR AND HARDWARE FITTINGS

5.1.0 General

a) The Contractor shall supply insulators of suspension, tension and post type as required complete with all necessary hardware and accessories, including fittings for fixing insulators to steel structures as required.

b) The porcelain shall be sound, free from defects, thoroughly vitrified and smoothly glazed.

c) Unless otherwise specified, the glaze shall be brown colour. The glaze shall cover all the porcelain parts of the insulators except those areas which serve as support during firing or are left unglazed for purpose of assembly.

d) The design of the insulator shall be such that stress due to expansion and contraction in any part of the insulator shall not lead to deterioration. The porcelain shall not engage directly with hard metal.

e) Cement use in the construction of insulator shall not cause fracture by expansion or loosening by contraction and proper care shall be taken to locate the individual parts correctly during cementing. The cement shall not give rise to chemical reaction with metal fitting and its thickness shall be as uniform as possible.

f) Pins and caps shall be made of drop forged steel, duly hot dip galvanized as per IS 2629.These shall not be made by jointing, welding, shrink fitting or any other process.

g) Security clips/split pins shall be made of good quality of stainless steel.

h) Suspension and tension insulators shall be wet process porcelain with ball and socket connection. Insulators shall be interchangeable and shall be suitable for forming either suspension or tension strings.

i) Post type insulators shall be of long rod type or solid core type and preferably of single piece type for all voltage classes. These shall be complete with necessary fittings to hold Aluminium tubes or ACSR conductor as required.

j) The items of hardware and fittings shall make complete assemblies which are necessary for their satisfactory performance. Such parts shall be deemed to be within the scope of this specification.

5.1.1 Disc Insulator Strings

Each insulator string shall consist of following numbers of Disc & parameters.

Sl. No.	Description	No of Disc Insulator Unit for		
		220 kV	132 kV	33 kV
1	No. of Disc, Suspension String	14	9	3
2	No. of Disc, Tension String	15	10	4

3	Creepage Distance of complete String (min)	7595 mm	4495 mm	1116 mm

5.1.2 Parameters

5.1.2.1 Disc Insulators

a) Type : Ball and Socket
b) Colour : Brown
c) Surface : Glazed
d) Locking Device : W or R type security clip
e) Size of Disc : 280 mm x 146 mm
f) Size of Pin Ball : 20 mm
g) Creepage Distance(Min subjected requirement of clause 2.19.2) :25 mm/kV
h) Electro mechanical Strength : 120 KN
i) Power frequency withstand test voltage : 85 KV Dry
j) Minimum dry Impulse withstand : 130 KV peak Test voltage (+/- wave)
k) Puncture Voltage : 1.3 X actual dry flash over voltage.

5.1.2.2 Post Insulators

Sl. No.	Parameters	220 kV	132 kV	33 kV
1	Highest system voltage	245 kV	145 kV	36 kV
2	Dry one minute power frequency test voltage	510 kV	275 kV	75 kV
3	Wet one minute power frequency test voltage	460 kV	275 kV	75 kV
4	Impulse voltage withstand test	510 kV	650 kV	170 kV
5	Minimum Creepage Distance	31mm/kV	31mm/kV	31mm/kV
6	Minimum Bending Strength (upright)	8 kN	6 kN	3 kN

5.3.0 CLAMPS, CONNECTORS AND SPACERS

Clamps and connectors shall conform to IS 2121 unless otherwise mentioned hereunder.

Clamps and connectors shall be made of materials listed below: -

(i) For connecting ACSR: Aluminium alloy casting conforming to designation A6 of IS 617.
(ii) For connecting equipment: Bimetallic connectors made from aluminium alloy terminals made of copper casting conforming to designation A 6 of IS 617.
(iii) For connecting GI Shield wire: Malleable iron casting.
(iv) Expansion Connectors: Copper lamination to grade FRTP-2 of IS 191.
(v) Bolts, nuts, plain washers: Hot dip galvanised mild steel and spring washers for items (i), (ii) and (iii).

5.4.0 Spacers

Spacers shall conform to IS 10162. Spacers for bundle conductors (where specified) shall be provided at but not limited to the following locations:

(i) At intervals not exceeding 2.5 meters in case of strung bus bars or other bundled strung conductors.
(ii) At one meter interval in case of jumper connections.
No magnetic material shall be used in fabrication of spacers except for the GI bolts and nuts.

5.4.0 T Clamp and Equipment Clamps

a) T Clamps:

i. Standard Specification and tests shall be as per IS:5561.
ii. For connecting ACSR conductor aluminium alloy casting conforming to designation A 6 of IS 617.
iii. Bolts, nuts and washers shall be made of mild steel and hot dip galvanized as per IS 2629. Small fittings like spring washers, nuts etc. may be electro galvanized.
iv. The quality of HDG ferrous components shall be determined by the test given in IS:2633 and shall satisfy the requirement of that standard.
v. The rated short time current shall be one of the standard values laid down in Indian Standards for the associated circuit breakers, Switches etc.
vi. Current carrying capacity same as conductor full current rating. For two different conductors, conductor with smaller rating shall be considered.
vii. No part of a clamp shall be less than 12 mm thick for fittings suitable up to size of ACSR Panther conductor, no part of a clamp shall be less than 15 mm thick for fittings suitable for ACSR Zebra conductor and ACSR Moose conductor.
viii. All sharp edges and corners shall be blurred and rounded off.
ix. For bimetallic connectors, copper alloy liner of minimum thickness of 2 mm shall be cast integral with aluminium body.
x. From outermost hole edge to nearest edge of any clamps and connectors the distance shall not be less than 10 mm.

b) Equipment Clamps (CVT, CB, ISOLATOR, CT, etc.):

i. Standard Specification and tests shall be as per IS:5561.
ii. For connecting ACSR conductor aluminium alloy casting conforming to designation A 6 of IS 617.
iii. Bolts, nuts and washers shall be made of mild steel and hot dip galvanized as per IS 2629. Small fittings like spring washers, nuts etc. may be electro galvanized.
iv. The quality of HDG ferrous components shall be determined by the test given in IS:2633 and shall satisfy the requirement of that standard.
v. The rated short time current shall be one of the standard values laid down in Indian Standards for the associated circuit breakers, Switches etc.
vi. Current carrying capacity same as conductor full current rating. For two different conductors, conductor with smaller rating shall be considered.
vii. No part of a clamp shall be less than 12 mm thick for fittings suitable up to size of ACSR Panther conductor, no part of a clamp shall be less than 15 mm thick for fittings suitable for ACSR Zebra conductor and ACSR Moose conductor.
viii. All sharp edges and corners shall be blurred and rounded off.
ix. For bimetallic connectors, copper alloy liner of minimum thickness of 2 mm shall be cast integral with aluminium body.
From outermost hole edge to nearest edge of any clamps and connectors the distance shall not be less than 10 mm.

SECTION 6

TECHNICAL SPECIFICATIONS OF ILLUMINATION SYSTEM

6.1.0 The Contractor shall design, supply and install illumination system for the entire substation. The average illumination level and limiting glare index for different parts of the substation shall be as follows:

Sl. No.	Location/Area	Average Illumination Level, 'Lux'	Limiting Glare Index
1	Control Room	300	19
2	Battery Room	100	19
3	Carrier Room	300	
4	Office/Conference Room	300	
5	Stairs and Corridors	100	
6	Air Conditioning Plant	150	
7	Outdoor Switchyard	20	
8	Approach Road	20	
9	Store Room	100	

6.1.1 The lighting system of a particular area whether indoor or outdoor shall be designed such a way that uniform illumination level is achieved. In outdoor switchyard illumination shall be aimed as far as possible towards transformers, circuit breakers, isolators etc.

6.1.2 Following types of lamps shall be used for various location of the substation:

Sl.No.	Location/Area	Type of Lamp	Type of Fitting
1	Control Room, Office, Carrier Room	LED	Decorative
2	Battery Room	Fluorescent	Acid Proof, Industrial
3	Outdoor Switchyard	LED	Water Tight Flood Light
4	External Lighting on Buildings	LED	Water Tight Flood Light
5	Gate Lighting	LED	Post type, water tight Flood Light

6.1.3 Provisions shall be made in the switchyard steel structures for mounting of lamps for switchyard.

SECTION 7

TECHNICAL SPECIFICATION OF OUTDOOR SF6 CIRCUIT BREAKERS

7.1.0 SCOPE

7.1.1 The intention of this Section of the Specification is to cover design, manufacture, testing at manufacturer's works of Circuit Breakers with all fittings and accessories including mounting structures as applicable

7.1.2 Loading at manufacturer's works, transportation and delivery at respective substation sites, including unloading at destination sites.

7.1.3 Erection, Testing and Commissioning of Circuit Breakers.

7.2.0 GENERAL REQUIREMENTS

7.2.1 The circuit breakers and accessories shall conform to IEC: 62271-100, IEC: 62271-1 and other relevant IEC standards except to the extent explicitly modified in the specification and shall also be in accordance with requirements specified in Section-GTR.

7.2.2 800/420/245/145/72.5kV circuit breakers offered would be of sulphur hexafluoride (SF6) type and of class C2-M2 as per IEC. The bidder may offer circuit breakers of either live tank type or dead tank type of proven design.

7.2.3 The circuit breaker shall be complete with operating mechanism, **common marshalling box**, piping, inter-pole cables, cable accessories like glands, terminal blocks, marking ferrules, lugs, pressure gauges, density monitors (with graduated scale), galvanized support structure, **platform with ladder** for CB, their foundation bolts and all other accessories required for carrying out all the functions of the CB.

7.2.4 All necessary parts to provide a complete and operable circuit breaker installation such as terminal pads, control parts and other devices shall be provided.

7.2.5 Painting shall be done in line with Section – GTR. **Paint shade RAL-7032** or similar shades can be used for painting. The support structure, **platform & ladder** of circuit breaker shall be hot dip galvanised. Exposed hardware items shall be hot dip galvanised or Electro- galvanised.

7.2.6 The circuit breakers shall be designed for use in the geographic and meteorological conditions as given in Section-**Project**.

7.2.7 All 765kV & 400kV Circuit Breaker control schematics shall be finalized in such a way, that it may operate with or without CSD by using a suitable selector switch irrespective of whether circuit breakers to be supplied are envisaged along with CSD or not as per bid price schedules.

7.3.0 DUTY REQUIREMENTS

7.3.1 The circuit breakers shall be capable of performing their duties without opening resistors.

7.3.2 The circuit breaker shall meet the duty requirements for any type of fault or fault location and also for line switching when used on effectively grounded system and perform make and break operations as per the stipulated duty cycles satisfactorily.

7.4.0 PRE-INSERTION RESISTER

7.4.1 800kV & 420kV circuit breakers shall be provided with single step pre- insertion closing resistors (wherever the requirement of PIR is explicitly specified in bid price schedules) to limit the switching surges. The resistance value of pre-insertion resistor and the duration of pre-insertion time is given in clause 16.0 of this section. The resistor shall have thermal rating for the following duties:

i) TERMINAL FAULT
Close .... 1 Min .... Open Close Open…..2 min ..... Close ..... 1 Min .....
Open Close Open.

ii) RECLOSING AGAINST TRAPPED CHARGES
Duty shall be the same as under (i) above. The first, third and fourth closures are to be on de - energised line while second closing is to be made with lines against trapped charge of 1.2 p.u. of opposite polarity.

iii) OUT OF PHASE CLOSING
One closing operation under phase opposition, that is with twice the voltage across the terminals.

iv) No allowance shall be made for heat dissipation of resistor during time interval between successive closing operations. The resistors and resistor supports shall perform all these duties without deterioration. Test reports of resistors proving thermal rating for duties specified above shall be furnished during detailed engineering. The calculations shall be provided to take care of the effect of tolerances on resistance values and insertion time

The breaker shall be capable of:

i) Interrupting the steady and transient magnetizing current corresponding to Power transformers as follows:

Voltage rating of CB	Type of Transformer	Rating (in MVA)
800kV	**765/400kV**	**250 to 1500**
420kV	**765/400kV**	**250 to 1500**
	400/220kV	**250 to 630**
	400/132kV	**160 to 315**
245kV	**400/220kV**	**200 to 630**
	220/132kV	**50 to 200**
	220/66kV	**50 to 200**
145kV	**220/132kV**	**50 to 200**
	132/33kV	**10 to 50**

ii) Interrupting line/cable charging current as per IEC without use of opening resistors. **The breaker shall be able to interrupt the rated line charging current as per IEC- 62271-100 with test voltage immediately before opening equal to the product of U/ 3 and 1.4.**

iii) Clearing short line fault (kilometric faults) with source impedance behind the bus equivalent to symmetrical fault current specified.

iv) Withstanding all dielectric stresses imposed on it in open condition at lock out pressure continuously (i.e. shall be designed for 2 p.u. across the breaker continuously, for validation of which a power frequency withstand test conducted for a duration of at least 15 minutes is acceptable).

v) Circuit breakers shall be able to switch in and out the shunt reactor as detailed below:

Voltage rating of CB	Reactor Rating (in MVAR)	Max. rise of over voltage (in p.u.)
800kV	**150 to 330**	**1.9**
420kV	**50 to 150**	**2.3**
245kV	**25 to 50**	**2.3**

a. Capability of 400 kV circuit breakers to interrupt inductive current below 100 A without giving rise to overvoltage more than 2.3 p.u. (As specified in IEC-62271-110) shall be validated by carrying out the simulation study/analysis (EMTP/PSCAD) by modeling an equivalent circuit comprising all circuit component i.e. Inductance of Shunt Reactor, Stray capacitance of Shunt Reactor, Circuit Breaker, Stray capacitance of Bus Connection, Capacitance of grading Capacitor, inductance of neutral grounding reactor, Network Thevenin's equivalent, any other series/parallel inductance/capacitance connected to simulate the actual inductive load switching.

b. Current chopping capability (chopping number) of circuit breaker as per IEC- 62271-306 to be figured out from actual Laboratory test and / or field test report and same Current chopping capability (chopping number) shall be used in above said simulation study/analysis.

c. To validate the results of above said simulation study/analysis report, the same study shall be carried out for capability of tested circuit breaker and the study/analysis results shall be comparable with actual Laboratory test and / or field test reports.

d. Laboratory test/ field test reports shall be submitted for 400 kV CBs in case there is change in design including change in following:
   i. Different short circuit current capability
   ii. Different model/type

vi) The breakers shall also withstand the voltages as specified in this section.

7.5.0 CONTROLLED SWITCHING DEVICE (CSD) :

7.5.1 Circuit Breakers shall be equipped with controlled switching device with consequent optimization of switching behavior, when used in:
- Switching of transformer **(from 765kV and 400kV side circuit breakers only)**
- Switching of shunt Reactor

7.5.2 The CSD shall be provided in Circuit breaker of switchable line reactor **bay** and in Main & Tie **bay** circuit breakers of Transformers, line with non- switchable line reactors and Bus reactors. **The CSD shall be supplied as per bid price schedules.**

7.5.3 Technical Requirement for controlled switching device:

a) The CSD shall be designed to operate correctly and satisfactorily with the excursion of auxiliary A/C & DC voltages and frequency as specified in section - GTR.
b) The CSD shall meet the requirements of IEC-61000-4-16 class IV for HF disturbance test (for short and long durations both) and fast transient test shall be as per IEC-61000-4- 4 level IV and insulation test as per IEC 60255–5.
c) The CSD shall have functions for switching ON & OFF the circuit breakers.
d) The CSD shall get command to operate the breakers manually. The controller shall be able to analyze the current and voltage waves available through the signals from secondaries of CTs & CVTs for the purpose of calculation of optimum moment of the switching the circuit breaker and issue command to circuit breaker to operate
e) The CSD shall also have an adaptive control feature to consider the next operating time of the breaker in calculation of optimum time of issuing the switching command. In calculation of next operating time of the breaker, the CSD must consider all factors that may affect the operating time of the breaker such as, but not limited to, ambient temperature, control voltage variation, SF6 gas density variations etc. Schematic drawing for this purpose shall be provided by the contractor. The accuracy of the operating time estimation by the controller shall be better than ± 0.5 ms.
f) The CSD should have display facility at the front for the display of settings and measured values.
g) The CSD shall be PC compatible for the setting of various parameters and down loading of the settings and measured values, date, time of switching etc. Window based software for this purpose shall be supplied by the contractor to be used on the owner's PC
h) The controller shall be suitable for current input of 1 ampere from the secondary of the CTs. and 110 V (Ph to Ph) from the CVTs. The CSD shall withstand transient and dynamic state values of the current from the secondary of the CTs and CVTs.
i) The CSD shall have time setting resolution of 0.1 ms or better.
j) The CSD shall have sufficient number of output/input potential free contacts for connecting the monitoring equipment and annunciation system available in the control room. Necessary details shall be worked out during engineering of the scheme.
k) The CSD shall also record and monitor the switching operations and make adjustments to the switching instants to optimize the switching behavior as necessary. It shall provide self-diagnostic facilities, signaling of alarms and enable downloading of data captured from the switching events.
l) The provision for bypassing the Controlled switching device shall be provided through BCU and SCADA both so that whenever, the CSD is not healthy due to any reason (including auxiliary supply failure), uncontrolled trip/close command can be extended to the circuit
Breaker. Alternatively, in case of any non-operation of the CSD after receiving a close/trip command after a pre-determined time delay, the CSD should automatically be bypassed so as to ensure that the trip and close commands are extended to the Trip/Close coils through subsequent command.
m) The CSD shall be provided with a communication port to facilitate online communication of the CSD with Substation automation system directly on IEC 61850 protocols. If the CSD does not meet the protocols of IEC 61850, suitable gateway shall be provided to enable the communication of CSD as per IEC 61850.

7.6.0 TOTAL BREAK TIME

7.6.1 The total break time as specified under this section shall not be exceeded under any of the following duties:

i) Test duties T10, T30, T60, T100a, and T100s (with TRV as per IEC: 62271-100)
ii) Short line fault L75, L90 (with TRV as per IEC: 62271-100)

7.6.2 The total break time of the breaker shall not be exceeded under any duty conditions specified such as with the combined variation of the trip coil voltage (70-110%), arc extinguishing medium pressure etc. While furnishing the proof of the total break time of complete circuit breaker, the effect of non- simultaneity between contacts within a pole or between poles shall be brought out to establish guaranteed total break time.

7.6.3 The values guaranteed shall be supported with the type test reports.

7.7.0 CONSTRUCTIONAL FEATURES

7.7.1 The features and constructional details of circuit breakers shall be in accordance with requirements stated hereunder:

7.7.2 Contacts

7.7.3 The gap between the open contacts shall be such that it can withstand at least the rated phase to ground voltage for 8 hours at zero gauge pressure of SF6 gas due to the leakage. The breaker should be able to withstand all dielectric stresses imposed on it in open condition at lock out pressure continuously (i.e. 2 p.u. across the breaker continuously, for validation of which a power frequency dielectric with stand test conducted for a duration of at least 15 minutes is acceptable).If multi-break interrupters are used, these shall be so designed and augmented that a uniform voltage distribution is developed across them. Calculations/test reports in support of the same shall be furnished. The thermal and voltage withstand rating of the grading elements shall be adequate for the service conditions and duty specified.

7.7.4 The SF6 Circuit Breaker shall meet the following additional requirements:

i. The circuit breaker shall be single pressure type. The design and construction of the circuit breaker shall be such that there is a minimum possibility of gas leakage and entry of moisture. There should not be any condensation of SF6 gas on the internal insulating surfaces of the circuit breaker.
ii. All gasketted surfaces shall be smooth, straight and reinforced, if necessary, to minimise distortion and to make a tight seal, the operating rod connecting the operating mechanism to the arc chamber (SF6 media) shall have adequate seals. The SF6 gas leakage should not exceed 0.5% per year and the leakage rate shall be guaranteed **during the warrantee period**. In case the leakage under the specified conditions is found to be greater than 0.5% **per** year **after** commissioning of circuit breaker **during the warrantee period**, the manufacturer will have to supply free of cost, the total gas requirement for subsequent ten (10) years, based on actual leakage observed during **the warrantee period**.
iii. In the interrupter assembly there shall be an absorbing product box to minimise the effect of SF6 decomposition products and moisture. The material used in the construction of the circuit breakers shall be fully compatible with SF6 gas decomposition products.
iv. Each pole shall form an enclosure filled with SF6 gas independent of two other poles (for 800, 420 & 245 kV CBs) and the SF6 density of each pole shall be monitored individually. For CBs of voltage class of 145 kV or less, a common SF6 scheme/density monitor shall be acceptable.
v. The dial type SF6 density monitor shall be adequately temperature compensated to model the pressure changes due to variations in ambient temperature within the body of circuit breaker as a whole. **Separate density monitor and dial type temperature compensated pressure guage**

is also acceptable. The density monitor shall have graduated scale and it shall be possible to dismantle the density monitor for checking/replacement without draining the SF6 gas by providing suitable interlocked non return valve coupling.

vi. Circuit Breaker shall be capable of withstanding a vacuum of minimum 8 millibars without distortion or failure of any part.

vii. Sufficient SF6 gas (including that will be required for gas analysis during filling) shall be provided to fill all the circuit breakers being supplied. Spare gas shall be supplied in separate unused cylinders as per requirement specified in BPS.

Provisions shall be made for attaching an operational analyser to record contact travel, speed and making measurement of operating timings, pre insertion timings of closing resisters if used, synchronisation of contacts in one pole.

viii. The CO (Close-open) operation and its timing shall be such as to ensure complete travel/insertion of the contact during closing operation and then follow the opening operation.

7.8.0 SULPHUR HEXAFLUORIDE GAS (SF6 GAS)

a) The SF6 gas shall comply with IEC 60376 and shall be suitable in all respects for use in the switchgear under the operating conditions.

b) The high pressure cylinders in which the SF6 gas is shipped and stored at site shall comply with requirements of the relevant standards and regulations. **SF6 gas shall be supplied (in returnable cylinders) for all circuit breakers. However, SF6 gas for spare circuit breakers and mandatory spare quantity of SF6 gas shall be supplied in non- returnable cylinders.**

c) Test: SF6 gas shall be tested for purity, dew point, air, **hydro-soluble** fluorides and water content as per IEC 60376 and test certificates shall be furnished to Employer indicating all the tests as per IEC 60376 for each lot of SF6 gas and Material safety datasheet shall be provided. Gas bottles should be checked for leakage during receipt at site.

7.9.0 INSULATORS

a) The porcelain**/polymer** of the insulators shall conform to the requirements stipulated under Section-GTR.
b) The mechanical characteristics of insulators shall match with the requirements specified under this section.
c) All **porcelain & polymer** hollow **column** insulators shall conform to IEC-62155 & **IEC- 61462 respectively.**
d) Hollow Porcelain**/polymer** for pressurised columns/chambers should be in one integral piece in green and fired stage.

7.10.0 SPARE PARTS AND MAINTENANCE EQUIPMENT

7.10.1 The bidder shall include in his proposal, spare parts and maintenance equipment in accordance with BPS. Calibration certificates of each maintenance equipment shall be supplied along with the equipment.

7.10.2 OPERATING MECHANISM AND CONTROL

7.10.3 General Requirements

Circuit breaker shall be operated by spring charged mechanism. The mechanism box shall meet the requirements of IP-55.

The operating mechanism box shall be strong, rigid, rebound free and shall be readily accessible for maintenance.

The mechanism shall be anti-pumping and trip free under every method of closing.

The mechanism shall be such that the failure of any auxiliary spring will not prevent tripping and will not cause **unwanted** trip or closing operation of the Circuit Breaker

A mechanical indicator shall be provided to show open and close position of the breaker. It shall be located in a position where it will be visible to a man standing on the ground level with the mechanism housing closed. An operation counter shall also be provided in the common marshalling box.

Working parts of the mechanism shall be of corrosion resisting material, bearings which require grease shall be equipped with pressure type grease fittings. Bearing pin, bolts, nuts and other parts shall be adequately pinned or locked to prevent loosening or changing adjustment with repeated operation of the breaker.

The contractor shall furnish detailed operation and maintenance manual of the mechanism alongwith the operation manual for the circuit breaker. The instruction manuals shall contain exploded diagrams with complete storage, handling, erection, commissioning, troubleshooting, servicing and overhauling instructions.

Size of common marshalling Box shall be such that adequate space is available for working in the panel and all wiring shall be routed through non-inflammable wire troughs with covers.

Space shall be available in 765kV CB common marshalling box to mount monitoring device, of about 300x300x150mm size and of approximately 7kg weight, by the owner in future.

Operating mechanism and Marshalling box should be provided with space heater with thermostat, CFL/LED lamp and AC point /Socket.

7.10.4 Control:

The close and trip circuits shall be designed to permit use of momentary contact switches and push buttons.

Each breaker shall be provided with two (2) independent tripping circuits, pressure switches and coils each to be fed from separate DC sources.

The breaker shall normally be operated by remote electrical control. Electrical tripping shall be performed by shunt trip coils. However, provisions shall be made for local electrical control. For this purpose a local/remote selector switch and close and trip control switch/push buttonsshall be provided in the Breaker **common marshalling box**.

The trip coils shall be suitable for trip circuit supervision during both open and close position of breaker.

Closing coil and associated circuits shall operate correctly at all values of voltage between 85% and 110% of the rated voltage. Shunt trip coil and associated circuits shall operate correctly under all operating conditions of the circuit breaker up to the rated breaking capacity of the circuit breaker and at all values of supply voltage between 70% and 110% of ratedvoltage. However, even at 50% of rated voltage the breaker shall be able to open. If additional elements are introduced in the trip coil circuit their successful operation and reliability for similar applications on outdoor circuit breakers shall be clearly brought out during detailed engineering.

The 765kV kV, 3-Phase circuit breakers suitable for single phase switching shall be suitable for

taking a spare pole into service in case of any operational requirement and their marshalling box shall be suitable for accommodating the additional relays etc. required for changeover arrangement of all contacts, alarms, signals, indications, interlocks and lockouts.

In trip and closing circuits, relays/relay contacts shall preferably be used instead of contactors.

Controlled switching scheme/device, wherever required shall be considered as integral part of CB and shall be commissioned along with CB.

Density Monitor contacts and pressure switch contacts shall be preferably suitable for direct use as permissive in closing and tripping circuits. The devices shall provide continuous & automatic monitoring of the state of the gas as follows:

a) 'Gas Refill' level

This contact will be used for remote indication/ to annunciate the need for gas refilling.

b) 'SF6 gas density Low' Alarm level - 1
This contact will be used for remote indication/ to annunciate the need for the urgent gas refilling.

c) 'SF6 gas density Low' Alarm level - 2
This contact will be used to annunciate the need for gas refilling under emergency or trip the Circuit Breaker.

d) 'Breaker Block' level
This is the minimum gas density at which the manufacturer will guarantee the rated fault interrupting capability of the breaker. At this level the breaker block contact shall operate & the tripping & closing circuit shall be blocked.

It shall be possible to test all gas monitoring relays/devices without de- energizing the primary equipment & without reducing pressure in the main section. Plugs & sockets shall be used for test purposes. It shall also damp the pressure pulsation while filling the gas in service, so that flickering of the pressure switch contacts does not take place.

The density monitor shall be placed suitably inclined in such a way so that the readings are visible from ground level with or without using binoculars. Separate contacts have to be used for each of tripping and closing circuits. If contacts are not suitably rated and multiplying relays are used then fail safe logic/schemes are to be employed. DC supplies for all auxiliary circuits shall be monitored and provision shall be made for remote annunciations and operation lockout in case of D.C. failures. Density monitors are to be so mounted that the contacts do not change on vibration during operation of circuit Breaker.

The auxiliary switch of the breaker shall be positively driven by the breaker operating rod.

7.10.5 Spring operated mechanism:

a) Spring operated mechanism shall be complete with motor **as per manufacturer practice**. Opening spring and closing spring with limit switch for automatic charging and other necessary accessories to make the mechanism a complete operating unit shall also be provided.

b) As long as power is available to the motor, a continuous sequence of the closing and opening operations shall be possible. The motor shall have adequate thermal rating for this duty.

c) After failure of power supply to the motor one close open operation shall be possible with the energy contained in the operating mechanism.

d) Breaker operation shall be independent of the motor which shall be used solely for compressing the closing spring. Facility for manual charging of the closing spring shallalso be provided. The motor rating shall be such that it requires not more than 30seconds for full charging of the closing spring.

e) Closing action of circuit breaker shall compress the opening spring ready for tripping.

f) When closing springs are discharged after closing a breaker, closing springs shall be automatically charged for the next operation and an indication of this shall be provided in the local and remote control cabinet.

g) Provisions shall be made to prevent a closing operation of the breaker when the spring is in the partial charged condition. Mechanical interlocks shall be provided in the operating mechanism to prevent discharging of closing springs when the breaker is already in the closed position.

h) The spring operating mechanism shall have adequate energy stored in the operating spring to close and latch the circuit breaker against the rated making current and also to provide the required energy for the tripping mechanism in case the tripping energy is derived from the operating mechanism.

i) The spring charging failure alarm shall be provided with a time delay relay having setting range from 0-1minute.

j) Separate MCBs shall be provided for each spring charging motor and the rating of MCBs shall be suitably selected to match the starting, running and stalling time.

k) An overload relay shall be provided for protection of the spring charging motor.

7.10.6 SUPPORT STRUCTURE

a) The structure design shall be such that during operation of circuit breaker vibrations are reduced to minimum.

b) Ladder and Maintenance platform for 400kV and 765kV Circuit breaker:

A suitable ladder with the safety cage and a free standing maintenance platform with railing for each pole of the circuit breaker shall be supplied along with the equipment and it's support structure. The platform shall be suitable for maintenance personnel to stand and carryout the activities along with the tools and plant.

The ladder cum maintenance platform shall be designed as a free standing structure without taking any support from the main circuit breaker structure. The ladder having height more than 3.0m shall have at least 15 degree slope and is to be provided with safety guard above 2.0m level. All structural steel for the platform shall be as per IS: 2062 and to be galvanized. An indicative drawing of ladder and platform (Drg.Ref.: C-ENGG-IND.DWG-PLATFORM- CB, Rev.0) is added at page 27 of 27 with this specification for guidance which may be modified to suit the requirement of CB by CB manufacturer. However, the minimum size of the structural members shall be maintained as mentioned in the drawing.

c) For 220kV, 132kV & 66kV circuit breakers a suitable platform cum ladder shall be provided as per manufacturer design.

7.10.7 TERMINAL CONNECTOR PAD

The circuit breaker terminal pads shall be made up of high quality electrolytic copper or aluminium and shall be conforming to Australian Standard AS- 2935 or equivalent standard for rated current. The terminal pad shall have protective covers which shall be removed before interconnections.

INTER-POLE CABLING

All cables to be used by contractor shall be armoured and shall be as per IS – 1554/ IEC-60502 (1100 Volts Grade). All cables within & between circuit breaker poles and its marshaling box and up to the controlled

switching device is included in the scope of work. Special cables like screened cable if required for Circuit Breaker, **temperature Transducer/CB Status Signals for CSD** and its associated C&R panel shall be laid in 50mm diameter PVC pipe. Suitable supports for PVC pipe shall be included in the scope of Supply.

Only stranded conductor shall be used. Minimum size of the conductor for inter-pole control wiring shall be 1.5 sq.mm. Copper.

The cables shall be with oxygen index Minimum 29 and temperature index as 250^{O}C as per relevant standards.

Separate cables shall be used for AC, DC-I, DC-II and selected DC.

All inter-pole cabling of Circuit breakers and up to common marshalling box shall be done by plug-in type arrangement. Suitable removable type encasing cover shall be provided in case plug-in type connection arrangement is provided exterior side of LCC/MB. The plug-in type cable termination shall be conforming to IP-67 as per IEC60529. Cable sealing arrangement shall be provided (as per requirement) to avoid entry of moisture etc.

Vertical run of cables to the operating mechanism box shall be properly supported by providing the perforated closed type galvanized cable tray (Cable tray also to be supplied along with the Circuit Breaker) to be fixed as an integral part of the structures. The load of the cable shall not be transferred to the mechanism box/plug-in type terminal arrangement in any circumstances. Hanging or loose run of cable is notpermitted. The drawing of cable tray including fixing arrangement shall be incorporated in the GA drawing of CB also.

Wiring shall be done with stud type terminals and ring type lugs. More than two wires shall not be connected on each side of terminal.

7.10.8 FITTINGS AND ACCESSORIES

Following is list of some of the major fittings and accessories to be furnished by Contractor in the common marshalling box. Number and exact location of these parts shall be indicated in the drawing

i) Cable glands (Double compression type), Lugs, Ferrules etc.
ii) Local/remote changeover switch.
iii) Operation counter
iv) Control switches to cut off control power supply.
v) Fuses**/MCBs** as required.
vi) The number of terminals provided shall be adequate enough to wire out all contacts and control circuits plus 24 terminals spare for future use.
vii) Anti-pumping relay.
viii) Pole discrepancy relay (for electrically ganged CBs).
ix) D.C. Supervision relays.
x) Rating plate description in accordance with IEC incorporating year of manufacture.
xi) Controlled switching **accessories** like sensors, timers, relays etc.(as applicable)
xii) Transducers/Fixtures required for travel measurement shall be supplied by CB manufacturer. The complete set of Transducers/Fixtures for measurement of complete 3-phase CB shall be supplied for each station. Further, one set of gas filling adopter (Including coupling, regulator, connecting hose pipe up to ground level) shall be supplied as per BPS.

7.10.9 ADDITIONAL DATA TO BE FURNISHED

a) Drawing, showing contacts in close, arc initiation, full arcing, arc extinction and open position.

b) The temperature v/s pressure curves for each setting of density monitor along with details of density monitor.

c) Method of checking the healthiness of voltage distribution devices (condensers) provided across the breaks at site.

d) Data on capabilities of circuit breakers in terms of time and number of operations at duties ranging from 100% fault currents to load currents of the lowest possible value without requiring any maintenance or checks.

e) **Maximum** non-simultaneity between contacts, between poles and **effect of the same on the** guaranteed total break time.

f) Sectional view of non-return couplings used for SF6 pipes.

g) Details & type of filters used in interrupter assembly and also the operating experiencewith such filters.

h) Details of SF6 gas:

i) The test methods used in controlling the quality of gas used in the circuitbreakers particularly purity and moisture content.

ii) Proposed tests to assess the conditions of the SF6 within a circuit breaker aftera period of service particularly with regard to moisture contents of the gas.

j) Shall furnish curves supported by test data indicating the opening time under close open operation with combined variation of trip coil voltage.

k) Detailed literature and schematic diagrams of switching mechanism for closing resistor showing the duration of insertion shall also be furnished alongwith the calculations in respect of thermal rating of resistors for the duties specified under clause **2.2.1** of thissection in case of 420 kV **& 800kV** circuit breakers.

l) All duty requirements as applicable to 800 kV, 420 kV, 245 kV, 145 kV & 72.5kV CBs specified under Clause **2.0** of this section shall be provided with the support of adequate test reports.

7.10.10 DEAD TANK TYPE CIRCUIT BREAKER

In case dead tank type circuit breaker is offered, the Bidder shall offer bushing type CTs (whose secondary parameters are given in under **Section: Switchgear-Instrument Transformer** and in case of 765kV and 400kV these secondaries shall be provided in sets of3 cores, i.e., 2 cores of PX class and one core of metering, on both sides of dead tank circuitbreaker instead of conventional outdoor CTs.

The enclosure shall be made of either Al/Al Alloy or mild steel (suitably hot dip galvanized). The enclosure shall be designed for the mechanical and thermal loads to which it is subjected in service. The enclosure shall be manufactured and tested according to the pressure vesselcodes {i.e., latest edition of the ASME code for pressure vessel - Section VIII of BS-5179, IS4379, IS-7311 (as applicable) and also shall meet Indian Boiler Regulations}.

The maximum temperature of enclosure with CB breaker carrying full load current shall not exceed the ambient by

more than 20 deg C.

The enclosure has to be tested as a routine test at 1.5 times the design pressure for one minute. A bursting pressure test shall be carried out at 5 times the design pressure as type test on the enclosure.

7.10.0 TESTS

In accordance with the requirements stipulated under Section-GTR the circuit breaker alongwith its operating mechanism shall conform to **the type tests as per** IEC: 62271-100.

The type test reports **as per IEC** and the following additional type test reports shall also be submitted for purchaser's/**employer's** review:.

i) Corona extinction voltage test (**procedure** as per Annexure-A of Section-GTR).
ii) Out of phase closing test as per IEC: 62271-100.
iii) Line charging interrupting current for proving parameters as per clause no. **16.0** of this section.
iv) Test to demonstrate the Power Frequency withstand capability of breaker in open condition at Zero Gauge pressure and at lockout pressure (Ref. Clause 4.1.1).
v) Seismic withstand test **(procedure** as per Annexure-B of Section-GTR) in unpressurised condition.
vi) Verification of the degree of protection.
vii) Low temperature test (applicable only for minimum ambient temperatures of less than (-) 10 deg.C application purpose) and High temperature test. Contractor can also submit the field performance report in line with IEC stipulations.
viii) Static Terminal Load test.
ix) Critical Currents test (if applicable).
x) Switching of Shunt Reactors. Test reports shall be submitted as per IEC. Calculations shall be submitted for meeting the requirements of clause 2.3(v) of this section.
xi) Circuit breakers meant for controlled switching shall conform to requirements of IEC/TR-62271 – 302. The contractor shall submit test reports to demonstrate that the offered CB conforms to the requirements of performance verification tests and parameter definition tests as per IEC/TR 62271-302. The contractor shall also furnish the report for the re-ignition free arcing window for switching 3-phase shunt reactor as demonstrated in the shunt reactor switching test.

7.10.1 Routine Tests

7.10.2 Routine tests as per IEC:62271-100 shall be performed on all circuit breakers.

In addition to the mechanical and electrical tests specified by IEC, the following tests shall also be performed.

i. Speed curves for each breaker shall be obtained with the help of a suitable operation analyzer to determine the breaker contact movement during opening, closing, auto reclosing and trip free operation under normal as well as limiting operating **control voltage conditions**. The tests shall show the speed of contacts directly at various stages of operation, travel of contacts, opening time, closing time, shortest time between separation and meeting of contacts at break make operation etc. This test shall also be performed at site for which the necessary operation analyzer along with necessary transducers, cables, console etc. shall be **arranged by the contractor at his own cost**.

ii. During testing of CB, dynamic contact resistance measurement (DCRM) shall be carried out for close-open (CO) operations with delay of 300ms between close and trip operations. Minimum 100A **current shall be injected for DCRM test. Travel characteristics, injected current, trip/close coil current shall also be recorded along with DCRM test.**

iii. Routine tests on Circuit breakers with Controlled switching device as per IEC/TR 62271-302.

iv. Tan delta and Capacitance measurement for grading capacitors at rated voltage and also at 10kV (for reference).

7.11.0 TECHNICAL PARAMETERS FOR CIRCUIT BREAKER

(In addition to those indicated in section-GTR)

Sl. no.	Parameter	765kV system	400kV system	220kV system	132 kV system	66 kV system
1.	Rated voltage (U max) kV (rms)	800	420	245	145	72.5
2.	Rated frequency (Hz)	50	50	50	50	50
3.	No. of poles	3	3	3	3	3
4.	Type of circuit breaker	SF6 gas insulated	SF6 gas insulated	SF6 gas insulated	SF6 gas insulated	SF6 gas insulated
5.	Rated continuous current (A) at an ambient temperature of 50^0C	3150/4000	2000/3150/ 4000 (as applicable)	2500	1250	1250
6.	Rated short circuit capacitywith percentage of DC component as per IEC- 62271-100 corresponding to minimum opening time under operating conditionsspecified.	50kA (As applicable)	40/50/63kA(As applicable)	50 kA	31.5kA	25kA
7.	Symmetrical interrupting capability kA (rms)	50	40/50/63 (As applicable)	50	31.5	25
8.	Rated short circuit making current kAp	125	100/125/ 157.5 (As applicable)	125	80	63
9.	Short time current carrying capability kA (rms)	50 for onesecond	40/50/63 As applicablefor one second	50kA for one second	31.5 for onesecond	25 for three second
10.	Out of phase breaking current carrying capability kA (rms)	12.5	10/12.5/15.75 (As applicable)	As per IEC	As per IEC	As perIEC
11.	Rated line charging interrupting current at 90 deg. Leading power factor angle (A rms) (The breaker shall be able to interrupt the rated line charging current with test voltage immediately before opening equal to the product of U/ 3 and 1.4 asper IEC-62271-100	900	600	As per IEC	As per IEC	As per IEC
12.	First pole to clear factor	1.3	1.3	1.3	1.3	1.5
13.	Temperature rise over an ambient temperatureof 50^0C	As per IEC: 62271-100	As per IEC: 62271-100	As per IEC: 62271-100	As per IEC: 62271-100	As per IEC: 62271-100
14.	Rated break time as IEC(ms)	40	40	60	60	Less than 75

15.	Total break time (ms)	45	45	65	65	Less than80
16.	Total closing time (ms)	Not morethan 150	Not morethan 150	Not morethan **150**	Not morethan **150**	Not morethan **150**
17.	Operating mechanism or a combination of these	Spring	Spring	Spring	Spring	Spring
18.	Rated operating duty cycle	O-0.3s-CO-3 min-CO	O-0.3s-CO-3 min-CO	O-0.3s-CO-3 min-CO	O-0.3s-CO-3 min-CO	O-0.3s-CO-3 min-CO
19.	Reclosing	Single phase &Three phase autoreclosing.	Single phase &Three phase auto reclosing.	Single phase &Three phase autoreclosing.	Three phase autoreclosing. (Single phase autoreclosing if specified in section-project)	Three phase auto reclosing.
20.	Pre-insertion resistor requirement	As per BPS	As per BPS	NA	NA	NA
i)	Rating (ohms)	450(max.)with toleranceas applicable	400(max.)with toleranceas applicable	NA	NA	NA
ii)	Minimum electrical (mechanical insertion time +pre-arcing time) pre-insertion time (ms)	9	8	NA	NA	NA
iii)	Opening of PIR contacts	PIR contacts should open immediately after closing of main contacts OR At least 5 ms prior to opening of main contacts at rated air/gas pressure where the PIR contacts remain closed	PIR contacts should open immediately after closing of main contacts OR At least 5 ms prior to opening of main contactsat rated air/gas pressurewhere the PIR contacts remain closed	NA	NA	NA
21.	Max. difference in the instants of closing/opening of contacts (ms) between poles at rated control voltage and rated operating & quenching mediapressures	2.5(within a pole) 3.3(opening) 5.0(closing)	2.5(within a pole) 3.3(opening) 5.0(closing)	3.3(opening) 5.0(closing)	3.3(opening) 3.3(closing)	As per IEC
22.	Maximum allowable switching over voltage under any switchingcondition	1.9 p.u.	2.3 p.u.	As per IEC	As per IEC	As per IEC

23.	Trip coil and closing coil voltage with variation as specified	220V DC	220V DC	220V DC	220V DC or 110V DC	220V DC or 110V DC
24.	Noise level at base and up to 50 m distance from base of circuit breaker	As per IEC	140dB (max.)	140dB (max.)	140dB (max.)	140dB (max.)
25.	Rating of Auxiliarycontacts	10A at 220V DC	10A at 220V DC	10A at 220V DC	10A at 220V DC	10A at 220V DC
26.	Breaking capacity of Aux. Contacts	2A DC with circuit time constant not less than 20ms	2A DC with circuit time constant notless than 20ms	2A DC with circuit time constant not less than 20ms	2A DC with circuit time constant not less than 20ms	2A DC with circuit time constant not less than 20ms
27.	**Rated insulation levels**					
i)	Full wave impulse withstand (1.2 /50 µs) between line terminals and ground	2100kVp	1425 kVp	1050 kVp	650 kVp	325 kVp
ii)	Full wave impulse withstand (1.2 /50 µs) between terminals with circuit breaker open	2100kVp impulse on one terminal & 455 kVp power frequency voltage of opposite polarity on the other terminal	1425 kVp impulse on one terminal & 240 kVp power frequency voltage of opposite polarity on the other terminal	1050 kVp	+ 650kVp	325 kVp
iii)	Rated switching impulse withstand voltage (250/2500 µs) Dry & wet between line terminals and ground	+ 1550kVp	+1050 kVp .	NA	NA	NA
iv)	Rated switching impulse withstand voltage (250/2500 µs) Dry &wet Between terminals with circuit breaker open	1175kVp impulse on one terminal & 650 kVp power frequency	900 kVp impulse on one terminal & 345 kVp power frequency	NA	NA	NA
		voltage of opposite polarity on the other terminal	voltage of opposite polarity on the other terminal			
v)	One minute power frequency dry withstand voltage between line terminals and ground	830kV rms	520 kV rms.	460 kV rms.	275 kV rms	140 kV rms
vi)	One minute power frequency dry withstand voltage between terminals with	1150kV rms	610 kV rms.	460 kV rms.	275 kV rms	160 kV rms

	circuit breaker open					
28.	Minimum corona extinction voltage with CB in all positions	508 kV rms	320kV rms	156 kV rms	92 kV rms	NA
29.	Max. radio interference voltage for frequency between 0.5 MHz and 2 MHz (Micro volts)	2500 µV (at 508kVrms)	1000 µV (at 266kVrms)	1000 µV (at 156kVrms)	500µV (at 92kVrms)	NA
30.	Minimum Creepagedistance*					
i)	Phase to ground(31mm/kV)	20000mm	10500mm	7595mm	4495mm	1813mm
ii)	Between CB terminals	18000mm	10500mm	7595mm	4495mm	1813mm
31.	System neutral earthing	Effectively earthed				
32.	Rated terminal load	As per IEC or as per the value calculated based on specific switchyard layout requirement, whichever is higher.				
33.	Auxiliary contacts	Besides requirement of technical specification, the manufacturer/contractor shall wire up 10 NO + 10 NC contacts exclusively for purchaser's use and wired up to common marshalling box.				
34.	No. of terminals in common marshalling box	All contacts & control circuits to be wired out up to common marshalling box + minimum 24 terminals exclusively for purchaser's future use				
35.	Seismic level	0.5g horizontal for the site location under the Zone-V as per IS-1893 0.3g horizontal for the site location under other than the Zone-V as per IS-1893				

***The values indicated are for specific creepage of 25mm/kV. In case of specific creepage of 31mm/kV specified, the Minimum Creepage distance values shall be considered proportionately.

7.12.0 PRE-COMMISSIONING TESTS

An indicative list of tests is given below. All routine tests except power frequency voltage dry withstand test on main circuit breaker shall be repeated on the completely assembled breaker at site. For Pre-commissioning tests, procedures and formats for circuit breakers, POWERGRID/AEGCL document no. CF/CB/03/R-4 dated 01/04/2013 of document no. D-2-01-03-01-04 dated 01-04- 2013 will be the reference document. This document will be available at respective sites and shall be referred by the contractor. Contractor shall perform any additional test based on specialties of the items as per the field Q.P./instructions of the equipment Supplier or Employer without any extra cost to the Employer. The Contractor shall arrange all instruments required for conducting these tests alongwith calibration certificates and shall furnish the list of instruments to the Employer for approval.

(a) Insulation resistance of each pole.

(b) Check adjustments, if any suggested by manufacturer.

(c) Breaker closing and opening time.

(d) Slow and Power closing operation and opening.

(e) Trip free and anti pumping operation.

(f) Minimum pick-up voltage of coils.

(g) Dynamic Contact resistance measurement.

(h) Functional checking of control circuits interlocks, tripping through protective relays and auto reclose operation.

(i) Insulation resistance of control circuits, motor etc.

(j) Resistance of closing and tripping coils.

(k) SF6 gas leakage check.

(l) Dew Point Measurement

(m) Operation check of pressure switches and gas density monitor during gas filling.

(n) Checking of mechanical 'CLOSE' interlock, wherever applicable.

(o) Testing of grading capacitor.

(p) Resistance measurement of main circuit.

(q) Checking of operating mechanisms

(r) Check for annunciations in control room.

(s) Point of wave switching test (wherever applicable)

The contractor shall ensure that erection, testing and commissioning of circuit breaker shall be carried out under the supervision of the circuit breaker manufacturer's representative. The commissioning report shall be signed by the manufacturer's representative.

7.13.0 ACTIONS REQUIRED FOR DEFECTS OBSERVED DURING DEFECT LIABILITY PERIOD

The actions required to be taken by contractor in case of defects observed in AIS type Circuit Breakers of ratings 132kV & above during the warranty period (defect liability period) shall be as per following. Further, the replaced/repaired/ refurbished equipment (or part of equipment) shall have warranty in line with the GCC clause 22 in SCC.

Sl.no.	Nature of problem	Corrective measures to be taken by contractor
1.	Blasting of interrupter, PIR, pole column,	Replacement of compete CB pole Including SF6 gas
	a. Abnormal DCRM and Travel Measurement b. Contact assembly and internal component damage, misalignment not leading to complete failure of interrupter/ PIR	Repair/replacement of affected assembly/ component based on repair procedure approved by QA

2.	Crack in insulator, cementing joint of interrupter ,PIR , pole column	Replacement of affected part
3.	SF6 gas leakage from sealing and bolted joints. SF6 gas leakage detectable by any Leakage Detection Method	Rectification by replacement of gasket, O-ring, sealing, Interrupter or affected part to be replaced etc If unable to arrest the leakage in 02 attempts, replacement of interrupter/column
4.	SF6 gas low dew point: > (-)35 deg C at atmospheric pressure.	Re-conditioning of gas. If does not improve, complete evacuation of CB, replacement filter material and gas
5.	Oil leakage of grading capacitor Change in Capacitance value beyond +/- 5 % w.r.t. to value of Capacitance obtained at site during pre-commissioning test.	Replacement or Refurbishment of grading capacitor
6.	Pole/ break discrepancy (during O&M)Limits: Break to Break (Opening/Closing) : max. 2.5 ms Phase to Phase (Opening) : max. 3.33 ms Phase to Phase (Closing) : max 5 ms	Rectification/replacement of affectedparts
7.	Static Contact Resistance: increase >50% from factory/ pre-commissioning value or >75 micro-ohm/ break whichever is lower	Rectification/Replacement of pole
8.	Drive mechanism assembly failure	Rectification/ Replacement of affectedpart
9.	Trip/ close coil, density monitor, relays and contactors and components of common MB	Replacement of affected part

Note:

1) Replaced/Repaired/Refurbished Equipment (or part of equipment) shall have 2 years warranty without prejudice to contractual warranty period

2)The measurement at site shall be carried out as per POWERGRID/AEGCL standard Pre-commissioning procedures as indicated in Technical Specification.

SECTION-8

TECHNICAL SPECIFICATION OF OUTDOOR CURRENT AND POTENTIAL TRANSFORMERS

8.1.0 SCOPE

8.1.1 This Section of the Specification covers general requirements for design, engineering, manufacture, assembly and testing at manufacturer's works of Live Tank type outdoor Current and Potential Transformers, also referred to as Instrument transformers.

8.1.2 Loading at manufacturer's works, transportation and delivery at respective substation site including unloading at destination site.

8.1.3 Erection, Testing and Commissioning of Instrument Transformers.

8.2.0 GENERAL

The instrument transformers and accessories shall conform to the latest version of the standards specified below except to the extent explicitly modified in this specification and shall be in accordance with the requirements in Section-GTR.

Current Transformers (CT): IEC: ***61869-1 & 61869-2*** or IS: 2705 ***Part-1 to 4***

Capacitive Voltage Transformers (CVT): IEC: ***61869-1, 61869-5*** & IEC- 60358 ***or IS-3156 Part-1 to 4***

Inductive Voltage Transformers (IVT): IEC: ***61869-1 & 61869-3 or IS-3156 Part-1 to 3***

The instrument transformers shall be designed for use in geographic and meteorological conditions as given in Section-GTR **and Section-Project.**

8.3.0 CONSTRUCTION FEATURES:

The features and constructional details of instrument transformers shall be in accordance with requirements stipulated hereunder:

a) Instrument transformers of **800kV/420kV/245kV/145kV/72.5** kV class, shall be oil filled/SF_6 gas filled, suitable for outdoor service and upright mounting on steel structures. **245kV, 420kV and** 800kV CT shall be with polymer insulator.

b) Bushings/Insulators shall conform to requirements stipulated in Section-GTR. The bushing/insulator for CT shall be one piece without any metallic flange joint.

c) Oil filling and drain plugs, oil sight glass shall be provided for CT & IVT. Oil sight glass shall be provided for electromagnetic unit of CVT. ***The Instrument transformer shall have cantilever strength of not less than 500 kg, 500 kg, 350 kg, 350 kg and 250 kg respectively for 800kV, 420kV, 245kV, 145kV and 72.5kV Instrument Transformers.*** For CVT/IVT with polymer housing, the cantilever strength shall not be less than 150kg. Oil filling and drain plugs are not required for SF_6 gas filled CT/IVT.

d) Instruments transformers shall be hermetically sealed units. The details of the arrangements made for the sealing of instrument transformers shall be furnish during detailed engineering.

e) Polarity marks shall indelibly be marked on each instrument transformer and at the lead terminals at the associated terminal block.

f) SF_6 gas filled CT/IVT shall be provided with a suitable SF_6 gas density monitoring device, with NO/NC contacts to facilitate the remote annunciation and tripping in case of SF_6 gas leakage. Provisions shall be made for online gas

filling. Suitable rupture disc shall be provided to prevent explosion.

g) The instrument transformers shall be complete with its terminal box and a common marshalling box for a set of 3 instrument transformers.

h) The external surface of instrument transformer, if made of steel, shall be hot dip galvanized or painted as per Section-GTR. External surface of aluminum can have natural finish.

i) The impregnation details alongwith tests/checks to ensure successful completion of impregnation cycle shall be furnished for approval.

Terminal box/Marshalling Box:

Terminal box/**Marshalling Box** shall conform to the requirements of Section- GTR.

8.4.0 Insulating Oil/Gas:

a) Insulating oil to be used for instrument transformers shall be of EHV grade and shall conform to IS-335/IEC-60296 (required for first filling). Non–PCB based synthetic insulating oil conforming to IEC 60867 **shall** be used in the capacitor units of CVT.

b) The SF_6 gas shall comply with IEC-60376, 60376A, 60376B **& IEC- 60480** and shall be suitable in all respects for use in the switchgear under operating conditions.

Name Plate:

Name plate shall conform to the requirements of IEC incorporating the year of manufacture. The rated current **&** extended current rating in case of current transformers and rated voltage, voltage factor **& intermediate voltage** in case of voltage transformers shall be clearly indicated on the name plate.

8.5.0 CURRENT TRANSFORMERS:

a) Current transformers shall have single primary either ring type or hair pin type and suitably designed for bringing out the secondary terminals

In a weather proof (IP-55) terminal box at the bottom. PF **(Tan delta)** terminal formeasurement of tan delta and capacitance of the unit shall be provided. These secondary terminals shall be terminated to stud type non disconnecting terminal blocks inside the terminal box.

In case of inverted type **(Live Tank)** current transformers, the manufacturer shall meet following additional requirements:

(i) The primary conductor shall preferably be of bar type meeting the desired characteristics.

(i) The secondaries shall be totally encased in metallic shielding providing a uniform equipotential surface for even electric field distribution.

(ii) The lowest part of the insulation assembly **i.e. insulation at neck** shall be properly secured to avoid any risk of damage due to transportation stresses.

(iii) The upper part of insulation assembly resting on primary bar shall be properly secured to avoid any damage during transportation due to relative movement between insulation assembly & top dome.

(iv) Bellows made of stainless steel shall be used at the top for hermetic sealing of CT.

(v) Bidder/Manufacturer shall recommend whether any special storage facility is required for spare CT.

b) Different ratios specified shall be achieved by secondary taps only and primary reconnection shall not be accepted.

c) Core lamination shall be of cold rolled grain oriented silicon steel or other equivalent alloys. μ metal or nano-crystalline core can also be used for metering cores.

d) The expansion chamber at the top of the porcelain insulators should be suitable for expansion of oil.

e) Facilities shall be provided at terminal blocks in the marshalling box for star delta formation, short circuiting and grounding of CT secondary terminals.

f) Current Transformer's guaranteed burdens and accuracy class are to be intended as simultaneous for all cores.

g) The rated extended currents for 800kV and 420kV class Current transformers shall beas given below:

Tap Ratio	**800kV, 3000A**	**400kV, 3000A**
	Rated extended currents in % of rated current	
500/1	200	200
1000/1	---	---
2000/1	180	180
3000/1	120 (200 for 15 min)	120

h) The secondary winding shall be rated for 2A continuously.

Further, the intermediate tapping at 3000-2000 of metering core of 3000 A rated 400kV and 800kV CTs shall be suitable for using as 1000/1 ratio **also**. The Auxiliary reactor,**if used,** as referred at wiring diagram No.0000-000-T-E-L-028 shall be suitable for connecting to the selected taps. The requirements of 3000A CTs are given at TABLE II- A.

For 245/145/**72.5**kV class CTs, the rated extended primary current shall be 120% (or 150% if applicable) on all cores of the CTs.

i) For 800/420/245/145/**72.5**kV Current Transformer, characteristics shall be such as to provide satisfactory performance of burdens ranging from 25% to 100% of rated burden over a range of 5% to 120% (or specified rated extended current whichever ishigher) of rated current in case of metering CTs and up to the accuracy limit factor/knee point voltage in case of relaying CTs.

j) The current transformer shall be suitable for horizontal transportation. It shall be ensured that the CT is able to withstand all the stresses imposed on it while transporting and there shall be no damage in transit. The Contractor shall submit the details of packing **and transportation** design to the Employer for review.

k) For 800kV CTs, the instrument security factor at all ratios shall be less than ten (10) for metering core. For 420/245/145/**72.5**kV CTs, the instrument security factor at all ratiosshall be less than five (5) for metering core. If any auxiliary CTs/reactor are used in thecurrent transformers then all parameters specified shall have to be met treating auxiliary CTs as an integral part of the current transformer. The auxiliary CTs/reactor shall preferably be

inbuilt construction of the CTs. In case these are to be mounted separately these shall be mounted in the central marshalling box suitably wired upto the terminal blocks.

l) The wiring diagram plate for the interconnections of the three single phase CTs shall be provided inside the marshalling box. A typical wiring diagram no. 0000-000-T-E-L-028 (Sh.1 & 2) is enclosed herewith at Annexure-III **of this specification**.

m) The Current Transformers should be suitable for mounting on lattice structure (for 800 kV) or pipe structure (for 420 kV and below) to be provided by the Contractor in accordance with stipulations of Section-Project/**Section-Structures.**

n) The CT shall be designed so as to achieve the minimum risks of explosion in service. Bidder/Manufacturer shall bring out in his offer, the measures taken to achieve this.

o) 800/420/245/145kV Current Transformers shall be suitable for high speed auto reclosing.

8.6.0 VOLTAGE TRANSFORMERS:

a) 800/420/245/145kV Voltage Transformers shall be capacitor voltage divider type with electromagnetic units and shall be suitable for carrier coupling.

b) Voltage transformers secondaries shall be protected by HRC cartridge type fuses or MCBs for all the windings. In addition, fuses/MCBs shall be provided for the protection and metering windings for fuse monitor- ing scheme. The secondary terminals of the VTs shall be terminated to the stud type non-disconnecting terminal blocks in the individual phase secondary boxes via the fuse/MCBs.

c) CVTs shall be suitable for high frequency (HF) coupling required for power line carrier communication. Carrier signal must be prevented from flowing into potential transformer (EMU) circuit by means of a RF choke/reactor suitable for effectively blocking the carrier signals over the entire carrier frequency range i.e. 40 to 500 KHz.

H.F. terminal of the CVT shall be brought out through a suitable bushing and shall be easily accessible for connection to the coupling filters of the carrier communication equipment, when utilized. Further, earthing link with fastener to be provided for HF terminal.

d) The electromagnetic unit comprising compensating reactor, intermediate transformer and protective and damping devices should have separate terminal box with all the secondary terminals brought out.

e) The damping device, which should be permanently connected to one of the secondary windings, should be capable of suppressing the ferroresonance oscillations.

f) The accuracy of 0.2 on secondary III for all CVTs/IVTs should be maintained through out the entire burden range upto 50 VA on all the windings without any adjustments during operation.

g) The Voltage Transformers shall be suitable for mounting on lattice structure (for 800kV) or Pipe structure (for 420kV and below) to be provided by the Contractor in accordance with stipulations of Section-Project/Section-Structures.

h) It should be ensured that access to secondary terminals is without any danger of access to high voltage circuit.

i) A protective surge arrester shall be provided, if required, to prevent breakdown of insulation by incoming surges and to limit abnormal rise of terminal voltage of shunt capacitor/primary winding, tuning reactor/RF choke etc. due to short circuit in transformer secondaries. Alternate arrangement shall also be acceptable.

j) The wiring diagram for the interconnection of the three single phase CVTs/IVTs shall be provided inside the marshalling box in such a manner that it does not deteriorate with time. Wiring diagram no.: 0000-000-T-E-L-029

enclosed herewith at Annexure-IV of this specification shall be followed.

8.6.1 TERMINAL CONNECTORS:

The terminal connectors shall meet the requirements as given in Section-GTR and **technical parameters for the respective equipment as per Annexure- I and Annexure-II of this specification.**

8.7.0 TESTS

In accordance with the requirements in Section-GTR, Current Transformer and Voltage Transformer should have been type tested and shall be subjected to routine tests in accordance with **relevant IEC.**

The test reports of type tests, as applicable, as per IEC-61869-2 for CT, IEC-61869-5/IEC- 60358 for CVT, and IEC-61869-3 for IVT **and following additional tests shall be submitted for the Employer's review.** The type tests for which the procedure is under consideration as per above said IEC is not required to be considered.

8.7.1 Current Transformers (CT):

i) Corona test as per Annexure-A of Section-GTR **for 420kV and above voltage rating.**

ii) RIV test as per IEC-61869 or as per Annexure-A of Section- GTR for 145kV and above voltage rating. However, RIV level shall be as specified at Annexure-II of this specification.

iii) Seismic withstand test as per Annexure-B of Section-GTR **or IEC- 62271-2 (with Seismic acceleration requirement as per Annexure-I of thisspecification/Section-Project) for 145kV and above voltage rating.**

iv) Thermal stability test, i.e. application of rated voltage and rated extended thermal current simultaneously by synthetic test circuit **for 145kV and above voltage rating** (not applicable for SF_6 filled CT).

v) Thermal co-efficient test i.e. measurement of tan-delta as a function of temperature (at ambient and between 80^oC & 90^oC) and voltage (at 0.3, 0.7, 1.0 and 1.1 Um/√3) **for 145kV and above voltage rating** (not applicable for SF_6filled CT).

vi) Multiple chopped impulse test (not applicable for SF_6 filled CT) with theapplication of 600 chopped impulses **for 145kV and above voltage rating**.

vii) Transmitted over voltage test for 145kV and above voltage rating

viii) **Mechanical test (with minimum Cantilever load as per clause no. 2.1.c) for 145kV and above voltage rating**

ix) **Internal Arc fault test for 145kV and above voltage rating** (not applicable for CT with Polymer Insulator)

x) **E**nclosure tightness test at low & high temperature for SF_6 filled CT of 145kV and above voltage rating

xi) Gas dew point test for SF6 filled CT

xii) Corrosion test for 145kV and above voltage rating

8.7.2 Capacitive Voltage Transformers (CVT):

i) High frequency capacitance and equivalent series resistance measurement (as per IEC-60358)

ii) Seismic withstand test (as per Annexure-B of Section-GTR) ***or IEC-62271-2*** **(with Seismic acceleration requirement as per Annexure-II of this specification/Section-Project) for 145kV and above voltage class.**

iii) Stray capacitance and stray conductance measurement of the low voltage terminal (as per IEC-60358)

iv) Corona test as per Annexure-A of Section-GTR **for 420kV and above voltagerating**.

v) RIV test as per IEC-61869 or as per Annexure-A of Section- GTR for 145kV andabove voltage rating. However, RIV level shall be as specified at Annexure-II ofthis specification.

vi) Transmitted over voltage test for 145kV and above voltage rating

vii) Mechanical test (with minimum Cantilever load as per clause no. 2.1.c) for72.5kV and above voltage rating

viii) Determination of Temperature coefficient for 145kV and above voltage rating

ix) Tightness design test of capacitor units for 145kV and above voltage rating

x) Corrosion test for 145kV and above voltage rating

8.7.3 Inductive Voltage Transformers (IVT):

i) Seismic withstand test (as per Annexure-B of Section-GTR) ***or IEC-62271-2*** **(with Seismic acceleration requirement as per Annexure-II of this specification/Section-Project) for 145kV and above voltage rating.**

ii) Corona test as per Annexure-A of Section-GTR **for 420kV and above voltagerating**.

iii) RIV test as per IEC-61869 or as per Annexure-A of Section- GTR for 145kV andabove voltage rating. However, RIV level shall be as specified at Annexure-II of this specification.

iv) Multiple chopped impulse test with application of 600 chopped impulses for 145kV and above voltage rating (not applicable for SF6 filled CT).

v) Transmitted over voltage test for 145kV and above voltage rating

vi) Mechanical test (with minimum Cantilever load as per clause no. 2.1.c) for 72.5kV and above voltage rating

vii) Enclosure tightness test at low & high temperature for SF_6 filled CT of 145kV and above voltage rating

viii) Gas dew point test for SF_6 filled CT

ix) Corrosion test for 145kV and above voltage rating

x) Measurement of Capacitance and Dielectric dissipation factor for 145kV and above voltage rating

The current and voltage transformer shall be subjected to the following routine tests inaddition to routine tests as per ***relevant*** IEC

8.7.4 CURRENT TRANSFORMERS:

ROUTINE TESTS:

<u>For Oil filled CT</u>:

i) Measurement of Capacitance.
ii) Oil leakage test.
iii) Measurement of tan delta at 0.3, 0.7, 1.0 and 1.1 Um/√3.

<u>For SF6 filled CT:</u>

i) Dew point measurement

ii) SF_6 alarm/ lockout check.
iii) SF_6 gas leakage test: Gas leakage rate shall be maintained within 0.2% per annum.

8.7.5 VOLTAGE TRANSFORMERS:
Routine tests on CVT/IVT shall be done in line with IEC-61869-3/61869-5.

8.8.0 MANDATORY SPARES:
Bidder shall include in his proposal mandatory spares as mentioned in the Bidding Documents.

8.9.0 MAJOR TECHNICAL PARAMETERS:
Major technical parameters for 800kV/420kV/245kV/145kV/72.5kV Instrument Transformers are enclosed at Annexure-I and Annexure-II to this specification.

PRE-COMMISSIONING TESTS

An indicative list of tests is given below. Contractor shall perform any additional test based on specialties of the items as per the field Q.P./Instructions of the equipment Supplier or Employer without any extra cost to the Employer. The Contractor shall arrange all instruments required for conducting these tests alongwith calibration certificates at his own cost

Current Transformers

(a) Insulation Resistance Test for primary and secondary

(b) Polarity test

(c) Ratio identification test - checking of all ratios on all cores by primary injection of current

(d) Dielectric test of oil (wherever applicable)

(e) Magnetizing characteristics test

(f) Tan delta and capacitance measurement

(g) Secondary winding resistance measurement

(h) Contact resistance measurement (wherever possible/accessible)

(i) Test for SF6 (for SF6 filled CTs) – Dew point measurement, SF6 alarm/ lockout check

(j) DGA test of oil

Dissolved Gas Analysis (DGA) shall be carried out twice within the first year of service, first within the first month of commissioning/charging and second between six months to one year from the date of commissioning/charging.

CTs/IVTs must have adequate provision for taking oil samples from the bottom of the CT/IVT without exposure to atmosphere. Manufacturer shall recommend the frequency at which oil samples should be taken and norms for various gases in oil after being in operation for different durations. ~~Bidder/~~Manufacturer should also indicate the total quantity of oil which can be withdrawn from CT for gas analysis before refilling or further treatment of CT becomes necessary.

Bidder shall supply 2 nos. oil sampling device for every 20 nos. oil filled CT supplied with a minimum of 2 nos. oil sampling device for each substation.

Inductive Voltage Transformers/Capacitive Voltage Transformers

(a) Insulation Resistance test for primary (if applicable) and secondary winding
(b) Polarity test
(c) Ratio test
(d) Dielectric test of oil (wherever applicable)
(e) Tan delta and capacitance measurement of individual capacitor stacks
(f) Secondary winding resistance measurement

For pre-commissioning procedures and formats for Current Transformers, Doc.No.: CF/CT/04/R-4 dtd-01.04.2013 and for Voltage Transformers, CF/CVT/05/R-4 dtd-01.04.2011 under POWERGRID document no. D-2-01- 03-01-04 will be the reference document. **This document will be available at respective sites and shall be referred by the contractor.**

8.10.0 Defect Liability

The actions required to be taken by contractor in case of defects observed in CT/CVT of ratings 145kV & above during the warranty period (defect liability period) shall be as per enclosed Annexure-V of this specification. Further, the replaced/repaired/refurbished equipment (or part of equipment) shall have Two (2) years warranty without prejudice to contractual warranty period (defect liability period).

Table -IA
REQUIREMENTS OF 800 kV CAPACITIVE VOLTAGE TRANSFORMER

SL No	Particulars	Rating		
1	Rated primary voltage (kV rms)	800		
2	Type	Single phase Capacitor VT		
3	No. of secondaries	3		
4	Rated voltage factor	1.2 Continuous 1.5 - 30 seconds		
5	Phase angle error	± 10 minutes (For metering core)		
6	Capacitance (pf)	4400/8800* (+10% /- 5%)		
7	**Core Details**	**Core-1**	**Core-2**	**Core-3**
	a) Voltage Ratio	765/√3 : 0.11/√3	765/√3 : 0.11/√3	765/√3 : 0.11/√3
	b) Application	Protection	Protection	Metering
	c) Accuracy	0.5 & 3P	0.5 & 3P	0.2
	d) Min. Output burden (VA)	50	50	50

* Capacitance value shall be as specified in BPS.

Table -IB
REQUIREMENTS OF 420 kV VOLTAGE TRANSFORMER

SL No	Particulars	Rating
1	Rated primary voltage (kV rms)	420
2	Type	Single phase Electromagnetic or

		Capacitor VT		
3	No. of secondaries	3		
4	Rated voltage factor	1.2 Continuous 1.5 - 30 seconds		
5	Phase angle error	± 10 minutes (For metering core)		
6	Capacitance (pf)	4400/8800* (+10% /- 5%)		
7	**Core Details**	**Core-1**	**Core-2**	**Core-3**
	a) Voltage Ratio	400/√3 : 0.11/√3	400/√3 : 0.11/√3	400/√3 : 0.11/√3
	b) Application	Protection	Protection	Metering
	c) Accuracy	0.5 & 3P	0.5 & 3P	0.2
	d) Min. Output burden (VA)	50	50	50

* Capacitance value shall be as specified in BPS.

Table -IC

REQUIREMENTS OF 245 kV VOLTAGE TRANSFORMER

SL No	Particulars	Rating		
1	Rated primary voltage (kV rms)	245		
2	Type	Single phase Electromagnetic or Capacitor VT		
3	No. of secondaries	3 cores		
4	Rated voltage factor	1.2 Continuous 1.5 - 30 seconds		
5	Phase angle error	± 10 minutes (For metering core)		
6	Capacitance (pf)	4400/8800* (+10% /- 5%)		
7	**Core Details**	**Core-1**	**Core-2**	**Core-3**
	a) Voltage Ratio	400/√3 : 0.11/√3	400/√3 : 0.11/√3	400/√3 : 0.11/√3
	b) Application	Protection	Protection	Metering
	c) Accuracy	3P	3P	0.2
	d) Min. Output burden (VA)	50	50	50

* Capacitance value shall be as specified in BPS.

Table -ID

REQUIREMENTS OF 145 kV VOLTAGE TRANSFORMER

SL No	Particulars	Rating		
1	Rated primary voltage (kV rms)	145		
2	Type	Single phase Electromagnetic or Capacitor VT		
3	No. of secondaries	3 cores		
4	Rated voltage factor	1.2 Continuous 1.5 - 30 seconds		
5	Phase angle error	± 10 minutes (For metering core)		
6	Capacitance (pf)	8800 (+10% /- 5%)		
7	**Core Details**	**Core-1**	**Core-2**	**Core-3**
	a) Voltage Ratio	132/√3 : 0.11/√3	132/√3 : 0.11/√3	132/√3 : 0.11/√3

b) Application	Protection	Protection	Metering
c) Accuracy	3P	3P	0.2
d) Min. Output burden (VA)	50	50	50

Table -ID

REQUIREMENTS OF 72.5 kV VOLTAGE TRANSFORMER

SL No	Particulars	Rating	
1	Rated primary voltage (kV rms)	72.5	
2	Type	Single phase Electromagnetic or Capacitor VT	
3	No. of secondaries	2 cores	
4	Rated voltage factor	1.2 Continuous 1.5 - 30 seconds	
5	Phase angle error	± 20 minutes (For metering core)	
6	**Core Details**	**Core-1**	**Core-2**
	a) Voltage Ratio	**For 66 kV feeder application**	
		66/√3 : 0.11/√3	132/√3 : 0.11/√3
		For Tertiary loading (of ICT) application	
		33/√3 : 0.11/√3	33/√3 : 0.11/√3
	b) Application	Protection	Metering
	c) Accuracy	3P	0.5
	d) Min. Output burden (VA)	10	10

TABLE-IIA

REQUIREMENTS FOR 800 KV CURRENT TRANSFORMER

No. of Cores	Core No.	Application	Current Ratio	Output Burden (VA)	Accuracy Class	Min. Knee Pt. Voltage	Max. CT Sec. Wdg.Resistance (in Ω)	Max. Excit. Current at Vk (in mA
6	1	BUS DIFF. CHECK	3000-2000-500/1	-	PX	3000/ 2000/ 500	15/10/2.5	20 on 3000/1 TAP; 30 on 2000/1 TAP; 120 on 500/1 TAP
	2	BUS DIFF. MAIN	3000-2000-500/1	-	PX	3000/ 2000/ 500	15/10/2.5	20 on 3000/1 TAP; 30 on 2000/1 TAP; 120 on 500/1 TAP
	3	METERING	3000-2000-500/1	20	0.2S	-		-
	4	METERING	3000-2000-500/1	20	0.2S	-		-
	5	TRANSF DIFF/LINE	3000-2000-	-	PX	3000/ 2000/ 500	15/10/2.5	20 on 3000/1 TAP; 30 on

	PROTN	500/1					2000/1 TAP; 120 on 500/1 TAP
6	LINE PROTN/ LBB PROTN	3000-2000-500/1-	-	PX	3000/ 2000/ 500	15/10/2.5	20 on 3000/1 TAP; 30 on 2000/1 TAP; 120 on 500/1 TAP

Note:
1. Protection cores shall be of accuracy class PX as per IEC 61869.
2. Metering Core shall be of accuracy class 0.2S as per IEC: 61869

TABLE-IIB

REQUIREMENTS FOR 420 KV CURRENT TRANSFORMER

No. of Cores	Core No.	Application	Current Ratio	Output Burden (VA)	Accuracy Class	Min. Knee Pt. Voltage	Max. CT Sec. Wdg. Resisitance (in Ω)	Max. Excit. Current at Vk (in mA
6	1	BUS DIFF. CHECK	3000-2000-500/1	-	PX	3000/ 2000/ 500	15/10/2.5	20 on 3000/1 TAP; 30 on 2000/1 TAP; 120 on 500/1 TAP
	2	BUS DIFF. MAIN	3000-2000-500/1	-	PX	3000/ 2000/ 500	15/10/2.5	20 on 3000/1 TAP; 30 on 2000/1 TAP; 120 on 500/1 TAP
	3	METERING	3000-2000-500/1	20	0.2S	-		-
	4	METERING	3000-2000-500/1	20	0.2S	-		-
	5	TRANSF DIFF/LINE PROTN	3000-2000-500/1	-	PX	3000/ 2000/ 500	15/10/2.5	20 on 3000/1 TAP; 30 on 2000/1 TAP; 120 on 500/1 TAP
	6	LINE PROTN/ LBB PROTN	3000-2000-500/1	-	PX	3000/ 2000/ 500	15/10/2.5	20 on 3000/1 TAP; 30 on 2000/1 TAP; 120 on 500/1 TAP

Note:
1. Protection cores shall be of accuracy class PX as per IEC 61869.
2. Metering Core shall be of accuracy class 0.2S as per IEC: 61869

TABLE-IIC

REQUIREMENTS FOR 245 KV CURRENT TRANSFORMER

No. of Cores	Core No.	Application	Current Ratio	Output Burden (VA)	Accuracy Class	Min. Knee Pt. Voltage	Max. CT Sec. Wdg. Resisitance (in Ω)	Max. Excit. Current at Vk (in mA

5	1	BUS DIFF. CHECK	1600-1200-800/1	-	PX	1600/ 1200/ 800	8/6/4	25 on 1600/1 TAP; 50 on 800/1 TAP;
	2	BUS DIFF. MAIN	1600-1200-800/1	-	PX	1600/ 1200/ 800	8/6/4	25 on 1600/1 TAP; 50 on 800/1 TAP;
	3	METERING	1600-1200-800/1	20	0.2S	-		-
	4	TRANSF BACK UP/LINE PROTN.	1600-1200-800/1	-	PX	1600/ 1200/ 800	8/6/4	25 on 1600/1 TAP; 50 on 800/1 TAP;
	5	TRANSF DIFF/LINE PROTN	1600-1200-800/1	-	PX	1600/ 1200/ 800	8/6/4	25 on 1600/1 TAP; 50 on 800/1 TAP;

Note:
1. Protection cores shall be of accuracy class PX as per IEC 61869.
2. Metering Core shall be of accuracy class 0.2S as per IEC: 61869

TABLE-IID

REQUIREMENTS FOR 145 KV CURRENT TRANSFORMER

No. of Cores	Core No.	Application	Current Ratio	Output Burden (VA)	Accuracy Class	Min. Knee Pt. Voltage	Max. CT Sec. Wdg. Resisitance (in Ω)	Max. Excit. Current at Vk (in mA
5	1	BUS DIFF. CHECK	800-400/1	-	PX	800/400	8/4	25 on 800/1 TAP; 50 on 400/1 TAP
	2	BUS DIFF. MAIN	800-400/1	-	PX	800/400	8/4	25 on 800/1 TAP; 50 on 400/1 TAP
	3	METERING	800-400/1	20	0.2S	-		-
	4	TRANSF BACK UP/LINE PROTN.	800-400/1	-	PX	800/400	8/4	25 on 800/1 TAP; 50 on 400/1 TAP
	5	TRANSF DIFF/LINE PROTN	800-400/1	-	PX	800/400	8/4	25 on 800/1 TAP; 50 on 400/1 TAP

Note:
1. Protection cores shall be of accuracy class PX as per IEC 61869.
2. Metering Core shall be of accuracy class 0.2S as per IEC: 61869

TABLE-IIE

REQUIREMENTS FOR 145 KV CURRENT TRANSFORMER

No. of Cores	Core No.	Application	Current Ratio	Output Burden (VA)	Accuracy Class	Min. Knee Pt. Voltage	Max. CT Sec. Wdg. Resisitance (in Ω)	Max. Excit. Current at Vk (in mA
5	1	BUS DIFF. CHECK	600-300/1	-	PX	600/300	6/3	30 on 600/1 TAP; 60 on 300/1 TAP
	2	BUS DIFF. MAIN	600-300/1	-	PX	600/300	6/3	30 on 600/1 TAP; 60 on 300/1 TAP
	3	METERING TRANSF	300-150/1	20	0.2S	-		-
	4	BACK UP/LINE PROTN.	600-300/1	-	PX	600/300	6/3	30 on 600/1 TAP; 60 on 300/1 TAP
	5	TRANSF DIFF/LINE PROTN	600-300/1	-	PX	600/300	6/3	30 on 600/1 TAP; 60 on 300/1 TAP

Note:

1. Protection cores shall be of accuracy class PX as per IEC 61869.

2. Metering Core shall be of accuracy class 0.2S as per IEC: 61869

TABLE – IIF

REQUIREMENTS FOR 72.5 kV CURRENT TRANSFORMER (FOR TERTIARY LOADING OF ICT)

No. of Cores	Core No.	Application	Current Ratio	Output Burden (VA)	Accuracy Class
2	1	O/C & E/F	50/1	10	5P10
	2	METERING	50/1	10	0.5

Annexure-I

MAJOR TECHNICAL PARAMETERS FOR CT

S. No.	Description	765kV system	400kV system	220kV system	132 kV system	66 kV System (for Tertiary loading)
1	Rated voltage,U_m (kVrms)	800	420	245	145	72.5
2	Rated frequency (Hz)	50	50	50	50	50
3	No. of Poles	1	1	1	1	1
4	Design ambient temperature (°C)	50	50	50	50	50
5	Rated Primary Current (A)	3000	3000	1600	800/600	50
6	Rated extended primary current	120%	120%	120%/150%	120%/150%	120%
7	Rated short time thermal withstand current	40kA/50kA (as applicable) for 1 sec	40kA/50kA/63kA (as applicable) for 1 sec	50kA for 1sec	31.5kA for1sec	25kA for3sec
8	Rated dynamiccurrent	100kAp/125kAp(as applicable)	100kAp/125kAp/ 157.5kAp (as applicable)	125kAp	80kAp	63kAp
9	Temperature rise over design ambient temperature	As per IEC				
10	Rated Insulation levels					
a)	Full wave impulse withstand voltage (1.2/50 microsecond)					
i)	between line terminals and ground(kVpeak)	±2100	±1425	±1050	±650	±325
b)	Switching impulse withstand voltage (250/2500 microsecond) (dry and wet)					
i)	between line terminals and ground (kVpeak)	± 1550	± 1050	-NA-	-NA-	-NA-
c)	One minute power frequency dry withstand voltage (dry and wet)					
i)	between line terminals and ground (kVrms)	975 (dry only)	630 (dry only)	460	275	140
d)	One minute power frequency withstand voltage between secondary terminals & earth (kVrms)	5kV				
11	Max. radio interference voltage for frequency between0.5 MHz and 2	2500 at 508 kV rms	1000 at 266kV rms	1000 at 156kV rms	500 at 92kV rms	-NA-

	MHz at (microvolts)					
12	Minimum Corona extinction voltage (kVrms)	508	320	-NA-	-NA-	-NA-
13	Seismic acceleration (Horizontal)	0.3g	0.3g	0.3g	0.3g	-NA-
14	Partial Discharge	As per IEC	As per IEC	As per IEC	As per IEC	As per IEC
15	Number of terminals	All terminals of control circuits are to be wired up to marshaling box plus 20% spare terminals evenly distributed on all TBs.				
16	Minimum Creepage distance (mm) *	20000	10500	7595	4495	1813
17	System neutral earthing	Effectively Earthed				

For other parameters, refer respective Table for the applicable voltage class of CTs.

Annexure-II

MAJOR TECHNICAL PARAMETERS FOR CVT/IVT

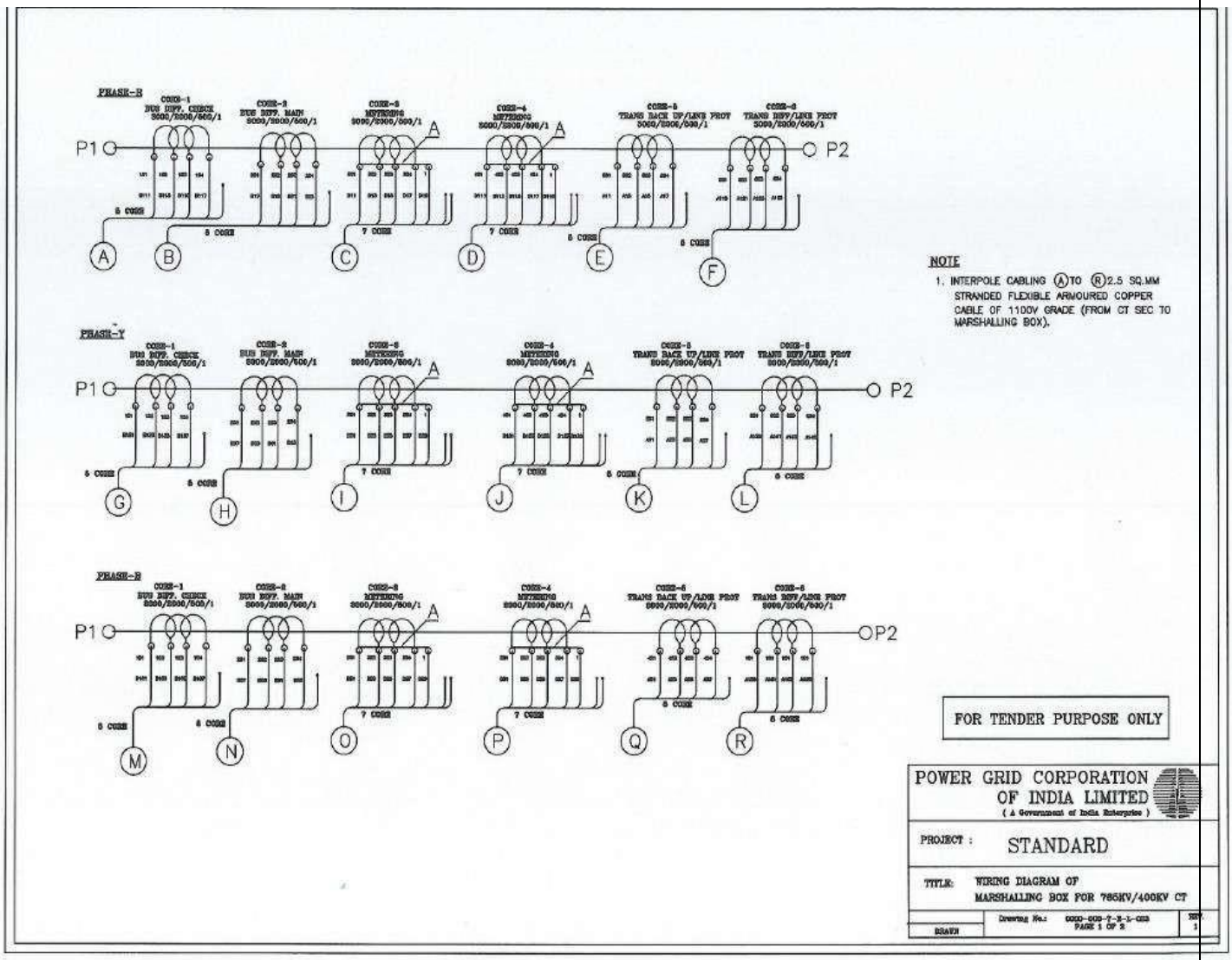
S. No.	Description	765kV system	400kV system	220kV system	132 kV system	66 kV System (for tertiary loading)
1	Type (CVT/IVT)	**CVT**	**CVT/IVT**	**CVT/IVT**	**CVT/IVT**	**CVT/IVT**
2	Rated voltage, U_m (kVrms)	800	420	245	145	72.5
3	Rated frequency (Hz)	50	50	50	50	50
4	No. of Poles	1	1	1	1	1
5	Design ambient temperature (°C)	50	50	50	50	50
6	System fault level(kA)	40kA/50kA (as applicable) for 1 sec	40kA/50kA/63kA (as applicable) for1 sec	50kA for 1sec	.5kA for1sec	5kA for3sec
6	Standard reference rangeof frequencies for which the accuracies are valid	96% to 102% for protection and 99% to 101% for measurement				
7	High frequency capacitance for entire carrier frequency range (for CVT only)	Within 80% to 150% of rated capacitance				-
8	Equivalent series resistance over entire carrier frequency range (for CVT)	Less than 40 Ohms				-
9	Stray capacitance and stray conductance of HF terminal over entire carrier frequency range (for CVT)	As per IEC-60358				-
10	Temperature rise over design ambient temperature	As per IEC				
11	Rated Insulation levels					
a)	Full wave impulse withstand voltage (1.2/50 microsecond)					
i)	between line terminals and ground (kVpeak)	±2100	±1425	±1050	±650	±325
b)	Switching impulse withstand voltage (250/2500 microsecond) (dry and wet)					

i)	between line terminals and ground (kVpeak)	± 1550	± 1050	-NA-	-NA-	-NA-
c)	One minute power frequency dry withstand voltage (dry and wet)					
i)	between line terminals and ground (kVrms)	975 (dry only)	630 (dry only)	460	275	i)
d)	One minute power frequency withstand voltage between secondary terminals & earth					
i)	between LV (HF) terminal and earth terminal (kVrms)	10kVrms for exposed terminals and 4kVrms for terminals enclosed in a weather proof box				
ii)	For secondarywinding	3kVrms				
11	Max. radio interference voltage for frequency between0.5 MHz and 2 MHz at (microvolts)	2500 at 508 kV rms	1000 at 266kV rms	1000 at 156kV rms	500 at 92kV rms	-NA-
12	Minimum Corona extinction voltage (kVrms)	508	320	-NA-	-NA-	-NA-
13	Seismic acceleration (Horizontal)	0.3g	0.3g	0.3g	0.3g	-NA-
14	Partial Discharge	As per IEC	As per IEC	As per IEC	As per IEC	As per IEC
15	Number of terminals	All terminals of control circuits are to be wired up to marshaling boxplus 20% spare terminals evenly distributed on all TBs.				
16	Rated Total Thermal Burden (VA)	300 VA (100VA/winding)				20VA
17	System neutralearthing	Effectively Earthed				
18	Minimum Creepage distance (mm) *	20000	10500	7595	4495	1813

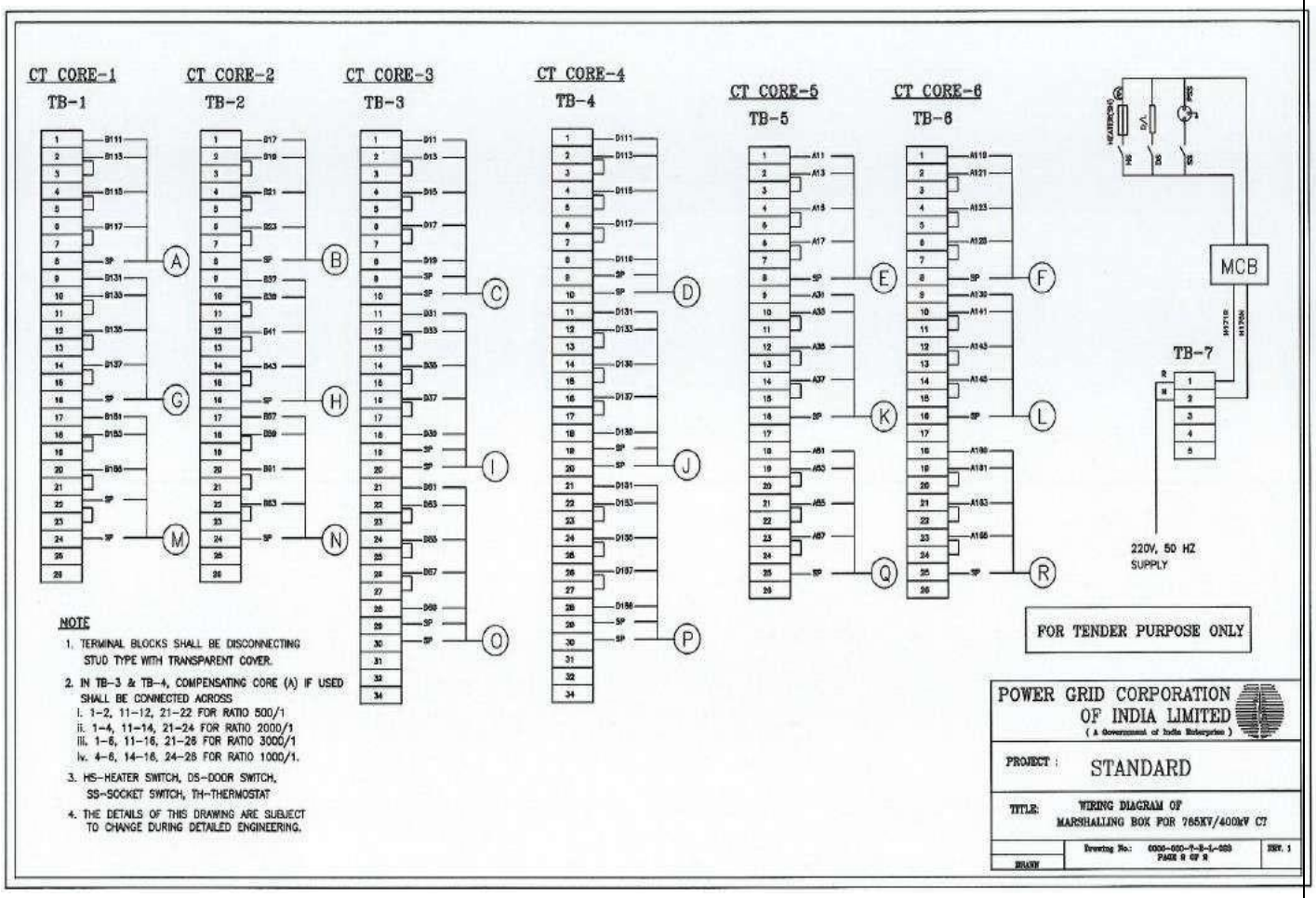
*The values indicated are for specific creepage of 25mm/kV. In case of specific creepage of 31mm/kV is specified, the Minimum Creepage distance values shall be considered proportionately.

For other parameters, refer respective Table for the applicable voltage class of CVTs/IVTs.

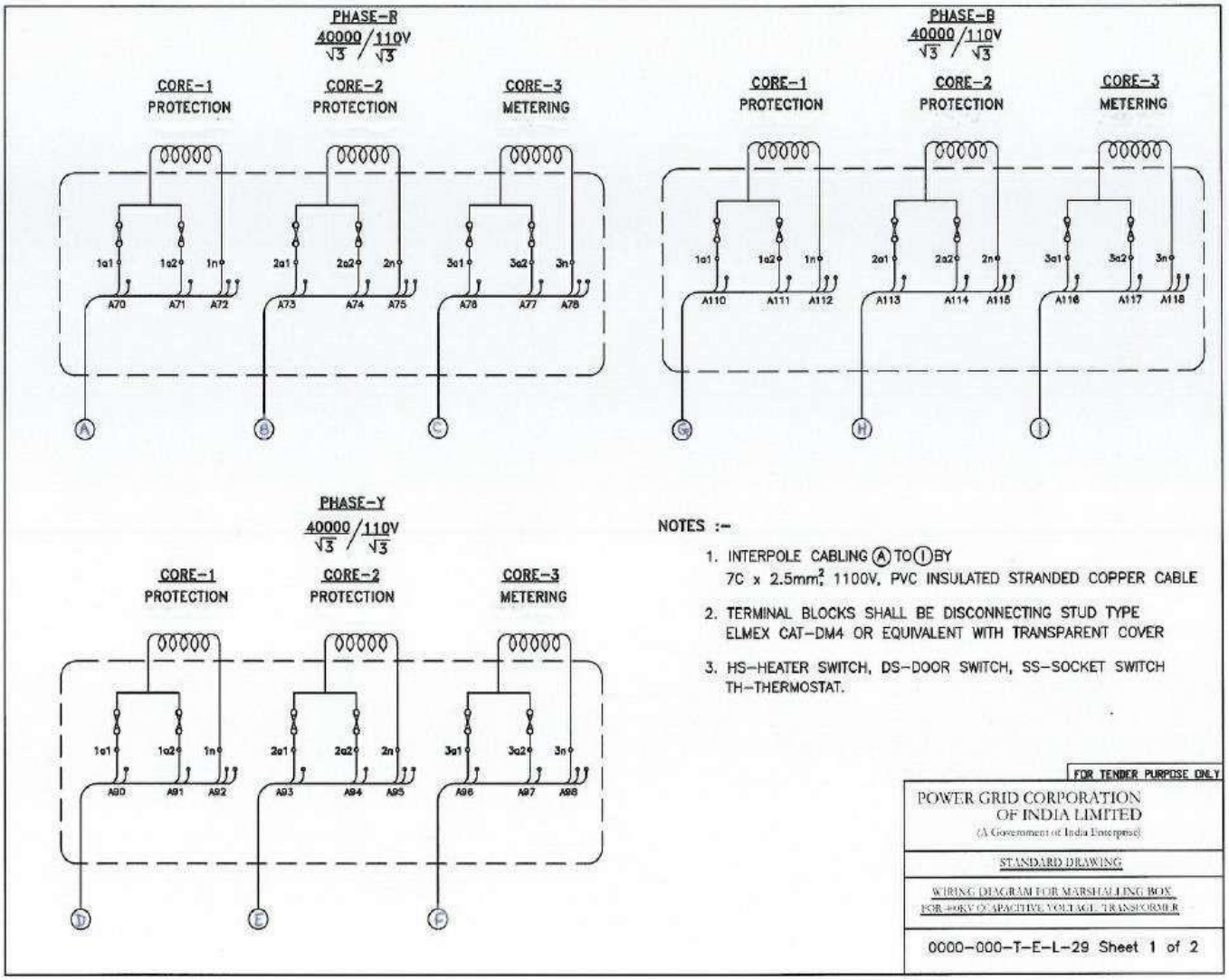
Annexure-III: Wiring Diagram of CT



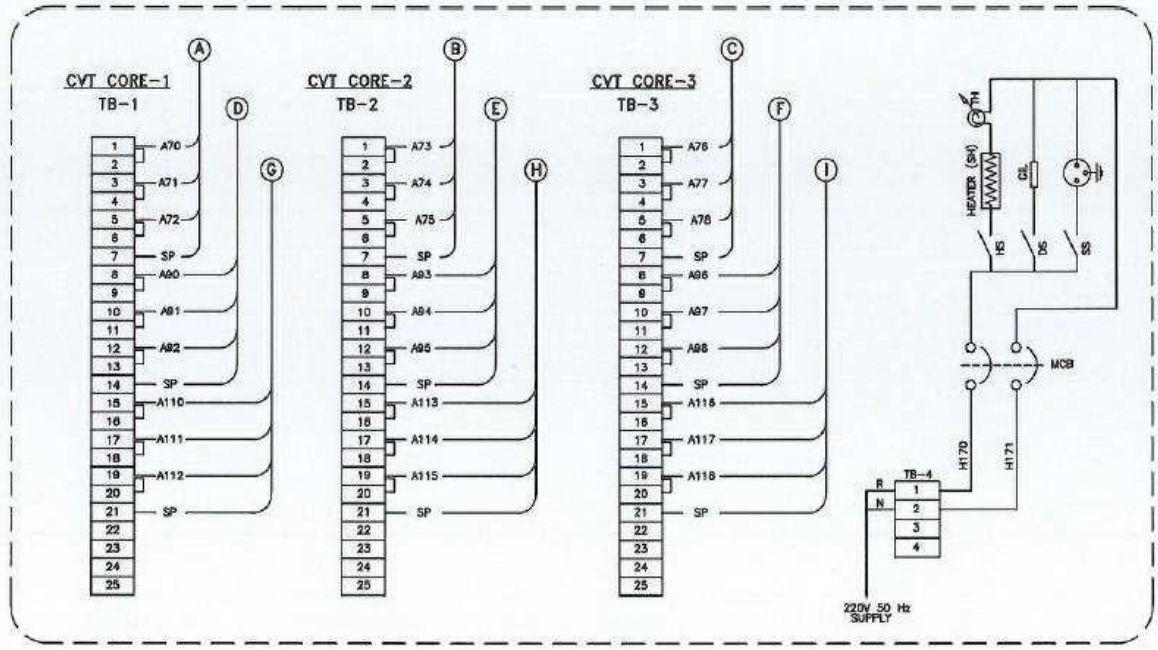
Annexure-III: Wiring Diagram of CT



Annexure-IV: Wiring Diagram of VT



Annexure-IV: Wiring Diagram of VT



CVT MARSHALLING BOX

NOTES :-

1. INTERPOLE CABLING Ⓐ TO Ⓘ BY 7C x 2.5mm, 1100V, PVC INSULATED STRANDED COPPER CABLE
2. TERMINAL BLOCKS SHALL BE DISCONNECTING STUD TYPE ELMEX CAT-DM4 OR EQUIVALENT WITH TRANSPARENT COVER
3. HS-HEATER SWITCH, DS-DOOR SWITCH, SS-SOCKET SWITCH TH-THERMOSTAT.

FOR TENDER PURPOSE ONLY

POWER GRID CORPORATION OF INDIA LIMITED
(A Government of India Enterprise)

STANDARD DRAWING

WIRING DIAGRAM FOR MARSHALLING BOX FOR 400KV CAPACITIVE VOLTAGE TRANSFORMER

0000-000-T-E-L-29 Sheet 2 of 2

Annexure-V: Actions required in case of defects observed during warrantee period

Equipment	Nature of problem	Corrective measures to be taken by contractor
CT (Oil filled)	**DGA Violation** H2 > 300 ppm C2H2> 2 ppm	CT to be **refurbished** or replaced
CT (SF6 filled)	a) SF6 gas leakage b) High Dew point of SF6 gas (> -36 deg C at atmpress)	a) Repair/ replacement b) Re-processing of gas andreplacement of Gas in case of no improvement
CT (Oil filled)	**Violation of Tan delta** Tan Delta: >0.5%(during pre-commissioning) >0.7% (in operation) or change w.r.t. to previous **year** value > 0.1%	Replacement of CT
CT & CVT	- Oil leakage - Low Oil level -Sec winding problem leading to open/ short circuit, saturation etc	Replacement or repair as per repair procedure approved by QA.
CVT	Secondary voltage drift: Upto ± 0.5 volts Healthy a) ± 0.5 **or beyond**	a) CVT to be replaced

***Replaced/Repaired/Refurbished Equipment (or part of equipment) shall have 2 yearswarranty without prejudice to contractual warranty period.**

SECTION-9

TECHNICAL SPECIFICATION OF ISOLATORS

9.1.0 SCOPE

9.1.1 This section of the specification is intended to cover design specifications for design, manufacture, testing at manufacturer's works of **gang operated Isolators** with all fittings and accessories, including mounting structures as applicable.

9.1.2 Loading at manufacturer's works, transportation and delivery at respective substation site, including unloading at destination site.

9.1.3 Erection, Testing and Commissioning of Isolators.

9.2.0 GENERAL:

The Isolators and accessories shall conform in general to IEC: 62271-102/103 except to the extent explicitly modified in specification and shall be in accordance with requirement of Section-GTR.

Complete isolator with all the necessary items for successful operation shall be supplied including but not limited to the following:

Isolator with complete Support Insulators, operating rod insulator, base frame, linkages, operating mechanism, control cabinet, interlock etc.

All necessary parts to provide a complete and operable isolator installation, control parts and other devices whether specifically called for herein or not.

The isolator shall be designed for use in the geographic and meteorological conditions as given in Section-GTR and Section-Project.

9.3.0 DUTY REQUIREMENTS

a) Isolators and earth switches shall be capable of withstanding the dynamic and thermal effects of the maximum possible short circuit current of the systems in their closed position. They shall be constructed such that they do not open under influence of short circuit current.

b) The earth switches, wherever provided, shall be constructionally interlocked so that the earth switches can be operated only when the isolator is open and vice versa. The constructional interlocks shall be built in construction of isolator and shall be in addition to the electrical interlocks. Suitable mechanical arrangement shall also be provided for delinking electrical drive for manual operation.

c) In addition to the constructional interlock, isolator and earth switches shall have provision to prevent their electrical and manual operation unless the associated and other interlocking conditions are met. All these interlocks shall be of failsafe type. Suitable individual interlocking coil arrangements shall be provided. The interlocking coil shall be suitable for continuous operation from station DC supply and within a variation range as stipulated in Section-GTR.

d) The earthing switches shall be capable of discharging trapped charges of the associated lines.

e) The isolator shall be capable of making/breaking normal currents when no significant change in voltage occurs across the terminals of each pole of isolator on account of make/break operation.

accordance with requirements stated hereunder:

9.4.0 CONSTRUCTIONAL FEATURES:

Isolators shall be outdoor, off-load type. Earth switches shall be provided on isolators wherever called for, with possibility of being mounted on any side of the isolator. 800kV isolator design shall be double break or vertical break or knee-type. 420kV & below rated isolators shall be double break type, unless specified otherwise. Isolator design shall be such as to permit addition of earth switches at a future date. The features and constructional details of isolators, earth switches and accessories shall be in

9.4.1 Contacts:

a) The contacts shall be self-aligning and self-cleaning type and shall be so designed that binding cannot occur after remaining in closed position for prolonged period in a heavily polluted atmosphere.

b) No undue wear or scuffing shall be evident during the mechanical endurance tests. Contacts and spring shall be designed so that readjustments in contact pressure shall not be necessary throughout the life of the isolator or earthing switch. Each contact or pair of contacts shall be independently sprung so that full pressure is maintained on all contacts at all time.

c) Contact springs shall not carry any current and shall not loose their characteristics due toheating effects.

d) The moving contact of double break isolator shall have preferably turn-and- twist type or other suitable type of locking arrangement to ensure adequate contact pressure.

e) Flexible braided copper, where used, shall have corrosion resistant coating such as tinning or silvering.

f) **Minimum thickness of silver plating on all contact points of male and female contact shall be 25 microns.**

9.4.2 Base:

Each single pole of the isolator shall be provided with a complete galvanised steel base provided with holes and designed for mounting on a standard supporting structure. Common base frame shall be provided for 400/220/132kV isolators suitable for mounting on pipe structures.

9.4.3 Blades :

a) All metal parts shall be of non-rusting and non-corroding material. All current carrying parts shall be made from high conductivity electrolytic copper/aluminium. Bolts, screws and pins shall be provided with lock washers. Keys or equivalent locking facilities if provided on current carrying parts shall be made of copper silicon alloy or stainless steel or equivalent. The bolts or pins used in current carrying parts shall be made of non-corroding material. Ferrous parts, other than stainless steel shall not be used in close proximity of main current path. All ferrous castings, if used elsewhere shall be made of malleable cast iron or cast-steel. No grey iron shall be used in the manufacture of any part of the isolator.

b) The live parts shall be designed to eliminate sharp joints, edges and other corona producing surfaces, where this is impracticable, adequate corona rings shall be provided. Corona shields are not acceptable. Corona rings shall be made up of aluminum/aluminum alloy.

c) Isolators and earthing switches including their operating parts shall be such that theycannot be dislodged from their open or closed positions by short circuit forces, gravity, wind pressure, vibrations, shocks or accidental touching of the connecting rods of the operating mechanism.

d) The isolator and earth switch shall be designed such that no lubrication of any part is required except at very infrequent intervals. i.e. after every 1000 operations or after 5 years whichever is earlier.

9.4.4 Insulator :

a) The insulator shall conform to IS: 2544, IEC-60168 and IEC-60815. The porcelain of theinsulator shall conform to the requirements stipulated under Section-GTR.

b) Pressure due to the contact shall not be transferred to the insulators after the main bladesare fully closed.

c) Insulator shall be type and routine tested as per IEC-60168. Besides following additionalroutine/acceptance tests shall also be conducted:

(i) Bending load test in four directions at 50% of minimum bending load guaranteed on all insulators, as a routine test.

(ii) Bending load test in four directions at 100% of minimum bending load as a sample test on each lot.

(iii) Torsional test on sample insulators of a lot.

(iv) Ultrasonic test as a routine test.

d) Requirement of Insulators of Isolators shall be as follows:

	i)	**For 800 kV Insulator**:	
Cantilever strength (min.)		=	1000kg
Top PCD		=	225 mm
No. of holes		=	4 x M16
Bottom PCD		=	356 mm
No. of holes		=	8 x 18mm dia.
	ii)	**For 420 kV Insulator**:	
Cantilever strength (min.)		=	1000kg
Top PCD		=	127 mm
No. of holes		=	4 x M16
Bottom PCD		=	325 mm
No. of holes		=	8 x 18mm dia
	iii)	**For 245 kV Insulator**:	
Cantilever strength (min.)		=	1000kg
Top PCD		=	127 mm
No. of holes		=	4 x M16
	iv)	**For 145 kV Insulator**:	
Cantilever strength (min.)		=	600kg
Top PCD		=	127 mm
No. of holes		=	4 x M16
Bottom PCD		=	254 mm
No. of holes		=	8 x 18mm dia

Name Plate : The name plate shall conform to the requirements of IEC incorporating year of manufacture

Locking device (applicable for 132kV and above):

9.5.0 Locking device (applicable for 132kV and above):

a) Locking device between Disconnectors and earth switches (wherever applicable) are to be provided and shall be designed to meet the requirement as per latest edition of IS/IEC 62271:102. For this, mechanical arrangements must be there to stop any forceful act (like push button operation of motor, handle operation etc) to operate earth switch (while main isolator is in closed position) or vice versa. Mechanical arrangements to be provided to hold operating pipe connected to motor shaft. Trapped Key Interlocking solution between Isolator and Earth switch is to be provided in such a way that each Isolator shall be connected with a mechanism with Key trapped in it. Once Isolator is completely open (Locally or Remote) the key will be released and blocks the isolator rotating pipe for any movement and same key shall be utilized to make Earth switch to operate.

   The earth switch shall be locked at two positions:
   (i) In normal condition the earth switch is blocked mechanically so that it cannot be rotated until trapped key from key exchange box (in case of bus isolator)/isolator is released.
   (ii) Once connected to earth, rotating shaft shall be blocked at that position with key out and can only be operated once key is again placed in E/S.

b) The Locks used for earth switch shall be of electromechanical type lock. Lock and mechanical arrangement to hold rotating shaft must be suitable for long term outdoor operation and accordingly, stainless-steel material is to be used and enclosure of lock shall be such that ingression of dust and moisture inside is prevented.
c) In case of new substation, for interlock between bus isolators and bus earth switch, locks along with key is to be provided for present and future bays. In such case, key exchange box (IP 55 Class) is also to be provided (with provision of spares as per envisaged future) for each bus. The key exchange box will have arrangement of N Key IN and one key OUT, where N is the number of bus isolators of particular bus (present+future). In case of substation extension (where above system has been implemented), bus isolators are to be provided with mechanical arrangement at shaft compatible with existing locks.
d) Strength of mechanical interlock/shaft blocking must be designed as per IEC 62271-102 in such a way that it can withstand during motor operation, the strain produced by the motor starting torque at the maximum motor supply voltage.
e) The locking device must be type tested as per IS/IEC 62271 102.

9.6.0 EARTHING SWITCHES

a) Where earthing switches are specified these shall include the complete operating mechanism and auxiliary contacts.

b) The earthing switches shall form an integral part of the isolator and shall be mounted on the base frame of the isolator.

c) Earthing switches shall be only locally operated.

d) Each earth switch shall be provided with flexible copper/aluminum braids for connection to earth terminal. These braids shall have the same short time current carrying capacity as the earth blade. The transfer of fault current through swivel connection will not be accepted.

e) The plane of movement and final position of the earth blades shall be such that adequate electrical clearances are obtained from adjacent live parts in the course of its movement between ON and OFF position.

f) The frame of each isolator and earthing switches shall be provided with two reliable earth terminals for connection to the earth mat.

g) The earth switch should be able to carry the same fault current as the main blades of the Isolators and shall withstand dynamic stresses.

h) 800kV, 420 kV & 245 kV earth switches shall also comply with the requirements of IEC- 62271-102, in respect of induced current switching duty as defined for Class-B and short circuit making capability class E-0 for earthing switches.

i) Earth switch blade in open condition shall not project (from the centre line of Insulator) by more than 4200mm for 400kV and 2810mm for 220kV respectively.

9.7.0 OPERATING MECHANISM

a) The bidder shall offer motor operated Isolators and earth switches. Isolators of 36 kV and below and earth switches of 72.5 kV and below rating shall be manual operated.

b) Control cabinet/operating mechanism box shall conform to the requirement stipulated in Section-GTR and shall be made of cast aluminium/aluminum sheet of adequate thickness (minimum 3 mm) or stainless steel (grade-304) of minimum thickness 2mm.

c) A "Local/Remote" selector switch and a set of open/ close push buttons shall be provided on the control cabinet of the isolator to permit its operation through local or remote push buttons.

d) Provision shall be made in the control cabinet to disconnect power supply to prevent local/remote power operation.

e) Motor shall be an AC motor and conform to the requirements of Section- GTR.

f) Suitable reduction gearing shall be provided between the motor and the drive shaft of the isolator. The mechanism shall stop immediately when motor supply is switched off. If necessary a quick electro-mechanical brake shall be fitted on the higher speed shaft to effect rapid braking.

g) Manual operation facility (with handle) should be provided with necessary interlock to disconnect motor.

h) Gear should be of forged material suitably chosen to avoid bending/jamming on operation after a prolonged period of non-operation. Also all gear and connected material should be so chosen/surface treated to avoid rusting.

i) Blocked rotor test of motor shall be conducted as a routine test. During the blocked rotor test, overload protection relay should operate to prevent failure of motor.

j) Only stranded conductor shall be used for wiring. Minimum size of the conductor for control circuit wiring shall be 1.5 sq.mm. (Copper).

k) The operating mechanism shall be located such that it can be directly mounted on any one of the support

structure.

l) Snap type limit/auxiliary switches shall be used with Factory set values. No adjustment shall be required at site during commissioning.

9.8.0 OPERATION

a) The main Isolator and earth switches shall be individual pole operated for 800/420 kV and gang operated in case of 245 kV & 145 kV. However, 245 kV Tandem Isolators shall be individual-pole operated. The operating mechanism of all the three poles shall be well synchronized and interlocked.

b) The design shall be such as to provide maximum reliability under all service conditions. All operating linkages carrying mechanical loads shall be designed for negligible deflection and strain less than 1%. The length of inter insulator and interpole operating rods shall be capable of adjustments, by means of screw thread which can be locked with a lock-nut after an adjustment has been made. The isolator and earth switches shall be provided with "over dead center" device in the operating mechanism at open and close position to prevent accidental opening by wind, vibration, short circuit forces or movement of the support structures.

c) Each isolator/pole of isolator and earth switch shall be provided with a manual operating handle enabling one man to open or close the isolator with ease while standing at ground level. Non-detachable type manual operating handle shall have provision for padlocking. For detachable type manual operating handles, suitable provision shall be made inside the operating mechanism box for parking the detached handles. The provision of manual operation shall be located at a convenient operating height from the base of isolator support structure.

d) The isolator contacts shall be positively driven by the operating mechanism continuous control throughout the entire cycle of operation. The operating pipes and rods shall be sufficiently rigid to maintain positive control under the most adverse conditions and when operated in tension or compression for isolator closing / opening operation. They shall also be capable of withstanding all torsional and bending stresses due to operation of the isolator. Wherever supported, the operating rods shall be provided with bearings on each support and at the either ends. The operating rods/ pipes shall be provided with suitable universal couplings to account for any angular misalignment.

e) All rotating parts shall be provided with grease packed roller or ball bearings in sealed housings designed to prevent the ingress of moisture, dirt or other foreign matter. Bearings pressure shall be kept low to ensure long life and ease of operation. Locking pins wherever used shall be rust-proof.

f) Signaling of closed position shall not take place unless it is certain that the movable contacts, have reached a position in which rated normal current, peak withstand current and short time withstand current can be carried safely. Signaling of open position shall not take place unless movable contacts have reached a position such that clearance between contacts is atleast 80% of the isolating distance.

g) The position of movable contact system (main blades) of each of the Isolators and earthing switches shall be indicated by a mechanical indi- cator at the lower end of the vertical rod of shaft for the Isolators and earthing switch. The indicator shall be of metal and shall be visible from operating level.

h) The contractor shall furnish the following details alongwith quality norms, during detailed engineering stage:

(i) Current transfer arrangement from main blades of isolator alongwith milli volt drop immediately across transfer point.

(ii) Details to demonstrate smooth transfer of rotary motion from motor shaft to the insulator alongwith stoppers to prevent over travel.

9.9.0 TERMINAL CONNECTOR STUD/PAD:

The isolator terminal pads/studs shall be made of high quality copper or aluminum and shall be conforming to Australian standard AS-2935 for rated current. The terminal pad shall have protective covers which shall be removed before interconnections. Only terminal pads shall be used for current ratings above 1250A. Terminal pads shall be mounted below the current transfer contacts so that the cantilever pull from the terminal connector is not transferred through the current transfer point to the support insulator. The terminal pad shall be suitable for horizontal plane connection with terminal connector. The terminal pads for all isolators with 3150A & above rating shall have six holes for terminal pad.

9.11.0 SUPPORT STRUCTURE:

800 kV/420 kV/245 kV/145 kV Isolators along with Earth switches shall be suitable for mounting on standard support structures

9.11.0 TESTS

In continuation to the requirements stipulated under Section-GTR the isolator alongwith its earthing switch and operating mechanism should have been type tested as per IEC/IS and shall be subjected to routine tests in accordance with IEC-62271-102. Minimum 1000 Nos. mechanical operations in line with mechanical endurance test, M0 duty, shall be carried out on 1 (one) isolator out of every lot of Isolators, assembled completely with all accessories including insulators, as acceptance test for the lot. The travel characteristics measured at a suitable location in the base of insulator along with motor current/power drawn, during the entire travel duration are to be recorded at the start and completion and shall not vary by more than (+/-) 10% after completion of 1000 cycles of operation. After completion of test, mechanical interlock operation to be checked.

The test reports of the type tests as per IEC 62271-102 and the following additional type tests (additional type tests are required for isolators rated above 72.5 kV only) shall also be submitted for the Employer's review**.**

(i) Radio interference voltage test as per Annexure-A of Section-GTR.

(ii) Corona Extinction Voltage test as per Annexure-A of Section-GTR

(iii) Seismic withstand test on isolator mounted on Support structure as per Annexure-B ofSection-GTR. The test shall be performed in the following position :

Isolator open	E/S Closed
Isolator open	E/S Open
Isolator Closed	E/S Open

9.12.0 MANDATORY SPARES:

Bidder shall include in his proposal mandatory spares as mentioned in the Bidding Documents
All isolators and earthing switches shall be rigidly mounted in an upright position on their own supporting structures. Details of the supporting structures shall be furnished by the bidder. The isolators should have requisite fixing details ready for mounting them on structures.

TECHNICAL PARAMETERS: As per table given at Annexure-I:

9.14.0 PRE-COMMISSIONING TESTS

Contractor shall perform any additional test based on specialties of the items as per the field Q.P./Instructions of the equipment manufacturer or Employer without any extra cost to the Employer. The Contractor shall arrange all instruments required for conducting these tests alongwith calibration certificates at his own cost.

An indicative list of tests on isolator and earthswitch is given below. For pre- commissioning procedures and formats for Isolators and Grounding switch, Doc.No.: CF/ISO/07/R-4, dtd- 01.04.2013 under POWERGRID/AEGCL Document no. D- 2-01-03-01-04 will be the reference document. This document will be available at respective sites and shall be referred by the contractor.

(a) Insulation resistance of each pole

(b) Manual and electrical operation and interlocks

(c) Insulation resistance of control circuits and motors

(d) Ground connections

(e) Contact resistance

(f) Proper alignment so as to minimize vibration during operation

(g) Measurement of operating Torque for isolator and Earth switch

(h) Resistance of operating and interlocks coils

(i) Functional check of the control schematic and electrical & mechanical interlocks

(j) 50 operations test on isolator and earth switch

The Contractor shall ensure that erection, testing and commissioning of Isolators above 72.5 kV class shall be carried out under the supervision of the Isolator manufacturer's representative and the cost of the same shall be included in the erection price of the respective equipment.

Annexure-I

1. Technical Parameters for 765kV, 400kV, 220kV and 132kV Isolators

Sl. No.	Description	Unit	800kV ISO	420kV ISO	245kV ISO	145kV ISO
1	Rated voltage	kVrms	800	420	245	145
2	Rated frequency	Hz	50	50	50	50
3	No. of poles	Nos.	3	3	3	3
4	Design ambienttemperature	°C	50	50	50	50
5	Type		Outdoor	Outdoor	Outdoor	Outdoor
6	Rated current at 50°Cambient temperature	A	3150	3150	1600A / 2500 A (as applicable)	1250
7	Rated short time withstand current of isolator and earth switch	kA	40 / 50 for 1sec (as applicable)	40 /50 /63 for 1 sec (as applicable)	50 for 1sec (as applicable)	31.5 for 1 sec
8	Rated dynamic short time withstand current of isolator and earth switch	kAp	102kAp	100 kAp / 125 kAp / 157.5 kAp (as applicable)	125 kAp (as applicable)	80kAp
9	Temperature rise over design ambient temperature	As per Table-3 of IEC-62271-1				
10	Rated mechanical terminal load	N	As per table III of IEC-62271-102 or as per value calculated in Section-GTR whichever is higher			
11	Mechanical EnduranceClass	Isolator-M2 E/S-M0				
12	Operating mechanism of isolator/erathswitch	A.C. Motor operated				
13	No. of auxiliary contacts on each isolator	Besides requirement of this spec., 5 NO + 5 NC contacts wired on each isolatorto terminal block exclusively for Employer's use in future.				
14	No. of auxiliary contacts on each earthing switch	Besides requirement of this spec., 3 NO + 3 NC contacts wired on each isolatorto terminal block exclusively for Employer's use in future.				
15	Max. Operating time	secs	20 sec. for Isolator and25 secondsfor earth switch	20 secs	12 secs	12 secs
16	Number of terminal in control cabinet	All contacts & control circuits are to be wired up to control cabinet plus 24 spareterminals evenly distributed.				
17	Rated Insulation levels					
a)	Full wave impulse withstand voltage (1.2/50 microsec.)					

i)	between line terminals and ground	kVpeak	±2100	±1425	±1050	±650
ii)	between terminals withisolator open	kVpeak	±2100 kVp impulse on one terminal and 455 kVp power frequency voltage of opposite polarity on other terminal	±1425 kVp impulse on one terminal and 240 kVp power frequency voltage of opposite polarity on other terminal	±1200	±750
b)	Switching impulse withstand voltage (250/2500 micro-second) dry and wet					
i)	between line terminals and ground	kVpeak	± 1550	± 1050	-NA-	
ii)	between terminals with Isolator open	kVpeak	1175 kVp impulse on oneterminal and 650 kVp power frequency voltage of opposite polarity on other terminal	900 kVp impulse on oneterminal and 345 kVp powerfrequency voltage of opposite polarity on other terminal	-NA-	
c)	One minute power frequency dry withstand voltage					
i)	between line terminals and ground	kV rms	830	520	460	
ii)	between terminals with isolator open	kV rms	1150	610	530	
18	Minimum Corona extinction voltage with Isolator in all positions	KV rms	508	320	156	
19	Max. radio interference voltage for frequency between0.5 MHz and 2 MHz. in all positions	microvolts	2500 at 508 kVrms	1000 at 266 kVrms	1000 at 156 kVrms	
20	Minimum Creepage distance (31mm/kV)					
i)	Phase to ground	mm	As per Section-GTR	As per Section-GTR	As per Section-GTR	
21	Seismic acceleration		As per IS:1893	As perIS:1893	As per IS:1893	
22	Thermal Rating of AuxiliaryContacts	A	10 A at 220 V DC	10 A at 220 V DC	10 A at 220 V DC	

23	Breaking Capacity of auxiliary contacts		2 A DC with circuit time constant not less than 20ms	2 A DC with circuit time constant not less than 20ms	2 A DC with circuit time constant not less than 20ms
24	Distance between support structures foundations (within same phase)	m	6.0	4.0	2.5
25	System neutral earthing		EffectivelyEarthed	EffectivelyEarthed	EffectivelyEarthed

Note: The above insulation levels are applicable for altitude up to 1000 meters above M.S.L. For higheraltitudes, suitable correction factor as per relevant IEC shall be applied.

2. Technical Parameters for 72.5 kV, 36 kV and 11 kV Isolator

Sl. No.	Description	Unit	72.5kV ISO	36kV ISO	12kV ISO
1	Rated voltage	kVrms	72.5	36	11
2	Rated frequency	Hz	50	50	50
3	No. of poles	Nos.	3	3	3
4	Design ambienttemperature	°C	50	50	50
5	Type		Outdoor, Mechanically gang operated	Outdoor, Mechanically gang operated	Outdoor, Mechanicallygang operated
6	Rated current at 50°C ambient temperature	A	As per requirement	As per requirement	As per requirement
7	Rated short time withstand current of isolator and earth switch	kA	25 kA for 3 sec	25 kA for 3 sec	25 kA for 3 sec
8	Rated dynamic short time withstand current of isolator and earth switch	kAp	62.5kAp	62.5kAp	62.5kAp
9	Temperature rise over design ambient temperature	As per Table-3 of IEC-62271-1			
10	Rated mechanical terminal load	N	As per IEC or as per value calculated in Section- GTRwhichever is higher		
11	Mechanical EnduranceClass		Isolator-M1 E/S-M0		
12	Operating mechanism of isolator/Earth switch		Isolator - A.C. Motor operated E/S – Manual operated	Isolator -Manual operated E/S – Manual operated	Isolator -Manual operated E/S – Manual operated
13	No. of auxiliary contacts on each isolator	Besides requirement of this spec., 5 NO + 5 NC contacts wired on eachisolator to terminal block exclusively for Employer's use in future.			
14	No. of auxiliary contacts on each earthing switch	Besides requirement of this spec., 3 NO + 3 NC contacts wired on eachisolator to terminal block exclusively for Employer's use in future.			
14	Max. Operating time	sec	12 sec.	NA for manualoperation	NA for manual operation
15	Number of terminal in control cabinet	All contacts & control circuits are to be wired up to control cabinet plus24 spare terminals evenly distributed.			
16	Rated Insulation levels				

a)	Full wave impulse withstand voltage (1.2/50 microsec.)				
i)	between line terminals and ground	kVpeak	±325	±170	-
ii)	between terminals withisolator open	kVpeak	±375 kVp	±180 kVp	-
b)	One minute power frequency dry withstand voltage				
i)	between line terminals and ground	kV rms	140	70	-
ii)	between terminals withisolator open	kV rms	160	80	-
17	Minimum Creepage distance				
i)	Phase to ground	mm	As per Section- GTR	As per Section-GTR	As per Section- GTR
20	Seismic acceleration		As per IS:1893	As per IS:1893	As per IS:1893
21	Thermal Rating of Auxiliary Contacts	A	10 A at 220V/110VDC	10 A at 220V/110VDC	10 A at 220V/110V DC
22	Breaking Capacity of auxiliary contacts		2 A DC with circuittime constant not less than 20 ms	2 A DC withcircuit time constant notless than 20 ms	2 A DC with circuit time constant not less than 20 ms
	Distance between support structures foundations (within same phase)	m	As per layout		
23	System neutral earthing		EffectivelyEarthed	EffectivelyEarthed	EffectivelyEarthed

Note: The above insulation levels are applicable for altitude up to 1000 meters above M.S.L. For higher altitudes, suitable correction factor as per relevant IEC shall be applied.

SECTION-10

Technical Specification for Control and Relay Panels (With Automation)

10.1.0 SCOPE

10.1.1 This Section is intended to cover the design, manufacture, assembly, testing at manufacturer's works of Indoor Relay and Control Panels.

10.1.2 The Control and Relay Panels required are for control and protection of the Power Transformers, Feeders and for others according to requirements. The supply shall include all accessories, special tools, relevant software, supporting steels, spare parts, drawings, instruction manuals etc. The panels shall be supplied complete with all accessories as specified and completely assembled and all internal wiring completed.

10.1.3 The sub-stations will have automation as per guidelines of IEC 61850. The contractor has to supply the C&R panels to match the requirement of Sub-station Automation System (SAS) as specified in the subsequent chapter.

10.2.0 TYPE OFPANELS

- Simplex Panel
  Simplex panel shall consist of a vertical front panel with equipment mounted thereon and having wiring access from rear for control panels & front for relay/protection/**Interface** panels. In case ofpanel having width more than 800mm, double leaf-doors shall be provided. Doors shall have handles with built-in locking facility.
- Duplex Panel
  Duplex panel shall be walk-in tunnel type comprising two vertical front and rear panel sections connected back-on-back by formed sheet steel roof tie members and a central corridor in between. The corridor shall facilitate access to internal wiring and external cable connections. In case of number of duplex panels located in a row side by side, the central corridor shall be aligned to form a continuous passage. Both ends of the corridor shall be provided with double leaf doors with lift off hinges. Doors shall have handles with built-in locking facility. Separate cable entries shall be provided for the front and rear panels. However, inter-connections between front and back panels shall be by means of inter panel wiring at the top of the panel.

10.3.0 CONSTRUCTIONALFEATURES

10.3.1 TYPE OF PANEL

10.3.2 CONSTRUCTIONAL FEATURES

Control and Relay Board shall be **simplex type unless otherwise indicated in section-project / bill of quantity as duplex type**. It is the responsibility of the Contractor to ensure that the equipment specified and such unspecified complementary equipment required for completeness of the protective/control schemes be properly accommodated in the panels without congestion and if necessary, either more number of panels or panels with larger dimensions **shall be provided (as per panel layout requirement)**. No price increase at a later date on this account shall be allowed. However, the width of panels that are being offered to be placed in existing switchyard control rooms, should be in conformity with the space availability in the control room.

Panels shall be completely metal enclosed and shall be dust, moisture and vermin proof. The enclosure shall provide a degree of protection not less than IP-31 in accordance with IS: 2147.

Panels shall be free standing, floor mounting type and shall comprise structural frames completely enclosed with specially selected smooth finished, cold rolled sheet steel of thickness not less than 3 mm for weight bearing members of the panels such as base frame, front sheet and door frames, and 2.0mm for sides, door, top and bottom

portions. There shall be sufficient reinforcement to provide level transportation and installation.

All doors, removable covers of panels shall be gasketed all around with synthetic gaskets Neoprene/EPDM generally conforming with provision of IS 11149. However, XLPE gaskets can also be usedfor fixing protective glass doors. Ventilating louvers, if provided shall have screens and filters. The screens shall be made of either brass or GI wire mesh.

Design, materials selection and workmanship shall be such as to result in neat appearance, inside and outside with no welds, rivets or bolt head apparent from outside, with all exterior surfaces tune and smooth.

Panels shall have base frame with smooth bearing surface, which shall be fixed on the embedded foundation channels/insert plates. Anti vibration strips made of shock absorbing materials that shall be supplied by the contractor, which shall be placed between panel & base frame.

Cable entries to the panels shall be from the bottom. Cable gland plate fitted on the bottom of the panel shall be connected to earthing of the panel/station through a flexible braided copper conductor rigidly.
Relay/protection panels of modern modular construction **meeting the functional requirement** would also be acceptable.

10.3.3 MOUNTING OF EQUIPMENTS

All equipment on and in panels shall be mounted and completely wired to the terminal blocks ready for external connections. The equipment on front of panel shall be mounted flush.

Equipment shall be mounted such that removal and replacement can be accomplished individually without interruption of service to adjacent devices and are readily accessible without use of special tools. Terminal marking on the equipment shall be clearly visible.

The Contractor shall carry out cut out, mounting and wiring of the free issue items supplied by others which are to be mounted in his panel in accordance with the corresponding equipment manufacturer's drawings. Cut outs if any, provided for future mounting of equipment shall be properly blanked off with blanking plate.

The centre lines of switches, push buttons and indicating lamps shall be **preferably** not less than750mm from the bottom of the panel. The centre lines of relays, meters and recorders shall be **preferably** not less than 450mm from the bottom of the panel.

The centre lines of switches, push buttons and indicating lamps shall be matched to give a neat and uniform appearance. Like wise the top lines of all meters, relays and recorders etc. shall be matched.

No equipment shall be mounted on the doors.

At existing station, panels shall be matched with other panels in the control room in respect of dimensions, colour, appearance and arrangement of equipment (centre lines of switches, push buttons and other equipment) on the front of the panel.

10.3.4 PANEL INTERNAL WIRING

Panels shall be supplied complete with interconnecting wiring provided between all electrical devices mounted and wired in the panels and between the devices and terminal blocks for the devices to be connected to equipment outside the panels. When panels are arranged to be located adjacent to each other all inter panel wiring and connections between the panels shall be carried out internally.

All wiring shall be carried out with 650V grade, single core, stranded copper conductor wires with PVC insulation. The minimum size of the multi-stranded copper conductor used for internal wiring shall be as follows:

- All circuits except current transformer circuits and voltage **transformer** circuits meant for energy metering - one 1.5mm sq. per lead.
- All current transformer circuits - one 2.5 sq.mm per lead.
- Voltage transformer circuit (for energy meters): Two 2.5 mm sq. per lead.

All internal wiring including FO patch cords shall be securely supported, neatly arranged, readilyaccessible and connected to equipment terminals and terminal blocks. Wiring gutters & troughs shall be used for this purpose.

Wire termination shall be made with solderless crimping type and tinned copper lugs, which firmly grip the conductor. Insulated sleeves shall be provided at all the wire terminations. Core identification plastic ferrules marked to correspond with panel wiring diagram shall be fitted at both ends of each wire. Ferrules shall fit tightly on the wire and shall not fall off when the wire is disconnected from terminal blocks. All wires directly connected to trip circuit breaker or device shall be distinguished by the addition of red coloured unlettered ferrule.

Longitudinal troughs extending throughout the full length of the panel shall be preferred for inter panel wiring. Inter-connections to adjacent panel shall be brought out to a separate set of terminal blocks located near the slots of holes meant for taking the inter-connecting wires. **Wiring termination at interface panel end shall be through prefabricated plug-in type connectors.**

Contractor shall be solely responsible for the completeness and correctness of the internal wiring and for the proper functioning of the connected equipments.

10.3.5 TERMINAL BLOCKS

All internal wiring to be connected to external equipment shall terminate on terminal blocks. Terminal blocks shall be 650 V grade and have 10 Amps. Continuous rating, moulded piece, complete with insulated barriers, stud type terminals, washers, nuts and lock nuts. Markings on the terminal blocks shall correspond to wire number and terminal numbers on the wring diagrams. All terminal blocks shall have shrouding with transparent unbreakable material.

Disconnecting type terminal blocks for current transformer and voltage transformer secondary leads shall be provided. Also current transformer secondary leads shall be provided with short circuiting and earthing facilities.

At least 20% spare terminals shall be provided on each panel and these spare terminals shall beuniformly distributed on all terminal blocks.

Unless otherwise specified, terminal blocks shall be suitable for connecting the following conductors of external cable on each side

- All CT & PT circuits: minimum of two no. of 2.5mm Sq.copper.
- AC/DC Power Supply Circuits: **two** no. of **16mm** Sq.Aluminium.
- All other circuits: minimum of one no. of 2.5mm Sq. Copper.

There shall be an **approximate clearance** of 250mm between the first row of terminal blocks and the associated cable gland plate or panel side wall. **Similarly** the clearance between two rows of terminal blocks edges shall be of 150mm **approximate**.

Arrangement of the terminal block assemblies and the wiring channel within the enclosure shall be such that a row of terminal blocks is run in parallel and close proximity along each side of the wiring-duct to provide for convenient attachment of internal panel wiring. The side of the terminal block opposite the wiring duct shall be reserved for the external cable connections. All adjacent terminal blocks shall also share this field wiring corridor. All wiring shall be provided with adequate support inside the panels to hold them firmly and to enable free and flexible termination without causing strain on terminals.

The number and sizes of the Owner's multi core incoming external cables will be furnished to theContractor after placement of the order. All necessary cable terminating accessories such as gland plates, supporting clamps & brackets, wiring troughs and gutters etc. (except glands & lugs) for external cables shall be included in the scope of supply. **Terminal blocks provided on Interface panel used for external wiring from switchyard shall be provided with necessary surge protection device to safeguard IEDs from transient voltage surges, spikes.**

10.4.0 PAINTING

The painting shall be carried out as detailed in Section–GTR.

10.5.0 MIMIC DIAGRAM (FOR CONTROL PANELS)

Coloured mimic diagram and symbols showing the exact representation of the system shall be provided in the front of control panels.

Mimic diagram shall be made preferably of anodised aluminium or plastic of approved fast colour material, which shall be screwed on to the panel and can be easily cleaned. The mimic bus shall be 2mm thick. The width of the mimic bus shall be10mmfor bus bars and7mm for other connections.Painted overlaid mimic is also acceptable.

Mimic bus colour will be decided during detailed Engineering by the EMPLOYER.

When semaphore indicators are used for equipment position, they shall be so mounted in the mimic that the equipment in close position shall complete the continuity of mimic.

Indicating lamp, one for each phase, for each bus shall be provided on the mimic to indicate buscharged condition

10.6.0 NAME PLATES AND MARKINGS

All equipment mounted on front and rear side as well as equipment mounted inside the panels shall be provided with individual name plates with equipment designation engraved. Also on the top of each panel on front as well as rear side, large and bold nameplates shall be provided for circuit/feeder designation.

All front mounted equipment shall also be provided at the rear with individual name plates engraved with tag numbers corresponding to the one shown in the panel internal wiring to facilitate easy tracing of the wiring.

Each instrument and meter shall be prominently marked with the quantity measured e.g. kV, A, MW, etc. All relays and other devices shall be clearly marked with manufacturer's name, manufacturer's type and electrical rating data.

Name Plates shall be made of non-rusting metal or 3 ply lamicoid. Name plates shall be black with white engraving lettering.

Each switch shall bear clear inscription identifying its function e.g. 'BREAKER' '52A', "SYNCHRONISING" etc. Similar inscription shall also be provided on each device whose function is not other-wise identified. If any switch device does not bear this inscription separate name plate giving its function shall be provided for it. Switch shall also have clear inscription for each position indication e.g. "Trip- Neutral-Close", "ON- OFF", "R-Y-B-OFF"etc

All the panels shall be provided with name plate mounted inside the panel bearing LOA No & Date, Name of the Substation & feeder and reference drawing number.

10.7.0 MISCELLANEOUS ACCESSORIES

Plug Point: 240V, Single phase 50Hz, AC socket with switch suitable to accept 5 Amps and 15 Amps pin round standard Indian plug, shall be provided in the interior of each cubicle with ON-OFF switch.

Interior Lighting: Each panel shall be provided with a LED type lighting fixture (Min 7 Watt) rated for 240 Volts, single phase, 50 Hz supply for the interior illumination of the panel controlled by the respective panel door switch. Adequate lighting shall also be provided for the corridor in Duplex panels.

Switches and Fuses: Each panel shall be provided with necessary arrangements for receiving, distributing and isolating of DC and AC supplies for various control, signalling, lighting and space heater circuits. The incoming and sub-circuits shall be separately provided with Fuses. Selection of the main and sub-circuit Fuses rating shall be such as to ensure selective clearance of sub-circuit faults. Voltage transformer circuits for relaying and metering shall be protected by fuses. All fuses shall be HRC cartridge type conforming to IS: 13703 mounted on plug-in type fuse bases. The short time fuse rating of Fuses shall be not less than 9 KA. Fuse carrier base shall have imprints of the fuse 'rating' and 'voltage'.

Space Heater: Each panel shall be provided with a thermostatically controlled space heater rated for 240V, single phase, 50 Hz AC supply for the internal heating of the panel to prevent condensation of moisture. The fittings shall be complete with switch unit.

10.8.0 EARTHING

All panels shall be equipped with an earth bus securely fixed. Location of earth bus shall ensure no radiation interference from earth systems under various switching conditions of isolators and breakers. The material and the sizes of the bus bar shall be at least 25 X 6 sq.mm copper with threaded holes at a gap of 50 mm with provision of bolts and nuts for connection with cable armours and mounted equipment etc for effective earthing. When several panels are mounted adjoining each other, the earth bus shall be made continuous and necessary connectors and clamps for this purpose shall be included in the scope of supply of Contractor. Provision shall be made for extending the earth bus bars to future adjoining panels on either side.

Provision shall be made on each bus bar of the end panels for connecting Substation earthing grid. Necessary terminal clamps and connectors for this purpose shall be included in the scope of supply of Contractor.

All metallic cases of relays, instruments and other panel mounted equipment including gland plate, shall be connected to the earth bus by copper wires of size not less than 2.5 sq. mm. The colour code of earthing wires shall be green.

Looping of earth connections which would result in loss of earth connection to other devices when the loop is broken, shall not be permitted. However, looping of earth connections between equipment to provide alternative paths to earth bus shall be provided.

VT and CT secondary neutral or common lead shall be earthed at one place only at the terminal blocks where they enter the panel. Such earthing shall be made through links so that earthing may be removed from one group without disturbing continuity of earthing system for other groups.
An electrostatic discharge arrangement shall be provided in each panel so as to discharge human body before he handles the equipments inside the panels.

10.9.0 INDICATING INSTRUMENTS & TRANSDUCERS FOR CONTROL PANEL

All instruments, meters and transducers shall be enclosed in dust proof, moisture resistant, black finished cases and shall be suitable for tropical use. All Megawatt, Megavar, voltage and frequency indicating instruments shall be provided with individual transducers and these shall be calibrated along with transducers to read directly the primary quantities. They shall be accurately adjusted and calibrated at works and shall have means of calibration check and adjustment at site. The supplier shall submit calibration certificates at the time of delivery. However no separate transducers are envisaged for digital bus voltmeters and digital frequency meters and the indicating meters provided in the synchronising equipment.

Indicating Instruments

Unless otherwise specified, all electrical indicating instruments shall be of digital type suitable for flush mounting.
Instruments shall have 4-digit display; display height being not less than 25mm.
Instrument shall confirm to relevant IS and shall have an accuracy class of 1.5 or better. Watt and Var meters shall have an indication of (+) and (-) to indicate EXPORT and IMPORT respectively.
Digital voltage and frequency meters shall be of class: 0.5 and shall have digital display of 4 and 4.5 digits respectively, with display size, not less than 25mm (height)

Transducers

Transducers (for use with Indicating Instruments and Telemetry/Data Communication application) shall in general conform toIEC:60688-1.

The transducers shall be suitable for measurement of active power, reactive power, voltage, current and frequency in three phase four wire unbalanced system.

The input to the transducers will be from sub-station current & potential transformers. The output shall be in milli ampere D.C. proportional to the input & it shall be possible to feed the output current directly to the telemetry terminal or indicating instruments.

The transducer characteristic shall be linear throughout the measuring range. The transducer output shall be load independent.

The input & output of the transducer shall be galvanically isolated.
Each transducer shall be housed in a separate compact case and have suitable terminals for inputs &outputs.

The transducers shall be suitably protected against transient high peaks of voltage &current. The transducer shall withstand indefinitely without damage and work satisfactorily at 120% of the rated voltage and 120% of the rated input current as applicable.

All the transducers shall have an output of 4-20mA.

The response time of the transducers shall be less than 1second.

The accuracy class of transducers shall be 1.0 or better for voltage/current transducer, 0.5 or better for watt/VAR transducer and 0.2 or better for frequency transducer.

The transducers shall have a low AC ripple on output less than1%.

The transducer shall have dual output

10.10.0 ANNUNCIATION SYSTEM FOR CONTROL PANEL

Alarm annunciation system shall be provided in the control board by means of visual and audible alarm in order to draw the attention of the operator to the abnormal operating conditions or the operation of some protective devices. The annunciation equipment shall be suitable for operation on the voltages specified in this specification.

The visual annunciation shall be provided by annunciation facia, mounted flush on the top of the controlpanels.

The annunciation facia shall be provided with translucent plastic window for alarm point with approximate size of 35mm x 50mm. The facia plates shall be engraved in black lettering with respective inscriptions. Alarm inscriptions shall be engraved on each window in not more than three lines and size of the lettering shall not be less than 5mm.

Each annunciation window shall be provided with two white lamps in parallel to provide safety against lamp failure. Long life lamps shall be used. The transparency of cover plates and wattage of the lamps provided in the facia windows shall be adequate to ensure clear visibility of the inscriptions in the control room having high illumination intensity (350 Lux), from the location of the operator's desk.

All Trip facia shall have red colour and all Non-trip facia shall have white colour.

The audible alarm shall be provided by Buzzer/ Hooter /Bell having different sounds and shall be used asfollows.

Hooter AlarmAnnunciation
Bell Annunciation DCfailure
Buzzer AC supplyfailure

Sequence of operation of the annunciator shall be as follows:

Sl No	Alarm Condition	Fault Contact	Visual Annunciation	Audible Annunciation
1	Normal	Open	OFF	OFF
2	Abnormal	Close	Flashing	ON
3	Accept Push Button Pressed	Close	Steady On	OFF
		Open	Steady On	OFF
		Close	On	OFF
4	Reset Push Button Pressed	Open	OFF	OFF
5	Lamp Test Push Button Pressed	Open	Steady On	OFF

Audible annunciation for the failure of DC supply to the annunciation system shall be provided and this annunciation shall operate on 240 Volts AC supply. On failure of the DC to the annunciation system for more than 2 or 3 seconds (adjustable setting), a bell shall sound. A separate push button shall be

provided for the cancellation of this audible alarm alone but the facia window shall remain steadily lighted till the supply to annunciation system isrestored.
A separate voltage check relay shall be provided to monitor the failure of supply (240V AC) to the scheme mentioned in Clause above. If the failure of supply exists for more than 2 to 3 seconds, this relay shall initiate visual and audible annunciation. Visual and audible annunciation for the failure of AC supply to the annunciation system shall be provided and this annunciation shall operate on Annunciation DC and buzzer shall sound.

The annunciation system described above shall meet the following additional requirements:

a) The annunciation system shall be capable of catering to at least 20 simultaneous signals at atime.

b) One set of the following push buttons shall be provided on each control panel:

- Reset push button for annunciation system
- Accept push button for annunciation system
- Lamp test push button for testing the facia windows

c) One set of the following items shall be provided common for all the control panel (notapplicable for extension of substation):

- Flasher relay for annunciation system
- Push button for Flasher est
- Three Push buttons for test of all audible alarm systems

d) These testing circuits shall be so connected that while testing is being done, it shall notprevent the registering of any new annunciation that may land during thetest.

e) The annunciation shall be repetitive type and shall be capable of registering the fleeting signal. Minimum duration of the fleeting signal registered by the system shall be 15 milliseconds.

f) In case of static annunciator scheme, special precaution shall be taken to ensure that spurious alarm condition does not appear due to influence of external electromagnetic/ electrostatic interference on the annunciator wiring and switching disturbances from the neighbouring circuits within the panels and the static annunciator shall meet the high voltage susceptibility test , impulse voltage with stand test , high frequency disturbance test– class III and fast transient disturbance test –level III as per IEC 60255.

The annunciation system to be supplied for existing sub-stations shall be engineered as an extension to the existingscheme.

For the Control panel with BCU (if envisaged in section-Project), only common alarm lamp shall be provided for each Control panel. Each BCU of the control panel shall energize this common alarm lamp on occurrence of alarms/Trips. All alarms shall be available in the BCU mimic/HMI.

10.11.0 SWITCHES

Control and instrument switches shall be rotary operated type with escutcheon plates clearly marked to show operating position and circuit designation plates and suitable for flush mounting with only switch front plate and operating handle projecting out.

The selection of operating handles for the different types of switches shall be as follows:

Breaker, Isolator control switches	:	Pistol grip, black
Synchronising switches	:	Oval, Black, Keyed handle(one

		common removable handle for a group of switches or locking facility having common key
synchronising Selector switches	:	Oval or knob, black
Instrument switches	:	Round, knurled, black
Protection Transfer switch, Local / remote	:	Pistol grip, lockable and black

The control switch of breaker and isolator shall be of spring return to neutral type. The switch shall have spring return from close and trip positions to "after close" and "after trip" positions respectively.

Protection Transfer switch / BCU will energise a bi-stable relay for protection transfer function from local/ remote HMI.

Instrument selection switches shall be of maintained contact (stay put) type. Ammeter selection switches shall have make-before-break type contacts so as to prevent open circuiting of CT secondary when changing the position of the switch. Voltmeter transfer switches for AC shall be suitable for reading all line- to-line and line-to-neutral voltages forn on-effectively earthed systems and for reading all line to line
voltages for effectively earthed systems.

Synchronising switches shall be of maintained contact (stay put) type having a common removable handle for a group of switches. The handle shall be removable only in the OFF position and it shall be co-ordinated to fit in to all the synchronising switches. These switches shall be arranged to connect the synchronising equipment when turned to the 'ON' position. One contact of each switch shall be connected in the closing circuit of the respective breaker so that the breaker cannot be closed until the switch is turned to the 'ON' position.

Lockable type of switches which can be locked in particular positions shall be provided when specified. The key locks shall be fitted on the operating handles.

The contacts of all switches shall preferably open and close with snap action to rivets of pure silver or silver alloy. Springs shall not be used as current carrying parts minimise arcing. Contacts of switches shall be spring assisted and contact faces shall be with the contact combination and their operation shall be such as to give completeness to the interlock and function of the scheme.

The contact rating of the switches shall be as follows:

Description	**Contact Rating in Amps**		
	220V DC	**50V DC**	**240V AC**
Make and carry continuously	10	10	10
Make and carry for 0.5 sec.	30	30	30
Break for Resistive load	3	20	7
Break for Inductive load with L/R = 40m sec.	0.2	-	-

10.12.0 INDICATING LAMPS

Indicating lamps shall be of cluster LED type suitable for panel mounting with rear terminal connections. Lamps shall be provided with series connected resistors preferably built in the lamp assembly. Lamps shall have translucent lamp covers to diffuse lights coloured red, green, amber, clear white or blue as specified. The lamp cover shall be preferably of screwed type, unbreakable and moulded from heat resisting material.

The lamps shall be provided with suitable resistors.

Lamps and lenses shall be interchangeable and easily replaceable from the front of the panel. Tools, if required for replacing the bulbs and lenses shall also be included in the scope of the supply.

The indicating lamps with resistors shall withstand 120% of rated voltage on a continuous basis.

10.13.0 POSITION INDICATORS (If Applicable)

Position indicators of "SEMAPHORE" type shall be provided when specified as part of the mimic diagrams on panels for indicating the position of circuit breakers, isolating/earthing switches etc. The indicator shall be suitable for semi-flush mounting with only the front disc projecting out and with terminal connection from the rear.

Position indicator shall be suitable for DC Voltage as specified. When the supervised object is in the closed position, the pointer of the indicator shall take up a position in line with the mimic bus bars, and at right angles to them when the object is in the open position. When the supply failure to the indicator occurs, the pointer shall take up an intermediate position to indicate the supply failure.

The rating of the indicator shall not exceed 2.5W.

The position indicators shall withstand 120% of rated voltage on a continuous basis.

10.14.0 SYNCHRONISING EQUIPMENT

For sub-station equipped with sub-station Automation system, the requirement of synchronisation is specified in section Sub-station Automation System and the same shall prevail. For other sub-station which is not equipped with sub-station automation system following shall be applicable as per requirement.

The synchronising instruments shall be mounted either on a syn- chronising trolley or on a synchronising panel. The panel/ trolley shall be equipped with double analog voltmeters and double analog frequency meters, synchroscope and lamps fully wired. The size of voltmeters and frequency meters provided in the synchronising panel shall not be less than 144 X 144 sq. mm. Suitable auxiliary voltage transformers wherever necessary shall also be provided for synchronising condition. In case the synchroscope is not continuously rated, a synchroscope cut- off switch shall be provided and an indicating lamp to indicate that the synchroscope is energised, shall also be provided.

Synchronising check relay with necessary ancillary equipment's shall be provided which shall permit breakers to close after checking the requirements of synchronising of incoming and running supply. The phase angle setting shall not exceed 35 degree and have voltage difference setting not exceeding10%.This relay shall have a response time of less than 200 milliseconds when the two system conditions are met within present limits and with the timer disconnected. The relay shall have a frequency difference setting not exceeding 0.45% at rated value and at the minimum time setting. A

guard relay shall be provided to prevent the closing attempt by means of synchronising check relay when control switch is kept in closed position long before the two systems are in synchronism

The synchronising panel shall be draw out and swing type which can be swivelled in left and right direction. The synchronising panel shall be placed along with control panels and the number of synchronising panel shall be as indicated in BPS. The incoming and running bus wires of VT secondary shall be connected and run as bus wires in the control panels and will be extended to synchronising panel for synchronisation of circuit breakers. The selector switch provided for each circuit breaker in respective control panels shall be lockable type with a common key so that only one selector switch is kept in synchronising mode at a time.

Alternatively, the trolley shall be of mobile type with four rubber-padding wheels capable of rotating in 360 degree around the vertical axis. Suitable bumpers with rubber padding shall be provided all around the trolley to prevent any accidental damage to any panel in the control room while the trolley is in movement. The trolley shall have two meter long flexible cord fully wired to the instruments and terminated in a plug in order to facilitate connecting the trolley to any of the panels. The receptacle to accept the plug shall be provided on the panel.

At existing sub-stations, the synchronising scheme shall be engineered to be compatible with the existing synchronising scheme and synchronising socket/switch on the panel. In substations, where synchronising panels are available, the bidder shall carry out the shifting of the above panels, if required, to facilitate the extension of control panel placement.

10.15.0 RELAYS

All relays shall conform to the requirements of IS: 3231/IEC-60255/IEC 61000 or other applicable standards. Relays shall be suitable for flush or semi-flush mounting on the front with connections from therear.

All protective relays shall be of numerical type and communication protocol shall be as per IEC 61850. Protective relays shall also fulfil the requirements specified for Protection IEDs in Section- Substation automation system

All protective relays shall be in draw out or plug-in type/modular cases with proper testing facilities. Necessary test plugs/test handles shall be supplied loose and shall be included in contractor's scope of supply.

All AC operated relays shall be suitable for operation at 50 Hz. AC Voltage operated relays shall be suitable for 110 Volts VT secondary and current operated relays for 1 amp CT secondary. All DC operated relays and timers shall be designed for the DC voltage specified, and shall operate satisfactorily between 80% and 110% of rated voltage. Voltageoperated relays shall have adequate thermal capacity for continuous operation.

The protective relays shall be suitable for efficient and reliable operation of the protection scheme described in the specification. Necessary auxiliary relays and timers required for interlocking schemes for multiplying of contacts suiting contact duties of protective relays and monitoring of control supplies and circuits, lockout relay monitoring circuits etc. also required for the complete protection schemes described in the specification shall be provided. All protective relays shall be provided with at least two pairs of potential free isolated output contacts. Auxiliary relays and timers shall have pairs of contacts as required to complete the scheme; contacts shall be silver faced with spring action. Relay case shall

have adequate number of terminals for making potential free external connections to the relay coils and contacts, including spare contacts.

Timers shall be of solid state/numerical type. Time delay in terms of milliseconds obtained by the external capacitor resistor combination is not preferred and shall be avoided.

No control relay, which shall trip the power circuit breaker when the relay is de-energised, shall be employed in the circuits.

Provision shall be made for easy isolation of trip circuits of each relay for the purpose of testing and maintenance.

Auxiliary seal-in-units provided on the protective relays shall preferably be of shunt reinforcement type. If series relays are used the following shall be strictly ensured:

(a) The operating time of the series seal-in-unit shall be sufficiently shorter than that of the trip coil or trip relay in series with which it operates to ensure definite operation of the flag indicator ofthe relay.

(b) Seal-in-unit shall obtain adequate current for operation when one or more relays operate simultaneously.

(c) Impedance of the seal-in-unit shall be small enough to permit satisfactory operation of the trip coil on trip relays when the D.C. Supply Voltage is minimum.

(d) Trip-circuit seal-in is required for all trip outputs, irrespective of the magnitude of the interrupted current. The trip-circuit seal-in logic shall not only seal-in the trip output(s),but also the relevant initiation signals to other scheme functions, (e.g. initiate signals to the circuit-breaker failure function, reclosing function etc.), and the alarm output signals.

(e) Two methods of seal-in are required, one based on the measurement of AC current, catering for those circumstances for which the interrupted current is above a set threshold, and one based on a fixed time duration, catering for those circumstances for which the interrupted current is small (below the set threshold).

(f) For the current seal-in method, the seal-in shall be maintained until the circuit-breaker opens, at which time the seal-in shall reset and the seal-in method shall not now revert to the fixed time duration method. For this seal-in method, the seal-in shall be maintained for the set time duration. For the line protection schemes, this time duration shall be independently settable for single- and three-pole tripping.

(g) Seal-in by way of current or by way of the fixed duration timer shall occur irrespective of whether the trip command originates from within the main protection device itself (from any of the internal protection functions), or from an external device with its trip output routed through the main protection device for tripping. Trip-circuit seal-in shall not take place under sub- harmonic conditions (e.g. reactor ring down).

The setting ranges of the relays offered, if different from the ones specified shall also be acceptable if they meet the functional requirements.

Any alternative/additional protections or relays considered necessary for providing complete effective and reliable protection shall also be offered separately. The acceptance of this alternative/ additional equipment shall lie with the POWERGRID/AEGCL/Employer.

All relays and their drawings shall have phase indications as R-Red, Y- yellow, B-blue

For numerical relays, the scope shall include the following:

a) Necessary software and hardware to up/down load the data to/from the relay from/to the personal computer installed in the substation. However, the supply of PC is not covered under this clause.

b) The relay shall have suitable communication facility for future connectivity to SCADA. The relay shall be capable of supporting IEC 61850 protocol.

c) In case of line protection and transformer/reactor protection, the features like fault recorder and event logging function as available including available as optional feature in these relays shall be supplied and activated at no extra cost to the owner. Also necessary software/ hardware for automatic uploading to station HMI/DR work station (as applicable) shall be supplied. It is to be clearly understood that these shall be in addition to Fault recorder function as specified at clause no. 28.

10.16.0 TRANSMISSION LINE PROTECTION

All relays shall be suitable for series compensated line.

The line protection relays are required to protect the line and clear the faults on line within shortest possible time with reliability, selectivity and full sensitivity to all type of faults on lines. The general concept is to have two main protections having equal performance requirement specially in respect of time as called Main-I and Main-II for 765kV, 400KV and 220KV transmission lines and Main and back up protection for 132 KV transmission lines.

The Transmission system for which the protection equipment are required is indicated in Section – Project.

The maximum fault current could be as high as 63kA but the minimum fault current could be as low as 20% of rated current of CT secondary. The starting & measuring relays characteristics should be satisfactory under these extremely varying conditions.
The protective relays shall be suitable for use with capacitor voltage transformers having non-electronic damping and transient response as per IEC.

Fault Recorder, Distance to fault Locator and Over voltage relay (stage - 1/2) functions if offered as an integral part of line protection relays, shall be acceptable provided these meet the technical requirements as specified in the respective clauses.

Auto reclose relay function if offered as an integral part of line distance protection relay, shall be acceptable for 132kV & below lines only provided the auto reclose relay feature meets the technical requirements as specified in the respective clause.

The following protections shall be provided for each of the Transmission lines:

For 765kV, 400kV & 220kV Lines Main-I:

Distance protection scheme**. Main-II:** Distanceprotection scheme

- If specified in Section-Project, Main-I and / or Main-II relay shall be provided as Line differential protection relay with built in distance function. Further, matching Line differential protection relays for remote ends shall be provided as per Bid Price Schedule (BPS).
- Main-I & Main-II relay shall be of different make & model. Same make relay shallbe acceptable only if they are of different hardware & manufacturing platform.
- If specified in the "Section- Project, "back up Over current and Earth fault protectionshall be provided instead of Main -II protection scheme for 220KV lines to match with requirements at the remote ends.

- Existing 220kV Bus Scheme at Misa (Powergrid) substation is Double main cum transfer scheme.
- Existing 220kV bus bar scheme present at Misa (Powergrid) is centralized bus bar scheme.

For 132KV

Main: Distance protection scheme

Back up: Directional Over Current and Earth fault Protection The detaileddescription of line protections is given here under.

Main-I and Main-II Distance Protection scheme:

(a) shall have continuous self monitoring and diagnostic feature

(b) shall be non-switched type with separate measurements for all phase to phase and phase toground faults

(c) shall have stepped time-distance characteristics and independentthree forward zones and one reverse/offset zone

(d) shall have mho or quadrilateral or other suitably shaped characteristics for **all zones**.

(e) shall have following maximum operating time (including trip relay time, if any) under given set of conditions and with CVT being used on line (with all filters included)

For 765 kV, 400 kV & 220 kV lines:

For Source to Impedance ratio:	**4**	**15**
Relay setting (Ohms)	(10 or 20) and 2	2
Fault Locations (as % of relay setting)	50	50
Fault resistance (Ohms)	0	0
Maximum operating time (Milliseconds)	40 for all faults	45 for 3 ph. Faults & 60 forall other faults

(ii) for 132 KV lines:

A relaxation of 5 ms in above timings is allowed for 132 KV lines.

(f) The relay shall have an adjustable characteristics angle setting range of 30-85 degree or shall have independent resistance(R) and reactance (X)setting.

(g) shall have two independent continuously variable time setting range of 0-3 seconds for zone-2 and 0-5 seconds for zone-3/reverse zone.

(h) shall have resetting time of less than 55 milli-seconds (including the resetting time of trip relays)

(i) shall have variable residual compensation for each zone

(j) shall have memory techniques with defined characteristics in all three phases to ensure correct operation during close-up 3 phase faults and other adverse conditions and shall operate instantaneously when circuit breaker is closed to zero-volt 3 phase fault

(k) shall have weak end in-feed feature

(l) shall be suitable for single & three phase tripping

(m) shall have a continuous current rating of two times of rated current. The voltage circuit shall be capable of operation at 1.2 times rated voltage. The relay shall also be capable of carrying a high short time current of 70 times rated current without damage for a period of 1sec.

(n) Shall be provided with necessary self reset type trip duty contacts for completion of the scheme (Minimum number of these trip duty contacts shall be four per phase) either through built in or through separate high speed trip relays. Making capacity of these trip contacts shall be 30 amp for 0.2 seconds with an inductive load of L/R > 10 milli seconds. If separate high speed trip relays are used , the operating time of the same shall not be more than 10milliseconds

(o) shall be suitable for use in permissive under reach/ over reach/ blocking communication mode

(p) shall have suitable number of potential free contacts for Carrier aided Tripping, Auto reclosing, CB failure, Disturbance/**Fault** recorder & Data acquisition system

(q) include power swing blocking **and out-of-step** protection which shall

- have suitable setting range to encircle the distance protection described above
- block tripping **of distance function zones** during power swing conditions
- release blocking in the event of actual fault
- release tripping on detection of out-of-step power swing condition

Alternatively standalone relay for out of step protection shall also be acceptable, if the same is not part of main protection relays.

(r) Include fuse failure protection which shall monitor all the fuses of C.V.T. and associated cable against open circuit

- inhibit trip circuits on operation and initiate annunciation
- have an operating time less than 7milliseconds
- remain inoperative for system earth faults

(s) include a directional back up Inverse Definite Minimum Time (IDMT) earth fault relay with normal inverse characteristics as per IEC 60255-3 as a built in feature or as a separate unit for 765kV, 400 KV and 220KV transmission lines

(t) Must have a current reversal guard feature.

(u) Shall have Stub protection function with current setting minimum range of 1 to 3 pu with definite time delay setting minimum range of 0 to100msec.

(v) have feature of load encroachment blinder to safeguard the protection trip during heavy line loading condition.

Line Differential Relay protection scheme (If applicable)

The line current differential relay with built-in distance protection function shall be capable of being selected to differential function with back up distance function or shall activate back up distance automatically when the differential relay is out of service. The relay shall fulfil the requirement specified above at clause 18.9 for distance relay function.

Further, the line current differential function shall conform to the following main requirements:

i. The current differential shall be a unit system of protection.

ii. The line Current differential Protection shall comprise a well- proven high-speed phase segregated numerical current differential protection scheme, which shall be designed for the selective protection of the EHV network.

iii. The High speed numerical current differential protection shall be suitable to work through directly connected fiber

optics and the relay shall have the requisite teleprotection communication capability.

iv. Shall have built-in signalling modules for communication with the remote end relay via direct optical fibercables.

v. The contractor shall coordinate the requirements of the current differential relay withthe communication system in order to ensure compatibility between thetwo.

vi. The relay shall incorporate inter-tripping, VT Supervision functions and heavy duty contacts for tripping of the feeder circuit breaker as well as provide all flagging, alarms etc.

vii. Shall have high-speed fault detection capability with typical relay operation time of less than **30** ms for 765kV/400kV/220kV line faults and less than 40 ms for 132kV &below.

viii. Shall have high sensitivity for all types offaults.

ix. Shall detect and clear faults along the whole length of the feeder within the specifiedoperating time when the remote end breaker is open or there is a weak infeed.

x. Shall remain stable for fault on a parallel feeder under subsequent current reversal in the healthy feeder due to slow opening of one of the faulty feeder's circuit breakers.

xi. Shall not be affected by heavy load transfer, power swings, CT saturation, distortedprimary currents and voltages, VT fuse failure, line charging currents external switching, arc or tower footing resistance, sudden power reversal, zero sequence mutual coupling, fault resistance and out of phase source at the two line terminals producing misleading apparent fault reactance, power frequency variations, collapseof voltage on the faulted phase(s),etc.

xii. Shall have features to clear close in faults at high speed in the event of failure of signalling channel.

xiii. Shall have features to test at one end all the functions associated with the protection, without the presence of personnel at the remote end.

xiv. Shall have features to block relay in case of signalling channel,failure or remote relay out of service / block or setting mismatch or dc failure etc., to avoid inadvertent tripping and shall produce alarm during blocking.

xv. Shall have inter-tripping compliant with IEC60834-1 and IEC60834–2 respectively for signalling as appropriate.

xvi. The line differential device address shall be settable and shall be suitable to set for no. of feeders shown in SLD.

xvii. CT supervision / VT Supervision shall be configured to initiate alarm locally and tosub-station automation system or event recorder as per requirement.

xviii. Shall have single pole/three pole tripping feature.

xix. Shall have built-in SOTF logic feature.

xx. Shall have features to block auto-reclose internally or externally at local end and facility to send blocking signals to remote end relay internally (through FO communication channels) during SOTF trips.

xxi. Shall have facility to configure signal transferred between local and remote end relays in the internal event recorder and disturbance recorder.

xxii. Shall have configurable time delayed thermal protection element and back up earthfault protection element.

xxiii. Shall have following features:

- Satisfactory Performance of relay under CT saturation during through faults.
- Satisfactory Performance of relay under conditions of CT saturation for in zone faults.
- Satisfactory Performance of relay during transient (jitter) and permanent changes in signalling propagation delays.

xxiv. Shall include necessary Optical fibre cable & associated accessories for connection between the current differential relay panel and existing Fibre optic distribution panel(FODP).

Back-up Directional Over Current and Earth fault protection scheme

(a) shall have three over current and one earth fault element(s) which shall be either independent or composite unit(s)

(b) shall include necessary VT fuse failure relays for alarm purposes

(c) over current elements shall

- have IDMT characteristic (normal inverse as per IEC)
- have a variable setting range of 50-200% of rated current
- have a characteristic angle of 30/45 degree lead
- include hand reset flag indicators or LEDs

(d) earth fault element shall

- have IDMT characteristic (normal inverse as per IEC)
- have a variable setting range of 20-80% of rated current
- have a characteristic angle of 45/60 degree lag
- include hand reset flag indicators or LEDs
- include necessary separate interposing voltage transformers or have internal feature inthe relay for open delta voltage to the relay

LINE OVER VOLTAGE PROTECTION RELAY shall

(a) monitor all three phases

(b) have two independentstages

(c) be either a standalone relay for both stage-I & II or as built in function of Main-I & Main-II distance relay for both stage-I &II.

(d) have an adjustable setting range of 100-170% of rated voltage **with a setting least count of 0.1V (Secondary volts) and** an adjustable time delay range of 1 to 60 seconds for the first stage.

(e) have an adjustable setting range of 100-170% of rated voltage with a time delay of 100-200mill seconds for the second stage.

(f) be tuned to power frequency

(g) provided with separate operation indicators (flag target) and **signal** for each stage relays **with phase indication for event logging**.

(h) have a drop-off to pick-up ratio greater than**97%**

All trip relays used in transmission line protection scheme shall be of self/electrical reset type depending on application requirement.

10.8.0 CIRCUIT BREAKER PROTECTION

1. This shall include following functions:

Numerical AUTO RECLOSING function shall

(a) have single phase reclosing facilities

(b) have a continuously variable single phase dead time range of 0.1-2 seconds

(c) have a continuously variable reclaim time range of 5-300seconds

(d) Incorporate a two position selector switch, from which single phase auto-reclosure and non-auto reclosure mode can be selected. Alternatively, the mode of auto reclosing can be selected through **HMI of the relay or BCU &SAS**.

(e) be of single shot type

(f) have priority circuit for closing of both circuit breakers in case of one and half breaker arrangements to allow sequential closing of breakers

(g) However, Auto-reclose as in built function of bay controller unit(BCU)

(if supplied) is also acceptable **provided the signal exchange for auto-reclose functionfrom BCU to main Relays & vice-versa is achieved through hardwiring**.

LOCAL BREAKER BACK-UP (LBB) PROTECTION SCHEMEshall

(a) be triple poletype

(b) have an operating time of less than 15 milliseconds

(c) have a resetting time of less than 15 milli seconds

(d) have three over currentelements

(e) be arranged to get individual initiation from the corresponding phase of main protections of line for each over current element. However, common three phase initiation is acceptable for other protections and transformer /reactor equipmentprotections

(f) have a setting range of 10-80% of ratedcurrent

(g) have a continuous thermal withstand two times rated current irrespective of thesetting

(h) have a timer with continuously adjustable setting range of 0.1- 1seconds

(i) have necessary auxiliary relays to make a comprehensive scheme

(j) Shall have re-trip feature for tripping its own CB after initiation with a set timedelay.

(k) be acceptable as Built-in protection function of distributed bus bar protection scheme only; however in that case separate LBB relay shall be provided for tiebays.

(l) Be similar relays for complete scope of work as per specification (if provided as standalone relay unit).

(m) LBB protection shall be standalone as per present scheme.

10.18.0 REACTOR PROTECTION

Differential Protection Relay shall

(a) be triple pole type

(b) have operation time less than 25 milli-seconds at 5 times setting

(c) be tuned to system frequency

(d) have current setting range of 10 to 40% of 1 Amp. or a suitable voltage setting range

(e) be high impedance / biased differential type

(f) be stable for all external faults, CT saturation.

Restricted Earth Fault Protection Relays hall

(a) be single pole type

(b) be of current/voltage operated high impedance type

(c) have a current setting of **05**-40% of 1 Amp./have a suitable voltage setting range

(d) be tuned to system frequency

(e) have a suitable non-linear resistor to limit the peak voltage to 1000Volts

(f) Separate relay shall be provided for 1-phase spare reactor unit (if envisaged).

Back up impedance protection Relay shall

(a) be triple pole type, with faulty phase identification/indication
(b) be single step polarised 'mho' distance/ impedance relay suitable for measuring phase to ground and phase to phase faults
(c) have adequate ohmic setting range to cover at least 60% of the impedance of the reactor and shall be continuously variable
(d) have an adjustable characteristic angle of 30-80degree
(e) have a definite time delay relay with a continuously adjustable setting range of 0.2- 2.0seconds
(f) include VT failure relay which shall block the tripping during VT fuse failure condition
(g) have Back-up over current and earth fault protection as built in function

Further, Reactor auxiliary protections contacts (Buchholz, PRV, Oil Temperature, Winding Temperature etc.) can be wired suitably in above protections or provide separate Flag relays/Auxiliary relays as per scheme requirements. **Further reactor protections shall be grouped such that Differential protection, Buchholz-I trip and Winding temperature trip are on DC-A while REF protection, Back-up Impedance protection, PRD-I and Oil temperature trip are on DC-B. In case multiple trip contacts for Buchholz relay / PRD relays are available, then their contacts shall be wired to both Group of Protection.**

10.20.0 TRANSFORMER PROTECTION

Transformer differential protection scheme shall

(a) be triple pole type, with faulty phase identification/indication
(b) have an operating time not greater than 30 milli seconds at 5 times the rated current
(c) have three instantaneous high set over-current units
(d) **be bias differential type having** an adjustable bias setting range of10-50%
(e) be suitable for **04 nos. of 3-ph CT input** with rated **CT secondary** current of 1Amp.
(f) Have second harmonic or other inrush proof features and also should be stable under normal over fluxing conditions. Magnetising inrush proof feature shall not be achieved through any intentional time delay e.g. use of timers to block relay operation or using disc operated relays
(g) have an operating current setting of 15% or less
(h) include necessary separate interposing current transformers for angle and ratio correction or have internal feature in the relay to take care of the angle & ratio correction
(i) have a fault recording feature to record graphic form of instantaneous values of following analogue channels during faults and disturbances for the pre fault and post fault period:

Current in all three windings in nine / **twelve** analogue channels in case of 400kV class / **765kV class** respectively or 6 analogue channels for lower voltage transformers and Voltage in one channel

The disturbance recorder **function built in the Differential protection IED** shall have the facility to record the following external digital channel signals associated with transformer **which shall be wired to differential relay** apart from the digital signals pertaining to differential relay:

1. REF protection operated
2. HV Breaker status (Main & tie/transfer both separately)
3. IV Breaker status (Main & tie/transfer both separately)
4. Bucholz / OLTC/ WTI/ OTI alarm
5. Bucholz / PRD / SPR/Trip
6. Group-A, Group-B lock-out relay trip

Necessary hardware and software, for automatic up-loading the data captured by disturbance recorder to the personal computer (DR Work Station) available in the substation, shall be included in the scope.
Over Fluxing Protection Relays shall

(a) operate on the principle of Voltage to frequency ratio and shall be phase to phase connected
(b) have inverse time characteristics, matching with transformer over fluxing withstand capability curve
(c) provide an independent 'alarm' with the time delay continuously adjustable between 0.1 to 6.0 seconds at values of 'v/f' between 100% to 130% of rated values
(d) tripping time shall be governed by 'v/f' Versus time characteristics of the relay
(e) have a set of characteristics for Various time multiplier settings. The maximum operating time of the relay shall not exceed 3 seconds and 1.5 seconds at 'v/f' values of 1.4 and 1.5 times, the rated values, respectively.
(f) have an accuracy of operating time, better than 10%
(g) have a resetting ratio of **97 %** or better.

Restricted Earth Fault Protection shall

(a) be single pole type
(b) be of current/voltage operated type
(c) have a current setting range **of 5-40%** of 1 Amp./ have a suitable voltage setting range
(d) be tuned to the system frequency
(e) be phase segregated type for 1-ph transformer units
(f) Separate relay shall be provided for 1-phase spare transformer unit (if envisaged).

Back-up Over Current and Earth fault protection scheme with high set feature

(a) Shall have three over current and one earth fault element(s) which shall be either independent or composite unit(s).
(b) The scheme shall include necessary VT fuse failure relays for alarm purposes
(c) Over current relay shall

- have directional IDMT characteristic with a definite minimum time of 3.0 seconds at 10 times setting and have a variable setting range of 50-200% of rated current
- have low transient, over reach high set instantaneous unit of continuously variable setting range 500-2000 % of rated current
- have a characteristic angle of 30/45 degree lead
- include hand reset flag indicators or LEDs.

(d) Earth fault relay shall

- have directional IDMT characteristic with a definite minimum time of 3.0 seconds at 10 times setting and have a variable setting range of 20-80% of rated current
- have low transient, over reach high set instantaneous unit of continuously variable setting range 200-800 % of rated current
- have a characteristic angle of 45/60 degree lag
- include hand reset flag indicators or LEDs

- include necessary separate interposing voltage transformers or have internal feature in the relay for open delta voltage to the relay

Transformer Overload Protection Relay shall

(a) be of single pole type
(b) be of definite time over-current type
(c) have one set of over-current relay element, with continuously adjustable setting range of 50-200% of rated current
(d) have one adjustable time delay relay for alarm having setting range of 1 to 10.0 seconds, continuously.
(e) have a drop-off/pick-up ratio greater **than95%.**

Transformer Neutral Current Protection relay (for 1-Phase transformer bank neutral)shall

(a) have directional IDMT characteristic with a definite minimum time of 3.0 seconds at 10 times setting and have a variable setting range of 20-80% of rated current.
Further, Transformer auxiliary protections contacts (Buchholz, PRD, **SPRD**, Oil Temperature, Winding Temperature, OLTC Buchholz etc. can be wired suitably in above protections or provide separate Flag relays/Auxiliary relays as per scheme requirements. **Further, transformer protections shall be grouped such that Differential trip, Buchholz-I trip, Oil temperature alarm and Winding temperature trip are on DC source-A while REF trip, Buchholz alarm, PRD-I trip, winding temperature alarm and Oil temperature trip are on DC source-B. In case multiple trip contacts for Buchholz relay / PRD relays are available, then their contacts shall be wired to both Group of Protection.**

10.21.0 TEE DIFFERENTIAL PROTECTION RELAYS (If Applicable)

TEE-1 Differential (Bias) protection relay shall

(a) be triple pole type
(b) have an operating time less than 30 milliseconds at 5 times the rated current
(c) have three instantaneous high set over current units
(d) have an adjustable bias setting range of20-50%
(e) have an operating current setting of 15% of 1 Amp or less

TEE-2 Differential (High Impedance) Protection relay shall

(a) be triple pole type
(b) have operating time less than 25 milliseconds at 5 times setting
(c) be tuned to system frequency
(d) have current setting range of 20 to 80% of 1Amp
(e) be voltage operated, high impedance type
(f) be stable for all external faults
(g) be provided with suitable non linear resistors across the relay to limit the peak voltage to 1000volts

10.22.0 TRIP CIRCUIT SUPERVISION RELAY

(a) The relay shall be capable of monitoring the healthiness of each 'phase' trip-coil and associated circuit of circuit breaker during 'ON' and 'OFF' conditions.
(b) The relay shall have adequate contacts for providing connection to alarm and event logging.
(c) The relay shall have time delay on drop-off of not less than 200 milli seconds and be provided

with operation indications for each phase

10.23.0 TRIPPING RELAY

High Speed Tripping Relay shall

(a) be instantaneous (operating time not to exceed 10milli-seconds).
(b) reset within 20 milli seconds
(c) be D.C. operated
(d) have adequate contacts to meet the requirement of scheme, other functions like auto- reclose relay, LBB relay as well as cater to associated equipment like event logger (SAS), Disturbance recorder, fault Locator etc.
(e) be provided with operation indicators for each element/coil.

10.24.0 DC SUPPLY SUPERIVISION RELAY

(a) The relay shall be capable of monitoring the failure of D.C. supply to which, it is connected.

(b) It shall have adequate potential free contacts to meet the scheme requirement.

(c) The relay shall have a 'time delay on drop-off' of not less than 100 milli seconds and be provided with operation indicator/flag.

10.25.0 BUS BAR PROTECTION

Redundant (1+1) numerical **low impedance biased differential** Bus Bar protection scheme for each Main bus (Bus1 / Bus2) & Transfer Bus (as applicable) for 400kV and 765kV shall be provided**.** The scheme shall be engineered so as to ensure that operation of any one out of two schemes connected to faulty bus shall result in tripping of the same.
Single bus bar protection scheme shall be provided for each main bus and transfer bus (as applicable) for 220KV and 132 KV voltage levels.
Each Bus Bar protection scheme shall

(a) have maximum operating time up to trip impulse to trip relay of 25 milli seconds at 5 times setting value for all types of faults.
(b) operate selectively for each bus bar
(c) give hundred percent security up to 63 KA fault level for 400KV and 220KV and 31.5 KA for 132 KV system.
(d) incorporate continuous supervision for CT secondary against any possible open circuit and if it occurs, shall render the relevant zone of protection inoperative and initiate an alarm.
(e) not give false operation during normal load flow in bus bars
(f) not cause tripping for the differential current below the load current of heaviest loaded feeder. Contractor shall submit application check for the same.
(g) be of phase segregated and triple pole type
(h) incorporate clear zone indication
(i) provide independent zones of protection (including transfer bus if any). If the bus section is provided then each side of bus section shall have separate set of bus bar protection schemes
(j) include protection 'IN/OUT' switch for each zone
(k) include individual high speed electrically reset tripping relays for each feeder. However, in case of distributed Bus bar protection, individual trip relay shall not be required if bay unit is having trip duty contacts for breaker tripping.
(l) be transient free in operation
(m) include continuous D.C. supplies supervision

(n) shall include necessary C.T. switching relays wherever C.T. switching is involved and have 'CT' selection incomplete alarm
(o) shall include trip relays, CT switching relays (if applicable), auxiliary CTs (if applicable) as well as additional power supply modules, input modules etc. as may be required to provide a Bus-bar protection scheme for the complete bus arrangement i.e. for all the bays or breakers including future bays as per the Single line diagram for new substations. However for extension of bus bar protection scheme in existing substations, scope shall be limited to the bay or breakers **covered in the scope of work**. Suitable panels (if required) to mount these are also included in the scope of the work.
(p) In case of distributed Bus bar Protection, the bay units for future bays may be installed in a separate panel and the same shall be located in switchyard panel room where bus bar protection panel shall be installed.

At existing substations, Bus-bar protection scheme with independent zones for each bus, will be available. All necessary co-ordination for 'AC' and 'DC' interconnections between existing schemes (Panels) and the bays proposed under the scope of this contract shall be fully covered by the bidder. Any auxiliary relay, trip relay, flag relay and multi tap auxiliary CTs (in case of biased differential protection) required to facilitate the operation of the bays covered under this contract shall be fully covered in the scope of the bidder...

The test terminal blocks (TTB) to be provided shall be fully enclosed with removable covers and made of moulded, non-inflammable plastic material with boxes and barriers moulded integrally. All terminals shall be clearly marked with identification numbers or letters to facilitate connection to external wiring. Terminal block shall have shorting, disconnecting and testing facilities for CT circuits.

10.26.0 WEATHER PROOF RELAY PANELS (For CT switching, If Applicable)

(a) This panel shall include necessary number of electrically reset relays each with at least eight contacts for isolator auxiliary contacts multiplication and for changing the CT and DC circuits to relevant zones of bus bar protection.
(b) The panel shall be sheet steel enclosed and shall be dust, weather and vermin proof. Sheet steel used shall be at least 2.0 mm thick and properly braced to prevent wobbling.
(c) The enclosures of the panel shall provide a degree of protection of not less than IP-55 (as per IS:2147).
(d) The panel shall be of free standing floor mounting type or pedestal mounting type as per requirement.
(e) The panel shall be provided with double hinged doors with pad locking arrangement.
(f) All doors, removable covers and panels shall be gasketed all around with synthetic Neoprene/EPDM gaskets generally conforming with provision of IS 11149. However, XLPE gaskets can also be used for fixing protective glass doors. Ventilating louvers, if provided shall have screens and filters. The screens shall be made of either brass or GI wire mesh.
(g) Cable entries shall be from bottom. Suitable removable cable gland plate shall be provided on the cabinet for this purpose.
(h) All sheet steel work shall be degreased, pickled, phosphated and then applied with two coats of zinc chromates primer and two coats of finishing synthetic enamel paint, both inside and outside. The colour of the finishing paint shall be light grey in accordance with shade no.697 of IS:5.
(i) Suitable heaters shall be mounted in the panel to prevent condensation. Heaters shall be controlled by thermostats so that the cubicle temperature does not exceed 30oC. On-off switch and fuse shall be provided. Heater shall be suitable for 240V AC supply Voltage.

(j) The test terminal blocks (TTB) to be provided shall be fully enclosed with removable covers and made of moulded, non- inflammable plastic material with boxes and barriers moulded integrally. All terminals shall be clearly marked with identification numbers or letters to facilitate connection to external wiring. Terminal block shall have shorting, disconnecting and testing facilities for CT circuits.

10.27.0 FAULT RECORDER

The fault recorder shall be provided for transmission lines. The fault recorder as in-built feature of line distance relay is also acceptable provided the requirements of following clauses aremet.

Fault recorder shall be microprocessor based and shall be used to record the graphic form of instantaneous values of voltage and current in all three phases, open delta voltage & neutral current, open or closed position of relay contacts and breakers during the system disturbances.

The Fault recorder shall consist of individual acquisition units, one for each feeder and an Evaluation unit which is common for the entire Substation. Whenever, more than one acquisition units are connected to an Evaluation unit, necessary hardware and software shall also be supplied for on line transfer of data from all acquisition units to Evaluation unit.

The acquisition unit is connected with evaluation unit being supplied as described in section sub-station automation through bus conforming to IEC 61850. In case of extension sub-station which is equipped with Sub-station Automation System based on IEC 61850, one set of evaluation software shall be supplied and loaded in existing fault recorder evaluation unit. Automatic uploading of disturbance files from acquisition unit to evaluation unit shall be done through existing station bus only conforming to IEC 61850. Necessary configuration/updation including hardware if any shall be in the scope of the contractor.

In case of extension of existing substation(s) which are without sub- station automation system, one set of Evaluation unit shall be supplied for each substation where ever disturbance recorders are required **(as per section-Project)** to be supplied along with necessary evaluation software as specified above. The Evaluation unit shall consist of a desktop personal computer (including at least 17" TFT colour monitor, mouse and keyboard) and **A4 size colour** printer. The desktop PC shall have **I5** processor or better and having a clock speed **2.0** GHz or better. The hard disk capacity of PC shall not be less than **1000** GB and RAM capacity shall not be less than **4**GB.

The evaluation unit hardware, for substations having SAS, shall be as described in section sub- station automation system.

Fault recorder shall have atleast 8 analogue and 16 digital channels for each feeder.

Acquisition units shall acquire the Disturbance data for the pre fault and post fault period and transfer them to Evaluation unit automatically to store in the hard disk. The acquisition units shall be located in the protection panels of the respective feeders.

The acquisition unit shall be suitable for inputs from current transformers with 1A rated secondary and capacitive voltage transformers with 63.5V (phase to neutral voltage) rated secondary. Any device required for processing of input signals in order to make the signals compatible to the Fault recorder equipment shall form an integral part of it. However, such processing of input signals shall in no way distort its waveform.

The equipment shall be carefully screened, shielded, earthed and protected as may be required for its safe functioning. Also, the Fault recorder shall have stable software, reliable hardware, simplicity of maintenance and immunity from the effects of the hostile environment of EHV switchyard which are prone to various interference signals typically from large switching transients.

Void

Evaluation software shall be provided for the analysis and evaluation of the recorded data made available in the PC under WINDOWS environment. The Software features shall include repositioning of analog and digital signals, selection and amplification of time and amplitude scales of each analogue and digital channel, calculation of MAX/MIN frequency, phase difference values, recording of MAX/MIN values etc. of analogue channel, group of signal to be drawn on the same axis etc, listing and numbering of all analogue and digital channels and current, voltage, frequency and phase difference values at the time of fault/tripping. Also, the software should be capable of carrying out Fourier /Harmonic analysis of the current and voltage wave forms. The Disturbance records shall also be available in COMTRADE format (IEEE standard- Common Format for Transient data Exchange for Power System)

The Evaluation unit shall be connected to the color printer to obtain the graphic form of disturbances whenever desired by the operator.

Fault recorder acquisition units shall be suitable to operate from 220V DC or 110V DC as available at sub-station. Evaluation unit along with the printer shall normally be connected to 230V, single phase AC supply. In case of failure of AC supply, Evaluation unit and printer shall be switched automatically to the station DC through Inverter of adequate capacity which shall form a part of Fault recorder system. The inverter of adequate capacity shall be provided to cater the requirement specified in section - sub-station automation and DR evaluation unit.

The acquisition unit shall have the following features

(a) Facility shall exist to alarm operator in case of any internal faults in the acquisition units such as power supply fail, processor / memory fail etc and same shall be wired to annunciation system/SAS.
(b) The frequency response shall be 5 Hz on lower side and 250 Hz or better on upper side.
(c) Scan rate shall be 1000 Hz/channel or better.
(d) Pre-fault time shall not be less than **500** milliseconds and the post fault time shall not be less than 2 seconds (adjustable). If another system fault occurs during one post- fault run time, the recorder shall also be able to record the same. **However, the total memory of acquisition unit shall not be less than 5.0 seconds.**
(e) The open delta voltage and neutral current shall be derived either through software or externally by providing necessary auxiliary transformers.
(f) The acquisition unit for line fault recorder shall be typically used to record **at least** the following digital channels:
    1 Main CB R phase open
    2 Main CB Y phase open
    3 Main CB B phase open
    4 Tie/TBC CB R phase open
    5 Tie/TBC CB Y phase open
    6 Tie/TBC CB B phase open
    7 Main-1 carrier received

8 Main-1 protection operated
9 Main/Tie /TBC Auto reclosed operated
10 Over Voltage -Stage-1 /2operated
11 Reactor / Stub/TEE-1/2/UF protection operated
12 Direct Trip received
13 Main-2 carrier received
14 Main- 2/ Back Up protection operated
15 Bus bar protection operated
16 LBB operated of main /tie/TBC circuit breaker

(g) In case the Fault recorder is in-built part of line distance protection, above digital channels may be interfaced either externally or internally.

(h) The sequence of digital channels shall be as per above list and which shall be ensured by the contractor. Digital channels shall be named suitably for easy identification of signals in the fault recordings.

(i) Any digital signal can be programmed to act as trigger for the acquisition unit. Analog channels should have programmable threshold levels for triggers and selection for over or under levels should be possible.

10.28.0 STANDALONE DISTURBANCE RECORDER (for 765 KV Feeders only)

A separate numerical disturbance recording function shall be provided for each 765kV lines. The following requirements shall be met:

The disturbance recorder shall record the analogue values form of the instantaneous values of voltage and current in all three phases, the open delta voltage and the neutral current. The open or closed position of relay contacts and circuit breakers during system disturbances shall also be recorded.

The disturbance recorder shall comprise distributed individual acquisition units, one for each feeder and an evaluation unit which is common for the entire substation. The acquisition units shall acquire the disturbance data for the pre-fault, fault and post-fault periods and transfer them to the evaluation unit automatically for storage on a mass storage device. The acquisition unit shall be suitable for inputs from current transformers with 1 A rated secondaries and capacitive voltage transformers with
63.5 V (phase-to-neutral voltage) rated secondaries.

The acquisition units shall have the following features:

(a) A facility to alert the operator in the case of any internal faults (such as power supply fail, processor/memory fail etc.) in any of the acquisition units and this alarm shall be wired to the station annunciation system.

(b) The pre-fault time shall not be less than 200 milliseconds and the post fault time shall not be less than 2 seconds (adjustable). If another system disturbance occurs during a post- fault run time, the recorder shall also be able to record this subsequent disturbance. The scan rate should be selectable in the range from 1000 Hz to 5000 Hz.

(c) The open delta voltage and neutral current shall be derived either through software or externally by providing necessary auxiliary transformers.

(d) The acquisition unit shall be typically used to record **at least** the following digital channels:

1. Main circuit-breaker R-phase open
2. Main circuit-breaker Y-phase open
3. Main circuit-breaker B-phase open
4. Main 1 carrier received
5. Main 1 protection operated
6. Main/Tie auto-reclose operated
7. Overvoltage stage 1/2operated
8. Reactor/Stub-1/2 protection operated
9. Direct trip received

10. Main 2 carrier received
11. Main 2 protection operated
12. Bus bar protection operated
13. Breaker failure protection of main/tie circuit-breaker operated
14. Tie circuit-breaker R-phase open
15. Tie circuit-breaker Y-phase open
16. Tie circuit-breaker B-phase open

The sequence of digital channels shall be as per above list and which shall be ensured by the contractor. Digital channels shall be named suitably for easy identification of signals in the fault recordings.

The necessary hardware and software shall also be supplied for the on- line transfer of data from all acquisition units to the evaluation unit. The disturbance recording system shall be capable of handling the full complement of feeders in the substation.
In case of extension of existing substation(s), one set of Evaluation unit shall be supplied for each substation wherever required (as per section-Project) along with necessary evaluation software as specified above.

The disturbance recording equipment shall be screened, shielded, earthed and protected as may be required for its safe and proper functioning. Also, the disturbance recorder shall have stable software, reliable hardware, simplicity of maintenance and immunity from the effects of the hostile environment of a 765 kV EHV switchyard which is prone to numerous interference signals such as large switching transients.

The evaluation unit shall comprise all the necessary hardware and software for the proper evaluation of disturbances. The hardware would typically consist of a desktop personal computer (including a large high resolution colour monitor, mouse and keyboard) and a high- speed colour printer **(A4 size).** The desktop PC shall have **I5** processor or better and shall have a clock speed of **2.0 GHz** or better. The mass storage capacity of PC shall not be less than **1000GB** and the RAM capacity shall not be less than **4 GB**. The evaluation software required for the analysis and evaluation of the recorded data shall run on the PC under Microsoft Windows environment. The software features shall provide:

- clear and unambiguous display of all channels;
- the ability to reposition the analog and digital traces;
- recording of maximum/minimum values etc. of the analog channels;
- calculation of maximum/minimum frequency and phase difference values;
- grouping of signals for drawing on the same axis;
- listing and identification of all analog and digital channels as well as and current, voltage, frequency and phase difference values at the time of fault/tripping;
- the capability of carrying out Fourier/Harmonic analysis of the current and voltage waveforms; and,
- the availability of the disturbance records in COMTRADE format

The evaluation unit shall be permanently connected to the printer so as to obtain the graphic display of disturbances whenever desired by the operator. The printer shall be compatible with the desktop PC and shall use plain paper. The print out shall contain the feeder identity, date and time (in hour, minute and second up to 100th of a second), identity of the trigger source and graphic representation of the analog and digital signals of all the channels.

The disturbance recorder acquisition units shall be suitable to operate from the station DC. The evaluation unit along and the printer shall normally be connected to the 230 V, single phase AC supply. In the case of a failure of the AC supply, the evaluation unit and printer shall be automatically switched to the station DC through an inverter of adequate capacity and which shall form part of disturbance recording system.
The disturbance recorder shall be capable of being triggered by the following user-specified quantities:

(a) external start, both software and hardware
(b) cross triggering of groups of channels, either software or hardware or both
(c) binary channel (NO and NC contacts)
(d) over voltage and under voltage
(e) over current
(f) negative sequence voltage
(g) zero sequence voltage
(h) rate of change, voltage or current
(i) over frequency or under frequency
(j) logical or Boolean expressions, programmable
(k) powers wing
(l) rate of change of active or reactive power

The disturbance recorder shall have its own time generator and the clock of the time generator shall be such that the drift is limited to less than ± 0.5 seconds per day, if allowed to run without synchronisation. Further, the disturbance recorder shall have the facility to synchronise its time generator from the station Time Synchronisation Equipment using IRIG-B. The recorder shall give an alarm in the case of the absence of the synchronising pulse for a pre-determined time.

10.29.0 DISTANCE TO FAULT LOCATOR shall

a. be electronic or microprocessor based type
b. be 'On-line'type
c. be suitable for breaker operating time of 2cycles
d. have built-in display unit
e. the display shall be directly in percent of line length or kilometres without requiring any further calculations
f. have an accuracy of 3% or better for the typical conditions defined for operating timings measurement of distance relays
g. The above accuracy should not be impaired under the following conditions:
   - presence of remote end in feed
   - predominant D.C. component in fault current
   - high fault arc resistance
   - severe CVT transients
h. shall have mutual zero sequence compensation unit if fault locator is to be used on double circuit transmission line
i. built in feature of line distance relay is acceptable provided the requirements of above clauses are met.

10.30.0 DISTANCE TO FAULT LOCATOR shall
Distance to Fault locator, based on Travelling wave detection method, shall

a. be microprocessor based, On-line type
b. have programmable triggering thresholds
c. be suitable for breaker operating time of minimum 2cycles

d. consist of acquisition unit and one central unit
e. provide fault location reading directly in kilo-meter without requiring any further calculations
f. have fault location accuracy of + 150 Meter or better with a least count of atleast 50 meter for fault locator readings
g. The above accuracy should not be affected by followings:
- Line length
- Presence of remote end in-feed
- Series compensation
- Non-uniform line (having Cable &Over head line both)
- Mutual coupling
- Transposition of line
- Fault resistance
- Severe CVT transients

h. Acquisition units shall:
i. be either standalone for each line or with the capability to cater to a number of lines emanating from a substation. In case more than one lines are to be accommodated in one acquisition unit then suitable coupler unit/measuring unit shall be provided in individual line bay C&R panels and only secondary wiring shall be brought to common acquisition unit. While offering this option, bidders are advised to take care of maximum distance between Acquisition unit & line bays C&R panels. In the BPS, total no. of line bays envisaged for Travelling Wave type Fault Locators is mentioned for further assessment by the bidder for no. of Acquisition units required for total functional requirements based on equipment design.
ii. include all required accessories (like couplers, cables, connectors etc) to connect to the secondary wiring of the Instrument transformers (in C&R panels) for detection of travelling wave
iii. have built-in backlit display unit and keypad
iv. have the facility to locally download the data in case of communication failure
v. have minimum 02 nos. binary input per line for line protection trip input. Binary input shall be rated for 220V DC and it shall be possible to set the de-bounce time of the binary input.
vi. have minimum 1GB of storage space
vii. have facility to transmit the fault record to the Central unit by dialing mode, IEC60870-5- 103 or IEC60870-5-104 or TCP/IP net protocol etc. Scope shall include dialup modem, if required with each Acquisition unit.

i. include required GPS time synchronizing units for each substation (internal or external to Acquisition unit)

j. Central data processing unit shall:

i. Consist of a desktop personal computer (including at least 17" TFT color monitor, mouse and keyboard), colour laser jet multi-function printer (A4 size), LAN switches (as required), all special cables and other required accessories. The desktop PC shall have Intel Dual core processor or better. The hard disk capacity of PC shall not be less than 1000 GB and RAM capacity shall not be less than 4GB.

ii. have all necessary hardware & software for data download from Acquisition units, storage, processing, device (acquisition unit) creation and configuration, and comprehensive viewer for manual analysis of waveform. It will also have diagnostic feature to check the healthiness of connected devices & communication link.

iii. calculate & report the fault location based on the traveling wave data acquired from acquisition units of both end of the line. However, Central data processing unit shall have the facility to calculate the fault location even with only one end acquisition unit data of the line.

iv. be able to communicate to the Master station (Control centre) through IEC60870-5-104 net protocol. Alternate Standard protocol shall also be acceptable subject to fulfilling the functional requirements.

v. be located at local or any remote end based on the availability of communication link. End to end communication link shall be provided by POWERGRID/AEGCL. However Scope shall also include a dialup modem with central data processing unit.

i. In cases, Central data processing unit of Travelling wave fault locator is existing at a location the Acquisition units under present scope can be integrated with the existing Central data processing unit (Make & Model of existing unit should be mentioned in section-Project) by required augmentation (configuration and up gradation of data base including supply of any additional hardware / software etc.). Alternatively, bidder may offer separate Central data processing unit & associated hardware & software as may be required under the head of augmentation of Central data processing unit.

j. Include required no. of panels to house the offered equipments at various substations & central location. Acquisition units can also be mounted in respective line protection panels.

k. TWFL as built-in feature of Standalone fault recorder or Line Protection IED shall also be acceptable subject to meeting the functional requirement specified.

l. Type test (EMI/EMC) and additional functional test for accuracy shall be submitted for TWFL for review and approval.

10.31.0 TIME SYNCHRONISATION EQUIPMENT

The Time synchronisation equipment shall receive the co-ordinated Universal Time (UTC) transmitted through Geo Positioning Satellite System (GPS) and synchronise equipments to the Indian Standard Time in a substation.

Time synchronisation equipment shall include antenna, all special cables and processing equipment etc.

It shall be compatible for synchronisation of Event Loggers, Disturbance recorders and SCADA at a substation through individual port or through Ethernet realised through optic fibre bus.

Equipment shall operate up to the ambient temperature of 50 degree centigrade and 80%humidity.

The synchronisation equipment shall have 2 micro-second accuracy. Equipment shall give real time corresponding to IST (taking into consideration all factors like voltage, & temperature variations, propagation & processing delays etc).

Equipment shall meet the requirement of IEC 60255 for storage & operation.

The system shall be able to track the satellites to ensure no interruption of synchronisation signal.

The output signal from each port shall be programmable at site for either one hour, half hour, minute or second pulse, as per requirement.

The equipment offered shall have six (6) output ports. Various combinations of output ports shall be selected by the customer, during detailed engineering, from the following :

- Potential free contact (Minimum pulse duration of 50 milli Seconds.)
- IRIG-B
- RS232C
- SNTP Port
- **IEEE 1588 PTP (*Applicable only for Process bus automation station*)**

The equipment shall have a periodic time correction facility of one second periodicity.

Time synchronisation equipment shall be suitable to operate from 220V DC or 110V DC as available at Substation.

Equipment shall have real time digital display in hour, minute, second (24 hour mode) & have a separate time display unit to be mounted on the top of control panels/**SAS panel** having display size of approx. 100 mm height.

10.33.0 Bay Control Unit (BCU): BCU supplied shall meet the requirements mentioned under technical specification Section- Substation automation**.**

10.34.0 INTERFACE PANEL (If specified in BPS)

a) Interface panel is envisaged to minimize cabling/termination time during erection stage at site, minimize hindrance in protection panel and also ease of trouble shooting. This panel shall be installed in Switchyard panel room and one no. interface panel shall be provided for each feeder.Tie bay can be accommodated in the Interface unit of any one of the associated feeder.

b) All control wiring from switchyard except CTs & CVTs shall be terminated in the interface panel. CTs and CVTs wiring shall be directly connected to the relay panel as per scheme requirements.

c) All wiring from Interface panel to relay panels or other panels (Inter-panel wiring) in the switchyard panel room shall be factory fitted / terminated through Plug-in type termination arrangement. Plug- in type termination shall be heavy duty industrial grade with double locking latch or screw lockingarrangement with IP65 protection.

d) Minimum one number spare Plug-in type connector duly terminated on each side per inter-panelwiring circuit shall be provided for future use.

10.35.0 MONITORING, CONTROL & PROTECTION FOR AUXILIARY TRANSFORMER

Suitable monitoring, control (operation of associated circuit breaker & isolator) and protection for LT auxiliary transformer, connected to tertiary winding of auto transformer for the purpose of auxiliary supply shall be provided by the contractor. Over current and open delta protection is required to be provided for the auxiliary transformer. These protection and control shall be also be acceptable as built in feature either in the bay controller to be provided for the auxiliary system or in the control & protection IEDs to be provided for autotransformer.

10.36.0 RELAY Test KIT

One relay test kit shall comprise of the following equipment as detailed here under

3sets	Relay tools kits
2 nos.	Test plugs for each type of TTB

2 nos. Test plugs for using with modulartype relays (if applicable)

10.37.0 CONFIGURATION OF RELAY AND PROTECTION PANELS

The following is the general criteria for the selection of the equipments to be provided in each type of panel. However, contractor can optimise the requirement of panels by suitably clubbing the feeder protection and CB relay panels. It may be noted that Main-I and Main-II protections for line can not be provided in single panel. Similarly, Group-I & Group-II protections for transformer can not be provided in single panel.

I) LINE PROTECTION PANEL: The Line Protection panel for transmission lines shall consist of following protection features/schemes

Sl. No.	Description	765kV	400kV	220kV	132kV
1.	Main-1 protection scheme	1 Set	1 Set	1 Set	1 Set
2.	Main-2 protection scheme	1 Set	1 Set	1 Set	NIL*
3.	Over Voltage Protection Scheme	1 Set	1 Set	NIL	NIL
4.	Fault Recorder	1 Set	1 Set	1 Set	NIL
5.	Standalone Disturbance Recorder	1 Set	NIL	NIL	NIL
6.	Distance to fault Locator	1 Set	1 Set	1 Set	1 Set
7.	**Cut out for mounting of Distance tofault Locator (TWFL)**	**1 Set#**	**1 Set#**	NIL	NIL
8.	3 Phase Trip Relays	2 Nos.	2 Nos.	2 Nos.	2 Nos.
9.	Flag relays, carrier receive relays, aux. Relays, timers etc as per scheme requirements	As required	As required	As required	As required
10.	Under Voltage protection relay for isolator/earth switch **Interlock**	2 Nos	2 Nos	2 Nos	2 Nos
11. .	Cut-out and wiring with TTB for **Employer** supplied energy meter	1 Set	1 Set	1 Set	1 Set
12.	Directional Back up Over current and E/F protection scheme	NIL	NIL	NIL	1 Set
Note- 1)	*Back up –directional O/c & E/F protection is specified for 132kV system in place of Main-II				

Note- 2)	In a substation where 765kV, 400kV and 220 KV lines are under the scope of the contract,bidder is required to give identical Main-1 and Main-2 distance protection schemes for all voltage levels.
Note- 3)	Cut out & mounting arrangement of supplied energy meter shall be suitable for mounting of energy meter unit of 4" thickness
Note-IV	# **Cut out for mounting of Distance to Fault locator (Travelling wave type) shall beprovided.**

II) TRANSFORMER PROTECTION PANEL: The protection panel for Auto transformer/Transformer shall consists of the following features/schemes:

Sl. No.	**Description**	**HV side**	**MV/LV side**
1.	Transformer Differential Protection scheme	1 Nos.	Nil
2.	Restricted Earth fault protection scheme	1 no.	1 no@
	@ Not applicable for auto-transformer		
3.	Directional back up O/C and E/F relay with non-directionalhigh set feature	1 set	1 set
4.	Over Fluxing Protection scheme	1 no.	1 no.$
	$ Applicableonly for 400/220kV Transformer & 765/400kV Transformer		
5.	Overload protection scheme	1 nos.	NIL
6.	Three phase trip relays	2 nos.	2 nos.
7.	CVT selection relays scheme as per requirement	Lot	Lot
8.	Cut-out and wiring with TTB for energy meter	1 set	1 set
9.	Transformer Neutral Current Phase relay for1-transformer bank	1 Set	
10.	Tertiary side O/C and Open delta Voltage protection	1 Set	
11.	Flag Relays/Aux. Relays for wiring Transformer auxiliary protection contacts such as Buchholz, Oil Temperature, Winding Temperature, PRV, SPRD, OLTC Buchholz etc. asper schemerequirements	As required	
Note- 1)	**Tertiary side protections, over fluxing protection and overload protection can be clubbed in other transformer protection relay, however, over fluxing protection of HV and MV/LV side cannot be clubbed together. Further, tertiary side protection, if provided in auxiliary BCU, shall be excluded from this panel.**		

	This protection shall be applicable only for the transformer whose tertiary side is connected to LT transformer for station auxiliary supply.
Note- 2)	Cut out & mounting arrangement of energy meter shall be suitable for mounting of energy meter unit of 4" thickness

III) REACTOR PROTECTION PANEL: The protection panel for Reactor shall consist of the following features/schemes:

Sl. No.	Description	Qty.
1.	Reactor Differential Protection scheme	1 no.
2.	Restricted Earth fault Protection scheme	1 no.
3.	Reactor back up impedance protection scheme	1 set
4.	Three phase trip relays	2 nos.
5.	CVT selection relay as per scheme requirement	Lot
6.	Flag Relays/Aux. Relays for wiring Reactor auxiliary protection contacts such as Buchholz, Oil Temperature, Winding Temperature, PRV, SPRD etc. as per scheme requirements	As required

IV) BREAKER RELAY PANEL: The breaker relay panel shall consist of the following:

Sl. No.	Description	With A/R	Without A/R
1.	Breaker failure Protection Scheme *	1 No.	1 No.
2.	DC supply Supervision relay	2 Nos.	2 Nos.
3.	Trip Circuit supervision relays#	6 Nos.	6 Nos.
4.	Auto-reclose scheme (if standalone)	1 Nos.	NIL
5.	Flag relays, aux relays, timers, trip relays as per scheme requirements	As required	As required
Note- 1)	# Trip supervision relays shall be 2 **or 6** numbers **as per no. of trip coils** for each 132KV Circuit breaker		
Note- 2)	**Equipment/relays to be provided under CB Relay Panel may be accommodated in the Protection Panels to be provided forTransmission Line/Transformer/Reactor as applicable.**		
Note- 3)	*** In case of bay extension in existing half diameter, breaker failure relay for main CB /Tie CB shall be supplied only if BFR built-in Bus Bar protection bay unit is not available or Tie CB standalone BFR relay is not available inthe existing protection scheme.**		

V) <u>CONTROL PANEL</u>: Various types of control panels shall consist of the following:

a.	Ammeter	3 set	for each Line, BC, TBC Bus section, Bus Reactor and Transformer
b.	Ammeter with Selector switch	1 set	for each line reactor
c.	Wattmeter with transducer	1 set	for each line, transformer
d.	Varmeter with transducer	1 set	for each line, transformer, Bus reactor
e.	Varmeter with transducer	1 set	for each Line Reactor
f.	CB Control switch	1 no.	for each Circuit breaker
g.	Isolator Control switch	1 no.	for each isolator
h.	Semaphore	1 no.	for each earth switch
i.	Red indicating lamp	1 no.	for each Circuit breaker
j.	Red indicating lamp	1 no.	for each isolator
k.	Green indicating lamp	1 no.	for each Circuit breaker
l.	Green indicating lamp	1 no.	for each isolator
m.	White indicating lamp (DChealthy lamp)	2 nos.	for each feeder
n.	Annunciation windows with associated annunciation relays	18 nos.	for each feeder
o.	Push button for alarm Accept/reset/lamptest	3 nos.	for each control panel
p.	Synchronising Socket	1 no.	for each Circuit Breaker, ifrequired
q.	Synchronising selectorSwitch	1 no.	for each Circuit Breaker switch, if required
r.	Protection Transfer Switch	1 no.	for each breaker in case of DMT /DM with bypass isolator / SMT schemes (Except TBC and BCbreaker)
s.	Mimic to represent SLD	Lot	in all control panels
t.	Voltmeter with selectorSwitch	1 no.	for each line, transformer, bus reactor
u.	Cut out, mounting and wiring for RWTI and selector switch	Lot	for transformers/reactors

Notes:

1. For transformer feeders, all equipments of control panel shall be provided separately for HV and MV sides.

2. In case of incomplete diameter (D and I type layouts), control panel shall be equipped fully as if the diameter is complete, unless otherwise specified. Annunciation relays shall also be provided for the same and if required, necessary panel shall be supplied to accommodate the same.
3. The above list of equipments mentioned for control panel is generally applicable unless it is defined elsewhere and in case of bay extension in existing substations, necessary equipments for matching the existing control panel shall be supplied.
4. Each line/HV side of transformer/MV/LV side of transformer/Bus reactor/TBC /**Tie** / BC/ Bus Section shall be considered as one feeder for above purpose.

VI) **CONTROL PANEL WITH BAY CONTROL UNIT (BCU):**Various types of control panels shall consist of the following:

a.	Bay Control Unit (BCU)	1 set	for each Circuit Breaker
b.	Ethernet switch complyingIEC61850	1 no.	for each control panel
c.	Selector switch forLocal/Remote bay control	1 no.	for each Circuit Breaker
d.	Ammeter with transducer &Selector switch	1 set	for each Line, BC, TBC, Bus section, Bus reactor, Transformer and linereactor
e.	CB Control switch	1 no.	for each Circuit breaker
f.	Red indicating lamp	1 no.	for each Circuit breaker
g.	Green indicating lamp	1 no.	for each Circuit breaker
h.	White indicating lamp (DChealthy lamp)	2 nos	for each feeder
i.	Common Annunciation lamp	1 no.	for each control panel
j.	Common hooter	1 no.	for each control panel
k.	Synchronising Socket	1 no.	for each Circuit Breaker if required
l.	Synchronising selector Switch	1 no.	for each Circuit Breaker switch ifrequired
m.	Protection Transfer Switch	1 no.	for each breaker in case of DMT /DM with bypass isolator/ SMT schemes (Except TBC and BC breaker)
n.	Mimic to represent SLD	Lot	in all control panels
o.	Voltmeter with selector Switch	1 no.	for each line, transformer, bus reactor

Notes:

1. For transformer feeders, all equipments of control panel shall be provided separately for HV and MV sides.
2. In case of incomplete diameter (D and I type layouts), control panel shall be equipped fully as if the diameter is complete, unless otherwise specified. Annunciation relays shall also be provided for the same and if required, necessary panel shall be supplied to accommodate the same.
3. The above list of equipments mentioned for control panel is generally applicable unless it is defined elsewhere and in case of bay extension in existing substations, necessary equipments for matching the existing control panel, if applicable, shall be supplied.
4. Each line /HV side of transformer/MV/LV side of transformer /Bus reactor /TBC /BC/ Bus Section shall be considered as one feeder for above purpose.
5. Control panel with BCU can be combined in the CB relay panels being supplied under present scope.
6. The Bay Control unit and the numerical relays supplied under present scope shall be connected to the Ethernet switch. The ethernet switch shall comply with IEC 61850-3 requirements. It shall have sufficient number of ports to accommodate all the IEDs of the new bays and at least 6 spare ports for integrating the numerical Relays/BCUs with NTAMC system
7. i.e. redundant Gateways/RTU and redundant SDC and two spare ports. The IP addressing scheme for the devices shall be provided by POWERGRID/AEGCL.
8. Selector switch for Local/Remote bay control shall be provided to transfer the control between the BCU and the Control panel. The control shall be available to either the BCU or from the Control panel however data monitoring shall be available at both the devices
9. The Bay control unit shall be flush mounted in the panel with their mimic displays accessible from the front of the panel. The Bay control unit mimic shall dynamically represent the current value of the measurements, state of the devices and control of devices. The Bay control unit shall provide telemetry and tele-control for remote operation from control centres (NTAMC). The Bay control unit shall acquire all the analog measurements, Status of Circuit breakers, Isolators and Earth switches, status of alarms, and provide Control of devices (Circuit breaker/Isolators/Reset of Relays/position selection for Auto reclose etc). The Bay control unit shall also provide synchronization check facility for the circuit breakers suitable for the bus bar scheme.
10. For Protection transfer switch function in Transfer bus schemes- The High Speed Bi-stable relays for protection transfer from ‘Normal’ to ‘Transfer’ and vice versa, whose position can be controlled locally as well as from remote via BCU shall be provided. The position once selected should not change in case of Power cycling.
11. In case the control panel is being provided in switchyard panel room, its common alarm signal shall also initiate an alarm facia in any of the existing control panel in control room building.

10.38.0 ERECTION AND MAINTENANCE TOOLEQUIPMENTS

All special testing equipment required for the installation and maintenance of the apparatus, instruments devices shall be furnished in relevant schedule.

10.39.0 TROPICALISATION

Control room/ Panel room will be normally air-cooled/air- conditioned. All equipments shall however be suitable for installation in a tropical monsoon area having hot, humid climate and dry and dusty seasons with ambient conditions specified in the specification. All control wiring, equipment and accessories

shall be protected against fungus growth, condensation, vermin and other harmful effects due to tropical environment.

10.41.0 TYPE TESTS

The reports for following type tests shall be submitted during detailed engineering for the Protective relays, Fault Recorder, Fault locator and Disturbance recorder:

a) Insulation tests as per IEC60255-5

b) DC Voltage dips and interruptions/Variation as per IEC61000-4-29or IEC 60255-11

c) High frequency (1MHz burst) disturbance test **as per IEC 60255- 22-1** (Not applicable for electromechanical relays)

d) Electrostatic discharges as per IEC 61000-4-2, level; 4 **or IEC 60255-22-2 with severityClass III** (not applicable for Electromechanical relays)

e) Fast transient test as per IEC 61000, Level IV **or IEC 60255-22-4 with severity level IV**
(Not applicable for electromechanical relays)

f) Relay characteristics, performance and accuracy test as per IEC 60255

- Steady state Characteristics and operating time
- Dynamic Characteristics and operating time for distanceprotection relays and current differential protection relays
- Conformance test as per IEC61850-10.
  For Fault recorder, Disturbance recorder; only performance tests are intended under this item.

g) Tests for thermal requirements as per IEC60255-6

h) Tests for rated burden as per IEC60255-6

i) Contact performance test as per IEC 60255-0-20 **or IEC61810-2** (not applicable forDistance to fault locator and Disturbance recorder)

j) Tests for mechanical requirements (Vibration, shock & bumps and seismic) as per IEC60255-21-1, 2 & 3 with severity class-I

k) **Test for Radiated Electromagnetic Field Disturbance as per IEC 60255-22-3 with severity class III** (not applicable for electromechanical relays)

In case there is a change either in version or in model (Except firmware) of the relay, the contractor shall submit the type test reports for the offered revision/model.

Steady state & Dynamic characteristics test reports on the distance protection relays, as type test,shall be based on test programme specified in Appendix A on simulator/network analyser/PTL. Alternatively, the files generated using Electromagnetic transient Programme (EMTP) can also be used for carrying out the above tests. Single source dynamic tests on transformer differential relay shall be/ should have been conducted based on general guidelines specified in CIGRE committee34 report on

Evaluation of characteristics and performance of Power system protection relays and protective systems.

10.40.0 Other general requirement for Protection IEDs:

a. Relay setting template (in editable document format) shall be provided by the contractor for each typical protection IEDs for relay setting purpose.

b. POWERGRID/AEGCL has standardised binary input/output details, indication details, DR signals texts etc. of protection IEDs & Protection Panels CT/VT circuit termination detail and same shall be provided to contractor during detail engineering for preparation of schematics. Panel nomenclature, terminal blocks identification, as applicable, shall be according to typical detailgiven at APPENDIX-B.

10.41.0 Requirement for GIS substations:

GIS Gas zone trip signals, if provided, for each gas tight compartments (gas zone) in the GISLCC shall be integrated in the protection schematics to provide electrical isolation of faulty Gas zone by tripping/ inter-tripping its adjacent circuit breakers. The scheme shall be implemented through protection IEDs and auxiliary relay as required

APPENDIX-A

Test programme for distance relays

General Comments:

1. **These test cases are evolved from the report of working group 04 of study committee 34 (Protection) on evaluation of characteristics and performance of power system protection relays and protective systems. For any further guidelines required for carrying out the tests, reference may be made to the above document.**
2. **The test shall be carried out using network configuration and system parameters as shown in thefigure-1**
3. **All denotations regarding fault location, breakers etc are referred in figure–1**
4. **The fault inception angles are referred to R- N voltage for all types of faults**
5. **The fault inception angle is zero degree unless otherwise specified**
6. **Where not stated specifically, the fault resistance (Rf) shall be zero or minimum as possible in simulator**
7. **Single pole circuit breakers are to be used**
8. **The power flow in double source test is 500MW**

System parameters System voltage =400KV CTR= 1000/1
PTR = 400000/110 (with CVT, the parameters of CVT model are shown in figure –2)

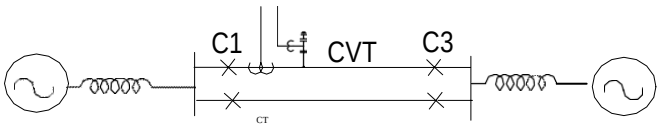


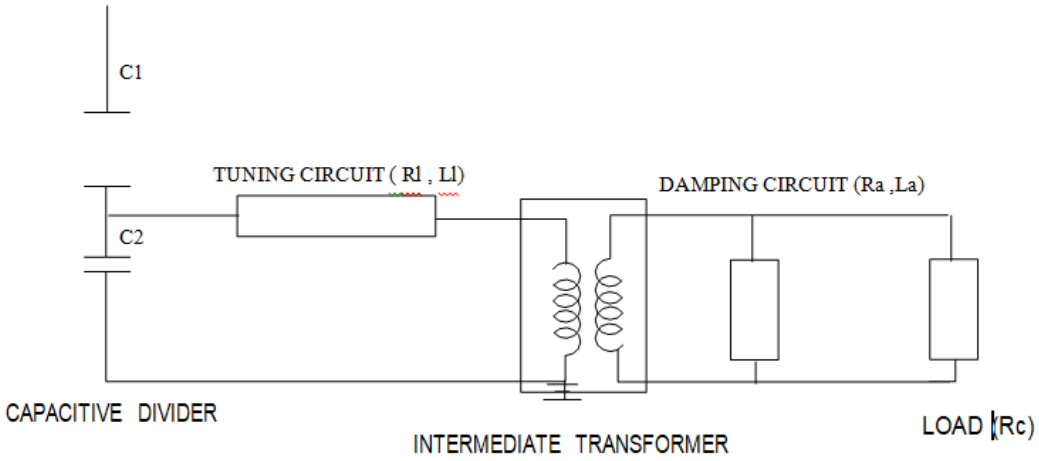
FIGURE 1

Line parameters/km

Positive Sequence Resistance, (r1)	= 0. 02897 Ω
Positive Sequence Reactance (x1)	= 0.3072 Ω
Zero Sequence Resistance (r0)	= 0.2597 Ω
Zero Sequence Reactance(x1)	= 1.0223 Ω
Zero Sequence Mutual Resistance (rm)	= 0.2281 Ω
Zero Sequence Mutual Reactance(xm)	= 0.6221 Ω
Zero Sequence succeptance (bo)	= 2.347 μ mho
Positive Sequence succeptance(b1)	=3.630 μ mho

Type of line	Short		Long
Secondary line impedance	2 Ω		20 Ω*
Length of line inKms	23.57		235.7
SIR	4	15	4
Source impedance (pry) (at a time constant of 50 ms)	29.09 Ω(5500 MVA)	109.09 Ω (1467 MVA)	290.9 Ω (550 MVA)

CVT Model



XC1	1.455 µmho
XC2	27.646 µmho
Rl	320 Ω
XLl	34243 Ω
Ra	4.200Ω
Xla	197.92Ω
Rc	14.00Ω
Transformation ratio of Intermediate transformer	ratio

APPENDIX-A

Details of fault cases to be done

Slno	Description	Single source with short line (2)		Single source long line (20)	Double source With short double line (2)	Double source with long single line (20)
		CLOSE C1, OPEN C2,C3,C4		CLOSE C1, OPEN C2,C3,C4	CLOSE C2,C3,C4 C1,	CLOSE C1,C3 OPEN C2,C4
		SIR=4	SIR=15	SIR =4	SIR = 4	SIR=4
1	Dynamic accuracy for zone 1	Tests to be doneat 2 locations (84 % and 76 % of line length) X 4 faults (RN, YB, YBN, RYB) X 2 faultinception angle (0°, 90°)= 16 cases	Tests to be done at 2 locations (84 % and 76 % of line length)X 4 faults (RN ,YB, YBN, RYB) X2 fault inception angle (0°,90°)= 16 cases	Tests to be done at 2 locations (84 % and 76 % of linelength) X 4 faults (RN ,YB, YBN, RYB) X2 fault inception angle(0°,90°)=16 cases		Tests to be Done at 2 locations (84% and 76% off line length) X 4 faults (RN ,YB, YBN, RYB) X 2 fault inceptionangle (0°, 90°)= 16 cases
2	Operating time for zone 1 at SIR =4	Tests to be doneat 3 locations (0% ,40% and 64% of line length) X 4 faults (RN, YB, YBN, RYB) X 4 Fault inception angle (0°,30°,60° and 90°) = 48 cases	Tests to be Done at 3 locations (0%, 40% and64% of line length) X 4 faults (RN, YB, YBN, RYB) X 4 fault inception angle (0°,30°,60°and90 °)=48 cases	Tests to be done at 3 locations (0%,40 % and 64% of linelength) X 4 faults (RN,YB, YBN,RYB) X4 faultinception angle (0°,30°,60° and 90°)= 48cases	Tests to be done at 1 location (40 % of line length) X 4 faults (RN, YB, YBN,RYB)X 4 fault Inception angle (0°,30°,60°and 90 °)= 16cases	Tests to be done at 1 location (40 % of line length)X 4 faults (RN, YB, YBN, RYB) X 4 fault inception angle (0°,30°,60° and 90°)=16cases
3	Operating time for zone II andZone III	Tests to done at location (100 %of line length) X1 Faults (RN, YB,YBN, RYB)X zones (II and III) = 2 cases	Tests to be done at 1 location (100 % of line length) X1 faults(RN,YB, YBN, RYB) X zones (II and III) = 2 cases	Tests to be done at 1 location (100 % of line length) X 1 faults (RN ,YB, YBN, RYB) X Zones (II and III) = 2 cases		

4	Switch on to fault feature		Tests to be done at 2 location (0% and 32 %) X 1 faults (RYB)Any fault inception angle = 2 cases			
5	Operation during current reversal				Tests to be Done at 2 location (0% and80% of line length)X1 faults (RN) X1fault inception angle (0degrees) = 2 cases	
		CLOSE C1, OPEN C2,C3,C4		CLOSE C1, OPEN C2,C3,C4	CLOSE C1, C2,C3,C4	CLOSE C1,C3 OPEN C2,C4
		SIR=4	SIR=15	SIR =4	SIR = 4	SIR=4
6	Operation at simultaneous faults				Tests to be done at 2 location (8 % and 64 % of line length)X2 faults (RNin circuit 1 to BN in circuit 2 and RN in circuit 1 to RYN in circuit 2 in 10 ms) X1 fault inception angle (0°) = 4 cases (*1)	
7	Directional					Tests to be done at 1 location (0% reverse) X6 faults (RN YB,YBN,RYB,RN with Rf=13.75 ohm(sec) and RYN with Rf=

						13.75 Ohm (sec)X2 fault inception angle (0°,90°) = 12cases
8	Limit for fault resistance					Tests to be done at 2 location (0% and 68 % of line length) X1 fault (RN with Rf = 13.75ohm (sec) X2 fault Inception angle (0°,90°) = 4 cases
9	Operation at evolving faults					Tests to be done at 2 location (32 % and 0% of line length)X 2 faults (RN to RYN) x in 2 timings (10 ms and 30ms) X2 load direction (from A to B and from B to A) = 16cases
9	Fault locator function ,in case the same is Offered as Built in feature	Measure fault location for all cases under 1 and 2	Measure fault location for allcases under 1 and 2	Measure fault location for all cases under 1 and 2	Measure fault location for all cases under 2and 6	Measure fault location for all cases under 2, 7 and 9

APPENDIX-B

Terminal Block (TB) Nomenclature for Relay & interface panels

Circuit type	TB for externalconnections	TB for Inter panel connections
CT	X:CT	XI:CT
PT	X:VT	XI:VT
AC Auxiliary	X:AC	XI:AC
DC Auxiliary	X:DC	XI:DC
Trip Circuit 1	X:TC1	XI:TC1
Trip Circuit 2	X:TC2	XI:TC2
LBB & BB	X:LBB	XI:LBB
CB	X:CB/X:CBT	XI:X
ISOLATOR	X:ISA/ISB/ISL/ISR	XI:X
EARTH SWITCH	X:ES	XI:X
PROTECTION COUPLER	X:PC	XI:PC
ENERGY METER	X:EM	---
Reactor	X:SR	XI:SR
Transformer	X:AT	XI:AT
Others Control & status signals	X:X	XI:X

Feeder relay Panels designation:

Typical Bay / Busbar	Panel Ref.
765kV Bay no. 1 (701)	7R1A, 7R1B and so on
400kV Bay no. 1 (401)	4R1A, 4R1B and so on
220kV Bay no. 1 (201)	2R1A, 2R1B and so on
132kV Bay no. 1 (101)	1R1A, 1R1B and so on
Bus 765kV	7BB1, 7BB2 and so on
Bus 400kV	4BB1, 4BB2 and so on
Bus220kV	2BB1, 2BB2 and so on
Bus132kV	1BB1, 1BB2 and so on

SECTION-10 (a)
TECHNICAL SPECIFICATION FOR SUBSTATION AUTOMATION SYSTEM

10.42.0 General

The Substation Automation System (SAS) shall be installed to control and monitor all the sub-station equipment from Remote Control Centres (RCC) & Remote Control and Supervision Centre (RSCC), as well as from local control centre.

The SAS shall contain the following main functional parts:

- Bay Control Unit (BCU) Intelligence Electronic Devices (IEDs) for control andmonitoring.
- Merging Units & Switchgear Controller IEDs (applicable for Process Busbased SAS only)
- Station Human Machine Interface (HMI) with industrial grade servers
- Redundant managed switched Ethernet Local Area Network communication infrastructure with hot standby.
- Redundant Gateway for remote monitoring and control via industrial grade hardware (to RCC) through Secure IEC60870-5-104 protocol. There will beat least 3RCCs.
- Redundant Gateway for remote monitoring and control via industrial grade hardware (to RSCC), the gateway should be able to communicate with RSCC on IEC 60870-5-104 protocol. It shall be the bidder's responsibility to integrate his offered system with existing RSCC system for exchange of desired data.
- DR / Engineering PCs, as specified.
- Remote HMI and work station along with necessary printers, only if specifiedin Section Project.
- Peripheral equipment like printers, display units, key boards, Mouse etc.

It shall enable local station control via a PC by means of human machine interface (HMI) and control software package, which shall contain an extensive range of supervisory control and data acquisition (SCADA) functions.

It shall include communication gateway, intelligent electronic devices (IED) for bay control and inter IED communication infrastructure. An architecture drawing for SAS is enclosed.

The communication gateway shall facilitate the information flow with remote control centres. The bay level intelligent electronic devices (IED) for protection and control shall provide the direct connection to the switchgear without the need of interposing components and perform control,protection, and monitoring functions. However, in case of Process Bus based SAS, SwitchgearControllers (SGCs) shall be used as digital interfaces between switchgear and bay level IEDs.

The Sub-station Automation system being offered shall generally conform to provision of IEC 62351, IEEE1686 and NERC CIP (applicable part such as CIP 003, CIP-005, and CIP-007) for cyber security.

Process bus based SAS shall be applicable only if specifically envisaged in Section-Project.

10.43.0 System design

General system design

The Substation Automation System (SAS) shall be suitable for operation and monitoring of the complete substation including future extensions as given in Section- Project.

The systems shall be of the state-of-the art suitable for operation under electrical environment present in Extra high voltage substations, follow the latest engineering practice, ensure long-term compatibility requirements and continuity of equipment supply and the safety of the operating staff.

The offered SAS shall support remote control and monitoring from Remote Control centres via gateways.

The system shall be designed such that personnel without any background knowledge in Microprocessor-based technology are able to operate the system. Theoperator interface shall be intuitive such that operating personnel shall be

able to operate the system easily after having received some basic training.

The system shall incorporate the control, monitoring and protection functions specified, self-monitoring, signalling and testing facilities, measuring as well as memory functions, event recording and evaluation of disturbance records. It shall also have provisions for inhibiting control on any or all devices for purpose of maintenance. The devices under maintenance shall be provided with tags which shall include provision for entering text (256 characters).

Maintenance, modification or extension of components may not cause a shutdown of the whole substation automation system. Self-monitoring of components, modules and communication shall be incorporated to increase the availability and the reliability of the equipment and minimize maintenance.

IP addressing of the system shall be as per the IP plan provided by the owner.

The system shall be remotely accessed for collection of disturbance records and hence shall be provided with a firewall/router to comply at least with the requirements of CIP-005, CIP-007 (Critical infrastructure protection) standard as per NERC (NorthAmerican Electric ReliabilityCouncil).

Bidder shall house the Bay level unit (a bay comprises of one circuit breaker and associated disconnector, earth switches and instrument transformer), bay mimic along with relay and protection panels and PLCC panels (described in other sections of technical specifications) in air-conditioned Switchyard Panel Room suitably located in switchyard (GIS hall relay room in case of GIS s/s) and Station HMI in Control Room building for overall optimisation in respect of cabling and control room building.

In case of Process bus based SAS, both bay level unit and station bus level components can also be placed at a centralised location like control room.

System architecture

The SAS shall be based on a decentralized architecture and on a concept of bay- oriented, distributed intelligence.

Functions shall be decentralized, object-oriented and located as close as possible to the process.

The main process information of the station shall be stored in distributed databases. The typical SAS architecture shall be structured in three levels, i.e. process level, bay level and station level. Process Level will be applicable only in Process Bus based SAS.

At Process Level (applicable, only in IEC 61850 Process Bus based SAS) is at the switchyard level where instrument transformers, switchgear, transformers/reactor are located, and employs IEC 61850 part 9-2 for communicating Sampled Measured Values (SMV) to the Bay Level IEDs and GOOSE messaging for binary values exchange.

At Bay Level, the IEDs shall provide all bay level functions regarding control, monitoring and protection, inputs for status indication and outputs for commands. The bay level intelligent electronic devices (IED) for protection and control shall provide the direct connection to the switchgear without the need of interposing components and perform control, protection, and monitoring functions. However, in case of Process Bus based SAS, Switchgear Controllers (SGCs) shall be used as digital interfaces between switchgear and bay level IEDs.

Each bay control IED shall be independent from each other and its functioning shall not be affected by any fault occurring in any of the other bay control units of the station.

The data exchange between the electronic devices on bay and station level shall take place via the communication infrastructure. This shall be realized using fibre-optic cables, thereby guaranteeing disturbance free communication. The fibre optic cables shall be run in G. I. conduit pipes. Data exchange is to be realised using the protocols defined and standardized in the latest edition of IEC 61850 with a redundant managed switched Ethernet communication infrastructure. The modelling of various aspects of Substation Automation System, like, Data Objects, Data Attributes, Logical Nodes, etc. shall be according to the latest edition of IEC61850.

The communication shall be made in fault tolerant ring, excluding the links between individual bay IEDs to switch wherein the redundant connections are not envisaged, such that failure of one set of fiber shall not affect the normal operation of the SAS. However failure of fiber shall be alarmed in SAS. Each fiber optic cable shall have four (4) spare fibers.

The typical architecture for SAS is enclosed as Annexure.

At Station Level, the entire station shall be controlled and supervised from the station HMI. It shall also be possible to control and monitor the bay from the bay level equipment at all times.
Clear control priorities shall prevent operation of a single switch at the same time from more than one of the various control levels, i.e. RCC, station HMI, bay level or apparatus level. The priority shall always be on the lowest enabled control level.

The station level contains the station-oriented functions, which cannot be realised atbay level, e.g. alarm list or event list related to the entire substation, gateway for thecommunication with remote control centres.

The GPS time synchronising signal (as specified in the section relay & protection) for the synchronization of the entire system shall be provided.

The SAS shall contain the functional parts as described in para 1.2 above.

10.45.0 FUNCTIONAL REQUIREMENTS

The high-voltage apparatus within the station shall be operated from different places:

- ➢ Remote control centres
- ➢ Station HMI
- ➢ Local Bay controller IED (in the bays)

Operation shall be possible by only one operator at a time with the priority to the lowest enabled control level.

The operation shall depend on the conditions of other functions, such as interlocking, synchro-check, control-inhibit tags etc. (see description in ``Bay level control function'').

Select-before-execute

For security reasons the command is always to be given in two stages: selection of the object and command for operation under all mode of operation except emergency operation. Final execution shall take place only when selection and command are actuated.

Command supervision

Bay/station interlocking and blocking

Software Interlocking is to be provided to ensure that inadvertent incorrect operation of switchgear causing damage and accidents in case of false operation does not take place.

In addition to software interlocking hardwired interlocking are to be provided for:

(a) Bus Earth switch Interlocking

(b) Transfer Bus interlocking (if applicable)

It shall be a simple layout, easy to test and simple to handle when upgrading the station with future bays. For software interlocking the bidder shall describe the scenario while an IED of another bay is switched off or fails.

A software interlock override function shall be provided which can be enabled to bypass the interlocking function.

Run Time Command cancellation

Command execution timer (configurable) must be available for each control level connection. If the control action is not

completed within a specified time, the command should get cancelled and an alarm shall be generated to indicate the failure ofcommand.

Self-supervision

Continuous self-supervision function with self-diagnostic feature shall be included. The redundant components such as servers, gateway shall monitor each other for availability and the active device shall takeover all the functions of the failed device. This failover shall happen within 30 seconds. The events occurring when a server is in failed state shall be synchronised from the active server.

10.46.0 User configuration

The monitoring, controlling and configuration of all input and output logical signals and binary inputs and relay outputs for all built-in functions and signals shall be possible both locally and remotely.

It shall also be possible to interconnect and derive input and output signals, logic functions, using built-In functions, complex voltage and currents, additional logics (AND-gates, OR gates and timers). (Multi-activation of these additional functions should be possible).

10.47.0 Bay level functions

In a decentralized architecture the functionality shall be as close to the process as possible. In this respect, the following functions can be allocated at bay level:

- Bay control functions including data collection functionality in bay control/protection unit.
- Bay protection functions

Separate IEDs shall be provided for bay control function and bay protection function.

Bay control functions

Overview of Functions

- Control mode selection
- Select-before-execute principle
- Command supervision:
  - Interlocking andb locking
  - Double command
- Synchro check, voltage election
- Run Time Command cancellation
- Transformer tap changer control (Raise and lower of tap) (for power transformer bays)
- Transformer Master/follower selection
- Operation counters for circuit breakers and pumps
- Hydraulic pump/ Air compressor run time supervision
- Operating pressure supervision through digital contacts only
- Breaker position indication per phase
- Alarm annunciation
- Measurement display
- Local HMI (local guided, emergency mode)
- Interface to the station HMI.
- Data storage for at least 200 events
- Auto-reclose mode selection (Non-Auto/1-phaseetc.)

- Protection transfer switch control (for Transfer Bus scheme arrangement)
- Monitoring of Gas Tight Chambers in GIS
- Monitoring of temperature of Transformer and Reactor
- Monitoring of Multi-gas output of Transformer and Reactor
- Any other requirement specified elsewhere in the specification.

10.48.0 Control mode selection

Bay level Operation:

As soon as the operator receives the operation access at bay level the operation is normally performed via bay control IED. During normal operation baycontrol unit allows the safe operation of all switching devices via the bay control IED.

EMERGENCY Operation

It shall be possible to close or open the selected Circuit Breaker with ON or OFF push buttons even during the outage of bay IED. All the interlocks shall be get bypassedunder such circumstances.

REMOTE mode

Control authority in this mode is given to a higher level (Remote Control Centre/Station HMI) and the installation can be controlled only remotely. Control operation from lower levels shall not be possible in this operating mode

Synchronism and energizing check

The synchronism and energizing check functions shall be bay-oriented and distributed to the bay control and/or protection devices. These features are:

- ➢ Settable voltage, phase angle, and frequency difference.
- ➢ Energizing for dead line - live bus, live line - dead bus or dead line – dead bus with no synchro-check function.
- ➢ Synchronising between live line and live bus with synchro-check function

10.49.0 Voltage selection

The voltages relevant for the Synchro check functions are dependent on the station topology, i.e. on the positions of the circuit breakers and/or the isolators .The correct voltage for synchronizing and energizing is derived from the auxiliary switches of the circuit breakers, the isolator, and earthing switch and shall be selected automatically by the bay control and protection IEDs.

Transformer tap changer control

Digital RTCCs shall be integrated with the SAS to provide Tap Changer Controlfu nctions.

Auto-reclose mode selection

Auto –reclose mode selection for each of the Circuit breaker shall be facilitated through bay controller IED.

Protection transfer switch control(As applicable)

Based on selection of isolator for double main with transfer switching scheme or single main with transfer switching scheme for the switchyard, the protection shall be transferred automatically with an alarm indication that protection is successfully transferred.

Monitoring of Gas Chambers in GIS Sub-stations:

In case of a GIS sub-stations, all the gas tight chambers are required to be monitored individually phase wise for their SF6 gas density status by the bay control unit in a bay. Sufficient numbers of inputs are required to be provided in the BCU. In case there is any limitation of number of inputs in the BCU, additional BCUs are required to be provided without any cost implication to POWERGRID/AEGCL. These inputs shall be used for necessary monitoring, control and protection purpose.

10.50.0 Bay protection functions

General

The protection functions are independent of bay control function. The protection shall be provided by separate protection IEDs (numerical relays) and other protection devices as per section Relay & Protection.

IEDs, shall be connected to the communication infrastructure for data sharing and meet the real-time communication requirements for automatic functions. The data presentation and the configuration of the various IEDs shall be compatible with the overall system communication and data exchange requirements.

Event and disturbance recording function

Each IED should contain an event recorder capable of storing at least 200 time- tagged events. The disturbance recorder (DR) function shall be as per detailed in section CRP. The DR(s) shall be integrated with the SAS.

Bay Monitoring Function:

Analogue inputs for voltage and current measurements shall be connected directly to the voltage transformers (VT) and the current transformers (CT) without intermediate transducers or through merging units. The values of active power (W), reactive power (VAR), frequency (Hz), and the rms values for voltage (U) and current (I) shall be calculated in the Bay control/protection unit.

10.51.0 Station Level Functions

Status supervision

The position of each switchgear, e.g. circuit breaker, isolator, earthing switch, transformer tap changer, Transformer/Reactor Temperature, Transformer/Reactor Multi-gas conditions, Temperature of Switchyard Panel Room, Ambient Temperature etc., shall be supervised continuously. Every detected change of position shall be immediately displayed in the single-line diagram on the station HMI screen, recorded in the event list, and a hard copy printout shall be produced. Alarms shall be initiated in the case of spontaneous positionchanges.

The switchgear positions shall be indicated by two auxiliary switches, normally closed (NC) and normally open (NO), which shall give ambivalent signals. An alarm shall be initiated if these position indications are inconsistent or if the time required for operating mechanism to change position exceeds a predefined limit.

The SAS shall also monitor the status of sub-station auxiliaries. The status and control of auxiliaries shall be done through separate one or more IED and all alarm and analogue values shall be monitored and recoded through this IED.

Measurements

The analogue values acquired/calculated in bay control/protection unit shall be displayed locally on the station HMI and in the control centre. The abnormal values must be discarded. The analogue values shall beu pdated based on the deadband settings and the same shall be demonstrated during FAT of the system.

Threshold limit values shall be selectable for alarm indications**.**

Event and alarm handling

Events and alarms are generated either by the switchgear, by the control IEDs, or by the station level unit. They shall be recorded in an event list in the station HMI. Alarms shall be recorded in a separate alarm list and appear on the screen. All, or a freely selectable group of events and alarms shall also be printed out on an event printer. The alarms and events shall be time-tagged with a time resolution of 1 ms. The tentative list for various feeders and systems are enclosed as Annexure-I.

Station HMI

Substation HMI Operation:
On the HMI the object has to be selected first. In case of a blocking or interlocking conditions are not met, the selection shall not be possible and an appropriate alarm/annunciation/notification shall occur. If a selection is valid the position indication will show the possible direction, and the appropriate control execution button shall be pressed in order to close or open the corresponding object.

Control operation from other places (e.g. RCCs) shall not be possible in this operating mode.

Presentation and dialogues

The operator station HMI shall be a redundant with hot standby and shall provide basic functions for supervision and control of the substation. The operator shall give commands to the switchgear on the screen via mouse clicks.

The HMI shall give the operator access to alarms and events displayed on the screen. Aside from these lists on the screen, there shall be a printout of alarms or events in an event log.

An acoustic alarm shall indicate abnormalities, and all unacknowledged alarms shall be accessible from the screen selected by the operator.

The following standard pictures shall be available from the HMI:

- ➢ Dynamic Single-line diagram showing the switchgear status and measured values
- ➢ Control dialogues with interlocking or blocking information details. This control dialogue shall tell the operator whether the device operation is permitted or blocked and also show the Interlocking logic with status.
- ➢ Measurement dialogues
- ➢ Alarm list, station /bay-oriented
- ➢ Event list, station /bay-oriented System status

HMI design principles

Consistent design principles shall be adopted with the HMI concerning labels, colours, dialogues and fonts. Non-valid selections shall be dimmed out.

The object status shall be indicated using different status colours for:

- ➢ Selected object under command
- ➢ Selected on the screen
- ➢ Not updated, obsolete values, not in use or not sampled

- ➢ Alarm or faulty state
- ➢ Warning or blocked
- ➢ Update blocked or manually updated
- ➢ Control blocked
- ➢ Normal state
- ➢ Energised ord energised state (based on substation topology)

Process status displays and command procedures

The process status of the substation in terms of actual values of currents, voltages, frequency, active and reactive powers as well as the positions of circuit breakers, isolators and transformer tap-changers shall be displayed in the station single-line diagram.

In order to ensure a high degree of security against undesired operation, a "select- before-execute" command procedure shall be provided. After the "selection" of a switch, the operator shall be able to recognize the selected device on the screen, and all other switchgear shall be blocked. As communication between control centre and device to be controlled is established, the operator shall be prompted to confirm the control action and only then final execute command shall be accepted. After the “execution” of the command the operated switching symbol shall flash until the switch has reached its new position.

The operator shall be in a position to execute a command only, if the switch is not blocked and if no interlocking condition is going to be violated. The interlocking statements shall be checked by the interlocking scheme implemented at bay and station level.

After command execution the operator shall receive a confirmation that the new switching position has been reached or an indication that the switching procedure was unsuccessful with the indication of the reason for non-functioning.

System supervision & display

The SAS system shall be comprehensively self-monitored such that faults are immediately indicated to the operator, possibly before they develop into serious situations. Such faults are recorded as a faulty status in a system supervision display. This display shall cover the status of the entire substation including all switchgear, IEDs, communication infrastructure and remote communication links, and printers at the station level, etc.

Event list

The event list shall contain events that are important for the control and monitoring of the substation.

The event and associated time (with1 ms resolution) of its occurrence has to be displayed for each event.

The operator shall be able to call up the chronological event list on the monitor at any time for the whole substation or sections of it.

A printout of each display shall be possible on the hard copy printer.

The events shall be registered in a chronological event list in which the type of event and its time of occurrence are specified. It shall be possible to store all events in the computer for at least one month. The information shall be obtainable also from a printed event log.

The chronological event list shall contain:

- ➢ Position changes of circuit breakers, isolators and earthing devices
- ➢ Indication of protective relay operations
- ➢ Fault signals from the switchgear
- ➢ Indication when analogue measured values exceed upper and lower limits. Suitable provision shall be made in the system to define two level of alarm on either side of the value or which shall be user defined for each measurands.
- ➢ Loss of communication.
- ➢ User actions (control/Tag placement/manual update) with USER identity
- ➢ System messages (Operator logging info, System supervision and device monitoring, failure of supervisory control etc.)

Filters for selection of a certain type or group of events shall be available. The filters shall be designed to enable viewing of events grouped per:

- ➢ Date and time
- ➢ Bay
- ➢ Device
- ➢ Function e.g. trips, protection operations etc.
- ➢ Alarm lass

Alarm list

Faults and errors occurring in the substation shall be listed in an alarm list and must be displayed in a flashing state along with an audible alarm. After acknowledgement of the alarm, it should appear in a steady (i.e. not flashing) state and the audible alarm shall stop. The alarm should disappear only if the alarm condition has physically cleared and the operator has reset the alarm with a reset command. The state of the alarms shall be shown in the alarm list (Unacknowledged and persistent, Unacknowledged and cleared, Acknowledged and persistent).

Filters for selection of a certain type or group of alarms shall be available as for events.

In addition to the regular alarms, following alarms shall also be displayed and logged:

- Alarms shall be displayed on the HMI, for each device of SAS when theylose time synchronization.
- 'GOOSE Fail Alarm' shall be configured which shall be generated when any of the subscriber IEDs fails to receive any of the GOOSE messages. These alarms shall be mapped IED-wise in the station HMI.

Object picture

When selecting an object such as a circuit breaker or isolator in the single- line diagram, the associated bay picture shall be presented first. In the selected objectpicture, all attributes like

- ➢ Type of blocking/Control inhibit Tag
- ➢ Authority

- ➢ Local / remote control mode
- ➢ RCC / SAS control
- ➢ Errors etc., shall be displayed.

Control dialogues

The operator shall give commands to the system by means of mouse click locatedon the single-line diagram. Data entry is performed with the keyboard. Dedicated control dialogues for controlling at least the following devices shall be available:

- ➢ Breaker and disconnector
- ➢ Transformer tap-changer
- ➢ Mode selection (L/R, Non-Auto/1-ph, Auto/Manualetc.)

User-authority levels

It shall be possible to restrict activation of the process pictures of each object (bays, apparatus...) within a certain user authorisation group. Each user shall then be given access rights to each group of objects, e.g.:

- ➢ Display only
- ➢ Normal operation (e.g. open/close of switchgear)
- ➢ Restricted operation (e.g. by-passed interlocking)
- ➢ System administrator

For maintenance and engineering purposes of the station HMI, the following authorisation levels shall be available:

- ➢ No engineering allowed
- ➢ Engineering/configuration allowed
- ➢ Entire system management allowed

The access rights shall be defined by passwords assigned during the log-in procedure. Only the system administrator shall be able to add/remove users and change access rights.

In case of non-activity for a pre-determined period (say 30 minutes), the system will automatically logged out the user and user has to log in again for doing any operation. Further each operation must be logged in in the event/alarm list along with the user name.

Reports

The reports shall provide time-related follow-ups of measured and calculated values. The data displayed shall comprise:

- ➢ Trendreports:
  - Day (mean, peak)
  - Month (mean, peak)
  - Semi-annual (mean, peak)
  - Year (mean, peak)
- ➢ Historical reports of selected analogue Values:
  - Day (at 15 minutes interval)
  - Week
  - Month

- Year

It shall be possible to select stored values from the database in the process display on-line. Scrolling between e.g. days shall be possible. Unsure values shall be indicated. It shall be possible to select the time period for which the specific data are stored in the memory.

Following printouts shall be available from the printer and shall be printed on demand:

i. Daily voltage and frequency curves depicting time on X-axis and the appropriate parameters on the Y-axis. The time duration of the curve is 24hours.

ii. Weekly trend curves for real and derived analogue values.

iii. Printouts of the maximum and minimum values and frequency of occurrence and duration of maximum and minimum values for each analogue parameter for each circuit in 24 hr period.

iv. Provision shall be made for logging information about breaker status like number of operation with date and time indications along with the current vale it interrupts (in both condition i.e. manual opening and fault tripping)

v. Equipment operation details shift wise and during 24hours.

vi. Printout on adjustable time period as well as on demand for MW, MVAR, Current, Voltage on each feeder and transformer as well as Tap Positions,temperature and status of pumps and fans for transformers.

vii. Printout on adjustable time period as well as on demand system frequencyand average frequency.

viii. Reports in specified formats which shall be handed over to successful bidder. The bidder has to develop these reports. The reports are limited tothe formats for which data is available in the SAS database.

ix. It shall be possible to generate user made reports based on measured/recorded values of various combination of parameters particularly for transformer and reactors for healthiness of equipment depending upon defined criterion. These generation of reports must be user friendly and shall be easy to define.

All the utilities/tools used for building a report shall be provided with the system so that the owner is able to build new reports. The tools shall be user friendly with 'drag & drop' or 'menu based selection' features and shall not require any knowledge of programming.

The reports utility shall be configured such that reports requiring long duration data (yearly) shall not take more than 2 minutes and does not impact the other applications running in the system.

Trend display (historical data)

It shall be possible to illustrate all types of process data as trends - input and output data, binary and analogue data. The trends shall be displayed in graphical form ascolumn or curve diagrams with a maximum of 10 trends per screen. Adjustable time span and scaling ranges must be provided.

It shall be possible to change the type of value logging (direct, mean, sum, or difference) on-line in the window. It shall also be possible to change the update intervals on-line in the picture as well as the selection of threshold values for alarming purposes.

Automatic disturbance file transfer

All recorded data from the IEDs with integrated disturbance recorder as well as dedicated disturbance recording systems

shall be automatically uploaded (event triggered and once per day in case no event during the day) to a dedicated computer and be stored on the hard disc in specified folders.

Disturbance analysis

The PC-based work station shall have necessary software to evaluate all the required information for proper fault analysis.

IED parameter setting

It shall be possible to access all protection and control IEDs for reading the parameters (settings) from the station HMI or from a dedicated monitoring computer. The setting of parameters or the activation of parameter sets shall only be allowed after entering a password.

Automatic sequences

The available automatic sequences in the system should be listed and described, (e.g. sequences related to the bus transfer in a GIS). It must be possible to initiate pre-defined automatic sequences by the operator and also define new automatic sequences. The automatic sequencing is required to be developed at SCADA level.

Gateway

Communication Interface

The Substation Automation System shall have the capability to support simultaneous communications with multiple independent remote master stations,

The Substation Automation System shall have communication ports on each gateway (two gateways per station) as follows:

(a) Three ports for Remote Control Centres on Secure IEC 60870-5-104protocol.

(b) One port on IEC 60870-5-104 for Regional System CoordinationCentre(RSCC)

The communication interface to the SAS shall allow scanning and control of defined points within the substation automation system independently for each control centre. The substation automation system shall simultaneously respond to independent scans and commands from employer's control centres (RCCs & RSCC). The substation automation system shall support the use of a different communication data exchange rate (bits per second), scan- ning cycle, and/or communication protocol to each remote control centre. Also, each control centre's data scan and control commands may be different for different data points within the substation automation system's database.

The Gateway shall collect the IEC 61850 data directly from the IEDs through Ethernet switches, without using any other intermediate interface or network device, and should be implemented in a separate hardware, so that the failure of the local SCADA Server would not impact the remote communication through the Gateway.

The Gateway shall identify the actions performed by the each of the remote mastersindividually and log it in its database. The logs for last 30 days shall be stored and accessible at the Station HMI.

10.53.0 Remote Control Centre Communication Interface

Employer will supply communication channels between the Substation Automation System and the

remote control centre. The communication channels provided by Employer will consist either of power line carrier, optical fibre, or leased line, the details of which shall be provided during detailed Engineering.

Interface equipment

The Contractor shall provide interface equipment for communicating between Substation Automation system and Remote control centres and between Substation Automation system and Regional System Coordination Centre (RSCC). However, the communication channels available for this purpose are specified in section project.

The communication interface with the RCCs is an Ethernet interface. In case of PLCC communication any modem supplied shall not require manual equalization and shall include self-test features such as manual mark/space keying, analogue loop-back, and digital loop-back. The modems shall provide for convenient adjustment of output level and receive sensitivity. The modem should be stand alone complete in all respects including power supply to interface the SAS with communication channel. The configuration of tones and speed shall be programmable and maintained in non- volatile memory in the modem. All necessary hardware and software shall also be in the scope of bidder except the communication link along with communication equipment between substation control room and Remote Control Centre.

Communication Protocol

The communication protocol for gateway to control centre must be open protocol and shall support IEC 60870-5-104 and IEC 61850 for all levels of communication for sub-station automation such as Bay to station HMI, bay to bay etc. based on requirement specified. The protocol shall support the features such as Report by exception; Periodic reporting so that the data update times at the RCC/RSCC can be optimised.

System hardware:

Redundant Station HMI, Remote HMI (RemoteHMI only if mentioned in section project) and Disturbance Recorder Workstation:

The contractor shall provide redundant station HMI in hot standby mode. The servers used in these work stations shall be of industrial grade.

It shall be capable to perform all functions for entire substation including future requirements as indicated in the SLD. It shall use industrial grade components. Processor and RAM shall be selected in such a manner that during normal operation not more than 30% capacity of processing and memory are used. Supplier shall demonstrate these features.
The capacity of hard disk shall be selected such that the following requirement should occupy less than 50% of disk space:

1. Storage of all analogue data (at 15 Minutes interval)and digital data including alarm , event for two years and trend data for thirty(30) days,
2. Storage of all necessary software,

3. 500GB space for OWNER'S use.

Supplier shall demonstrate that the capacity of hard disk is sufficient to meet the above requirement.

HMI (Human Machine Interface)

The VDU shall show overview diagrams (Single Line Diagrams) and complete details of the switchgear with a colour display. All event and alarm annunciation shall be selectable in the form of lists. Operation shall be by a user friendly function keyboard and a cursor positioning device. The user interface shall be based on WINDOWS concepts with graphics & facility for panning, scrolling, zooming, decluttering etc.

Visual Display Units/TFT's(Thin Film Technology)

The display units shall have high resolution and reflection protected picture screen. High stability of the picture geometry shall be ensured. The screen shall be at least 21" diagonally in size and capable of colour graphic displays.

The display shall accommodate resolution of 1280 X 1024 pixels.

Printer

It shall be robust & suitable for operation with a minimum of 132 characters per line. The printing operation shall be quiet with a noise level of less than 45 dB suitable for location in the control room. Printer shall accept and print all ASCII characters via master control computer unit interface.

The printer shall have in built testing facility. Failure of the printer shall be
indicated in the Station HMI. The printer shall have an off line mode selector switch to enable safe maintenance. The maintenance should be simple with provisions for ease of change of print head, ribbon changing, paper insertion etc.

All reports and graphics prints shall be printed on laser printer. One dot matrix printer shall be exclusively used for hourly log printing.

All printers shall be continuously online.

Mass Storage Unit

The mass storage unit shall be built-in to the Station HMI. All operational measured values, and indications shall be stored in a mass-storage unit in form of DVD RW The unit should support at least Read (48X), Write(24X), and Re-Write (10X) operations, with Multi-Session capability. It should support

ISO9660, Rockridge and Joliet File systems. It should support formatting and use under the operating system provided for Station HMI. The monthly back up of data shall be taken on disc. The facility of back up of data shall be inherent in the software.

Switched Ethernet Communication Infrastructure:

The bidder shall provide the redundant switched optical Ethernet communication infrastructure for SAS. One switch shall be provided to connect all IEDs in one diameter of each 765 and 400kV yard and for two bays of 220kV yard to communication infrastructure. Each switch shall have at least two spare ports for connecting bay level IEDs and one spare port for connecting station bus.

The Ethernet Fast Switches shall be compliant to IEC 61850. These Switches shall be suitable for the substation environment and shall conform to type tests as per IEC 61850-3.

Firewall and Router

There shall be two sets of Firewall and Routers which shall be connected to a LAN. This LAN shall be different than the IEC 61850 LAN. The substation firewall and router shall be suitable for the substation environment and shall comply with the requirements for IEC61850-3.

The substation firewall shall have the following features:

- IP firewall features such as Address/port inspection andfiltering
- Shall be stateful firewall
- Shall support upto 4 Ethernet switches 10/100Mbps
- Shall support IPv4 and IPv6
- Shall have IP sec/VPN with 3DES/AES encryption
- Shall have NAT
- Shall have syslog capability
- Shall be NERC compliant
- Shall have hot- standby operation with similar router

The substation routers shall have the following features:

- Routing protocols such as OSPF and support for IPv4 and IPv6
- 4 Ethernet interfaces of 10/100Mbps
- 2 E1interfaces
- Hot standby operation with a similar router
- Support IEEE 802.3u, 802.1p, 802.1Q, 802.1d,802.1w,
- Traffic prioritization for routed IP flows/ports Thesubstation firewall and router can be a single device.

10.54.0 Bay level unit or Bay control unit (BCU)

General

- Bay Control Unit (BCU) shall be provided for each Bays (a bay comprises of one circuit breaker and associated disconnector, earth switches and instrument transformer, Number of bays shall be as per Section-Project) for

control and monitoring of the bay equipment. Separate BCU (as per section-project) shall be provided for the monitoring of substation auxiliaries.

- The BCUs shall have adequate capacity for the estimated hardwired Inputs & Outputs plus a minimum of two Inputs and a minimum of two outputs as spare capacity per BCU. Requirement for external IO modules shall be avoided as faras possible.
- BCUs shall have redundant DC Power Supply or with automatic changeover scheme, to be fed from the two station DC power supplies. Each power supplyshall be supervised separately and alarmed.
- Each BCU shall be equipped with Local HMI (display) facilities, enabling control of each particular bay from BCU whenever required. The Local HMI facilities shall be accomplished by means of Graphical LCD display embedded into the front panel of the BCU. Display will show the SLD (with device identification number) showing status of bay switching equipment (such as circuit breaker, isolators, earth switches) and enabling issuance of switching controls. Other display type will be multiple displays of analog values readings / reports, displays for controls other than switching, Alarm panel displays, Diagnostic/ on- line configuration displays etc.
- In the event of switchgear apparatus controls, the software-interlocking scheme should be applied based on hardwired analog/digital inputs or Process Bus signals. In the event of closing control for circuit breakers requiring checking of synchronization conditions, software synchro- check scheme should be applied as well. Auto-reclose functions mentioned elsewhere in the specification, if required, can also be applied.

Design

- The bay unit shall use industrial grade components. The bay level unit, based on microprocessor technology, shall use numerical techniques for the calculation and evaluation of externally input analogue signals. They shall incorporate select- before-operate control principles as safety measures for operation via the HMI.Following power interruption and/or communications failure, the BCU shall be capable to restart automatically. Time synchronisation of BCUs with UTC time shall be done over the IEC 61850 field LAN for Substation with SAS. For conventional substation, Time synchronisation of BCU shall be done by other suitable Time synch input like IRIG-B, RS232etc.
- They shall perform all bay related functions, such as control commands, bay interlocking, data acquisition, data storage, event recording and shall provide inputs for status indication and outputs for commands. They shall be directly connected to the switchgear. However, in case of Process Bus based SAS, Switchgear Controllers (SGCs)/Merging Units (MUs) shall be used as digital interfaces between switchgear/instrument transformers and bay level IEDs. The bay unit shall acquire and process all data for the bay (Equipment status, fault indications, measured values, alarms etc.) and transmit these to the other devices in sub- station automation system. In addition, this shall receive the operation commands from station HMI and controlcentre.
- One no. Bay Control unit shall be provided for supervision and control of each 765, 400, 220, 132 kV bay (a bay comprises of one circuit breaker and associated disconnector, earth switches and instrument transformer). The Bay level unit shall be equipped with analogue and binary inputs/outputs for handling the control, status monitoring and analogue measurement functions. All bay level interlocks are to be incorporated in the Bay level unit so as to permit control from the Bay level unit/ local bay mimic panel, with all bay interlocks in place, during maintenance and commissioning or in case of contingencies when the Station HMI is out ofservice.
- The bay control unit to be provided for the bays shall be preferably installed in the CB relay panel/feeder protection panel for respective bay. Further in case of one and half breaker schemes, the BCU for Tie CB shall be provided in Tie CB relaypanel. The tie CB relay panel shall also house the Ethernet switch(es) to be provided for the diameter. The bay control unit for future bay (if required as persection project) shall be installed in a separate panel.
- The Bay level unit shall meet the requirements for withstanding electromagnetic interference according to relevant parts of IEC 61850. Failure of any single component within the equipment shall neither cause unwanted operation nor lead to a complete system breakdown.

Input /Output(I/O)modules(applicable form on-Process Bus SAS)

- The I/O modules shall form a part of the bay level unit / Bay control unit and shall provide coupling to the substation equipment. The I/O modules shall acquire allswitchgear information (i.e. data coming directly from the switchgear or from switchgear interlocking devices) and transmit commands for operation of the switchgear.
- It shall be suitable for analog inputs from secondary of instrument transformers.
- The BCU/IED shall be able to integrate at least 10 analog input channels as a minimum and digital input / output channel to meet the control & monitoring scheme requirement.
- Plant alarms and indications will be derived as digital input. Plant contacts shall change state to register the specified status change or alarm, and each input shall be configurable to register a positive input from either a closed or open contact, i.e. input signals may be either a normally open or a normally closed contact. Alarm contacts may be either fleeting or sustained inputs. Digital filtering to suppress plant contact bounce shall be provided for each input. Time taggingto a resolution of 1 ms shall be provided.
- The pulse counting inputs shall be provided as per scheme requirement. These inputs shall acquire and count impulses produced by potential free contacts, which can be either, normally open or normally closed. Pulse counting inputs shall be provided as either a separate input module or using digital inputs. These inputs shall meet the same requirements specified for digital inputs; additionally they shall be able to cater for pulse rates up to 10 per second.
- Where DC analogue measurement inputs are provided as per the scheme requirement, they shall be capable of accepting unipolar and bipolar current of range 0-10/4-20mA and -10 to +10 mA (range as applicable for the project), with over/under range detection.
- The command outputs shall be designed to provide select and execute outputs. The period of the command pulse shall be configurable between 0.1 second and15 seconds on point basis. The command pulses shall reset immediately after the command is executed. Controls transmitted between the operator workstation of SAS / SCADA and the BCU shall comprise a select, check back & execute sequence (or other means of providing high message security).

The BCU supplied for substation automation system shall further meet the requirements mentioned elsewhere in the specification

Extendibility in future

Offered substation automation system shall be suitable for extension in future for additional bays. During such requirement, all the drawings and configurations, alarm/event list etc. displayed shall be designed in such a manner that its extension shall be easily performed by the employer. During such event, normal operation of the existing substation shall be unaffected and system shall not require a complete shutdown. The contractor shall provide all necessary software tools along with detailsto perform addition of bays in future and complete integration with SAS by the user.These software tools shall be able to configure IED, add additional analogue variable, alarm list, event list, modify interlocking logics etc. for additional bays/equipment which shall be added in future.

Following is to been sured during initial supply of system:

- All the licenses for various components such as SCADA ,servers, configuration tools for various IEDs, Gateways etc. shall be for complete system i.e. system as per single line diagram including both present and future scope. The contractor shall submit the list of equipment and Inputs/Outputs covered under the licences provided.
- All the servers shall be capable of handling total system (present and future).

In case of extension packages, the interoperability between devices compliant to IEC 61850 Edition 2 (or latest) and existing devices compliant to IEC 61850 Edition 1 should be ensured.

Software structure

The software package shall be structured according to the SAS architecture and strictly divided in various levels. Necessary

firewall shall be provided at suitable points in software to protect the system. An extension of the station shall be possible with lowest possible efforts. Maintenance, modification or an extension of components ofany feeder may not force a shut-down of the parts of the system which are not affected by the system adaptation.

Station level software

Human-machine interface (HMI)

The base HMI software package for the operator station shall include the main SASfunctions and it shall be independent of project specific hardware version and operating system. It shall further include tools for picture editing, engineering and system configuration. The system shall be easy to use, to maintain, and to adapt according to specific user requirements. Systems shall contain a library with standard functions and applications.

Bay level software

System software

The system software shall be structured in various levels. This software shall be placed in a non-volatile memory. The lowest level shall assure system performance and contain basic functions, which shall not be accessible by the application and maintenance engineer for modifications. The system shall support the generation of typical control macros and a process database for user specific data storage. In case of restoration of links after failure, the software along with hardware shall be capable of automatically synchronising with the remaining system without any manual interface. This shall be demonstrated by contractor during integrated system test.

Application software

In order to ensure robust quality and reliable software functions, the main part of the application software shall consist of standard software modules built as functional block elements. The functional blocks shall be documented and thoroughly tested. They form part of a library.

The application software within the control/protection devices shall be programmed in a functional block language.

Network Management System:

The contractor shall provide network management system software for following management functions:

a. Configuration Management
b. Fault Management
c. Performance Monitoring

This system shall be used for management of communication devices and other IEDs in the system. This NMS can be loaded in DR work-station and shall be easy to use, user friendly and menu based. The NMS shall monitor all the devices in the SAS and report if there is any communication fault/problem in the monitored devices. The NMS shall

(a) Maintain performance, resource usage, and error statistics for all managed links and devices and present this information via displays, periodic reports and on demander ports.
(b) Maintain a graphical display of SAS connectivity and device status.
(c) Issue alarms when error conditions occurs
(d) Provide facility to add and delete addresses and links

Operating System

The Operating system of the Servers, HMIs and Gateways shall be hardened in line with the following suggested guidelines to reduce its vulnerability to cyber-attacks.

Secure Build Strategy

Packages unnecessary for system operation are not to be installed during the initial build of the servers and workstations, reducing the amount of post-build hardening required. Any package that must be installed but is not required to be actively running have to be disabled.

The software to be removed and/or disabled includes, but is not limited to:

- Games
- Messaging services
- Servers or clients for unused Internet services
- Software compilers (except where required, i.e. development platform)
- Unused networking and communication protocols
- Unused operating system features
- free utilities delivered with OS

Generic and Default Accounts

Disable or remove all unnecessary generic and default user accounts from the operating system and third party applications. Application accounts (such as daemon) that exist strictly for identification and ownership are disabled from all interactive, network, or other access to prevent unauthorized access. Required accounts and their functions have to be documented.

Insecure Protocol

Insecure protocols such as telnet, FTP, RSH, and RCP have to be disabled from operation.

Malicious Software Prevention

Implementation of anti-virus and other malicious software prevention tools to detect, prevent, deter, and mitigate the introduction, exposure, and propagation of malware. Supplier shall verify that commercially available anti- malware products do not cause harm to the product.

Provide procedures on how to update the signature database of the anti- malware software, if provided.

System White listing

System white listing is to be done i.e. the software takes an inventory of the host in a known good state, and any applications not present at that time (such as viruses, malware, games, portable applications, etc.) are prevented from executing.

Ports and Services

The system shall be configured by the supplier to only use those ports and services required for normal and emergency operations. The ports and services required for operation are documented and supplied to the customer as part of the deliverable system documentation.

Host-Based Firewalls

The host-based firewalls shall be configured with a standardized set of rules as an additional layer of security if the network firewall to fail. The host-based firewalls are configured with a default deny rule that logs any traffic not explicitly allowed.

In the case where a service cannot be disabled but does not require communication with hosts external to itself, this host-based firewall also serves to prevent any communication to the port(s) used by that service.

Removable Media

Removable media (CD and DVD, USB Drives, etc.) is not required for the operation of the SAS and may be inhibited from operation except in case of data back up on CD/DVD as per specification.

The contractor shall provide each software in two copies in CD to load into the system in case of any problem related with Hardware/Communication etc.

General Guidelines for IEC61850 SAS Engineering:

i. Data exchange is to be realised using the protocols defined and standardized in the latest edition of IEC 61850 with a redundant managed switched Ethernet communication infrastructure. The modelling of various aspects of Substation Automation System, like, Data Objects, Data Attributes, Logical Nodes, etc. shall be according to the latest edition of IEC 61850.

ii. During the GOOSE communication engineering, it shall be ensured that the publishing IEDs shall have the quality attribute included invariably for each GOOSE message in the GOOSE dataset. Further, the subscriber IEDs shall not use any GOOSE message which it receives without the quality attribute.

iii. The GOOSE subscribing IEDs shall have the feature of detecting duplicate GOOSE message and intrusion using State Number (StNum), Sequence Number (SqNum) fields of a GOOSE message. Once duplicate GOOSE messages or intrusion is detected, the subscribing device shall discard the GOOSE messages from that particular publishing device and shall generate an alarm.

iv. If the association between the publisher and subscriber is lost (please refer Sec. 6.2 of IEC 61850 part 7-3), the 'validity' field of the quality will be set to questionable, and the detailQual 'oldData' will be set. The rest of quality fields will not bechanged.

v. Separate VLANs shall be created for multicast communication between IEDs belonging to different voltage levels. Also, a 'Cross-VLAN' shall be created which will include the IEDs of different voltage levels together as per the requirement of the cross communication for control/protection schemes.

vi. A guideline over usage of logical nodes for Report Control/ GOOSE control engineering shall be issued during the detailed engineering.

vii. In the control and protection schemes, wherever GOOSE messages are used, the schematic documents submitted by the vendor should indicate the communication between LNs used in the indicating the source and destination LNs.

Additional Requirements for IEC 61850 based Process Bus Projects (Applicable only if Process Bus SAS is specified in Section Project):

(i) Switchgear Controllers (SGC)IED

- SGCs shall function as digital interface between switchgear and control and protection IEDs (bay level IEDs) and shall be installed near the switchgear in the switchyard.
- SGCs shall be able to withstand the electrical and environmental conditions of the switchyard, like, temperature (preferably in the range of -25˚C to 70˚C temperature), humidity, electromagnetic interference (EMI/EMC) conditions, radio interference etc. SGCs shall be installed in panels designed with IP55 protection (or better) for outdoor use. The SGCs shall be suitable for the hostile substation environment and shall comply with the requirements for IEC 61850-3.
- Modelling of SGCs shall adhere to the IEC 61850 standard. Logical nodes, such as, XCBR and XSWI shall be used as the interfaces to Circuit Breaker and Isolator respectively. Engineering of the device shall comply with IEC 61850 Part 6 (Substation Configuration Language). Further, to accommodate supervision inputs and other 4-20mA inputs, Logical Nodes, as defined in the standard (the latest edition of IEC 61850) shall be used.
- The devices shall use Parallel Redundancy Protocol (PRP), and be High- availability Seamless Redundancy (HSR) capable. SGC devices should be time synchronized via SNTP or IEEE 1588v2 (Precision Time Protocol – PTP).No separate cable shall be used for time synchronization purpose.

  Ethernet based Data Network which will be used for GOOSE communication shall also be used for time synchronization purpose.
- The user shall be able to configure/access the device from the Engineering PC inthe Control Room.
- The number of binary inputs and binary outputs along with 4-20mA inputs shall be as per the requirement of the project. These mA inputs can either be provided in SGCs or can be provided in separate IEDs mounted near the equipment.
- Each bay shall have at least one SGC.

- SGCs should be powered by redundant Station DC power supplies and if the same is not available, then external changeover circuit shall be used.

(ii) Merging Units(MU) for Conventional CT and VT

- Merging Units (MU) shall digitize the conventional CT and VT values as per IEC 61850 Sampled Measured Values(SMV).
- MUs shall be able to withstand the electrical and environmental conditions of the switchyard, like, temperature (preferably in the range of -25˚C to 70˚C temperature), humidity, electromagnetic interference (EMI/EMC) conditions, radio interference etc. MUs shall be installed in panels designed with IP55 protection (or better) for outdoor use. The SGCs shall be suitable for the hostile substation environment and shall comply with the requirements for IEC 61850-3.
- Modelling of MUs shall adhere to IEC 61850 standard. Logical nodes, such as, TCTR and TVTR shall be used as the interfaces to Current Transformer and Voltage Transformer respectively. Engineering of the device shall comply with IEC 61850 Part 6 (Substation Configuration Language).
- The devices shall use Parallel Redundancy Protocol (PRP), or/and High- availability Seamless Redundancy (HSR) capable as applicable to meet the SAS architecture requirement. Also, these devices should have the capability to be time synchronized via IEEE 1588v2 (Precision Time Protocol – PTP). No separate cable is envisaged for time synchronization purpose. Ethernet based Data Network which will be used for SMV transmission shall also be used for time synchronization purpose.
- The user shall be able to configure/access the device from a separate Engineering PC in the Control Room.
- Each bay shall have 2 nos. MUs, each having CT and CVT inputs from different cores. For Bus CVTs, separate MUs shall be provided.
- MUs should be powered from Station DC power supplies, one from source-1 & other fromsource-2.

(iii) Specific Requirement for Control & Protection IEDs to be used in Process Bus SAS:

- The control and protection IEDs shall have 4 optical ports (2 each for connection with Process Bus LAN and Station Bus LAN). In case of insufficient availability ofnumber of ports natively in the IED, then Redundancy Boxes (RedBox) shall be used. However, atleast 2 ports shall compulsorily be available natively on the IED (with one port having the capability to get connected with Process Bus LAN and other to get connected with Station Bus LAN).
- The IEDs, wherever required, shall have the capability to internally summate the Sampled Values (SV) streams from two or more instrument transformers.

(iv) For Transformers and Reactors, sufficient (redundant)SGCs/MUs shall be provided in the Transformer/Reactor MB (or in a separate panel near the Transformer/Reactor MB as per thesite specific conditions) for interfacing bushing CTs, Online DGA, PPM Monitor, Optical Temperature Sensor and other annunciation/data of Transformer/Reactor with the process bus/ station bus of SAS.

(v) Following alarms shall be generated by devices subscribing to SMV streams in the followingtwo cases:

Firstly, when a subscribing IED stops receiving SMV streams from the Merging Unit(s), alarms shall be generated.

Secondly, there shall be a mechanism in the IEDs to detect using the SMV streams, the loss of time synchronization of Merging Units.

In case, the IEDs are not receiving the Sampled Values or are receiving improper Sampled Values from the Merging Unit, the IEDs shall not process their functions which utilize those Sampled Values.

(vi) In addition to the requirements specified at Section 4.1.5 for Switched Ethernet Communication Infrastructure, the Ethernet Fast Switches shall be PRP (IEC 62439 - 3), HSR (IEC 62439 - 3) and PTP (IEEE 1588v2) capable.

(vii) A suggested architecture for Process bus based SAS is enclosed. The architecture of Process Bus based SAS shall be such that the failure of any one Ethernet switch or any one fibre section of the SAS LAN (either in Process Bus

LAN or in Station Bus LAN) shall not result into any communication interruption.

(viii) All the control and protection schemes/functions shall be designed and implemented with GOOSE messages and Sampled Values, unless specifically desired by POWERGRID/AEGCL to be implemented using hardwiring. For energy metering, hardwiring between CT & CVT and meters shall be done. For signal exchange between PLCC and Protection IEDs and between CT/CVT and Control Switching Devices (CSDs), hardwiring shall also be acceptable. For integration of analog and binary signals from station auxiliaries (DG, FFPH, Air Conditioning, AC and DC LT etc.), hardwiring to IEDs shall also be acceptable.

TESTS

The substation automation system offered by the bidder shall be subjected to following tests to establish compliance with IEC 61850 for EHV sub- station equipment installed in sheltered area in the outdoor switchyard and specified ambient conditions:

Type Tests:

Control IEDs/BCU and Communication Equipment:

The above equipment shall conform to following type tests as per IEC 61850-3 (latest Revision)

a. Power Input:
   i. Auxiliary Voltage
   ii. Current Circuits
   iii. Voltage Circuits
   iv. Indications

b. Accuracy Tests:
   i. Operational Measured Values
   ii. Currents
   iii. Voltages
   iv. Time resolution
c. Insulation Tests:
   i. Dielectric Tests
   ii. Impulse Voltage withstand Test
d. Influencing Quantities
   i. Limits of operation
   ii. Permissible ripples
   iii. Interruption of input voltage
e. Electromagnetic Compatibility Test:
   i. 1 MHZ. burst disturbance test
   ii. Electrostatic Discharge Test
   iii. Radiated Electromagnetic Field Disturbance Test
   iv. Electrical Fast transient Disturbance Test
   v. Conducted Disturbances Tests induced by Radio Frequency Field
   vi. Magnetic Field Test
   vii. Emission (Radio interference level) Test.
   viii. Conducted Interference Test
f. Function Tests:
   i. Indication
   ii. Commands
   iii. Measured valueAcquisition
   iv. Display Indications
g. Environmental tests:

i. Cold Temperature
ii. Dry Heat
iii. Wet heat
iv. Humidity (Damp heat Cycle)
v. Vibration
vi. Bump
vii. Shock

All the IEDs, other communication equipment including Ethernet switches and SCADA/SAS software shall be compliant with the latest edition of IEC 61850 and should conform to conformance tests as per IEC61850-10.

10.55.0 Factory Acceptance Tests:

The supplier shall submit a test specification for factory acceptance test (FAT) and commissioning tests of the station automation system for approval based on the standard SAS FAT procedure of POWERGRID/AEGCL. The Standard SAS FAT format & procedure is provided at Appendix-II for reference guideline. For the individual bay level IED's applicable type test certificates shall be submitted.

The manufacturing and configuration phase of the SAS shall be concluded by the factory acceptance test (FAT). The purpose is to ensure that the Contractor has interpreted the specified requirements correctly and that the FAT includes checking to the degree required by the user. The general philosophy shall be to deliver a system to site only after it has been thoroughly tested and its specified performance has been verified, as far as site conditions can be simulated in a test lab. During FAT the entire Sub- station Automation System including complete control and protection system to be supplied under present scope shall be tested for complete functionality and configuration in factory itself. The extensive testing shall be carried out during FAT. The purpose of Factory Acceptance Testing is to ensure trouble free installation at site. No major configuration setting of system is envisaged at site.

The bidder shall provide the SCD file after FAT to site so that any intermittent issues with FAT configuration and changed site configuration (if any) can be analysed.

If the complete system consists of parts from various suppliers or some parts are already installed on site, the FAT shall be limited to sub-system tests. In such a case, the complete system test shall be performed on site together as part of site acceptance test(SAT).

In case of an extension of sub-station, Factory Acceptance Test shall be carried out with the help of a demo system owned by supplier. However, the complete system is to be tested along with SCADA at site by the supplier after complete integration of the system as part of SAT.

Hardware Integration Tests:

The hardware integration test shall be performed on the specified systems to be used for Factory tests when the hardware has been installed in the factory. The operation of each item shall be verified as an integral part of system. Applicable hardware diagnostics shall be used to verify that each hardware component is completely operational and assembled into a configuration capable of supporting software integration and factory testing of the system. The equipment expansion capability shall also be verified during the hardware integration tests. The vendor specifically demonstrates how to add a device in future in SAS during FAT. The device shall be from a different manufacturer than the SAS supplier.

Integrated System Tests:

Integrated system tests shall verify the stability of the hardware and the software. During the tests all functions shall run concurrently and all equipment shall operate a continuous 100 Hours period. The integrated system test shall ensure the SAS is free of improper interactions between software and

hardware while the system is operating as a whole.

Site Acceptance Tests:

The site acceptance tests (SAT) shall completely verify all the features of SAS hardware and software. The contractor shall submit the detailed SAT procedure and SAT procedure shall be read in conjunction with the specification.

10.56.0 SYSTEM OPERATION

Substation Operation

NORMAL OPERATION

Operation of the system by the operator from the remote RCC or at the substation shall take place via industry standard HMI (Human Machine interface) subsystem consisting of graphic colour VDU, a standard keyboard and a cursor positioning device(mouse).

The coloured screen shall be divided into 3 fields:

i) Message field with display of present time anddate
ii) Display field for single line diagrams
iii) Navigation bar with alarm/condition indication

For display of alarm annunciation, lists of events etc a separate HMI View node shall be provided.

All operations shall be performed with mouse and/or a minimum number of function keys and cursor keys. The function keys shall have different meanings depending on the operation. The operator shall see the relevant meanings as function tests displayed in the command field (i.e. operator prompting). For control actions, the switchgear (i.e. circuit breaker etc.) requested shall be selectable on the display by means of the cursor keys. The switching element selected shall then appear on the background that shall be flashing in a different color. The operator prompting shall distinguish between:-

- Prompting of indications e.g. fault indications in the switchgear, and
- prompting of operational sequences e.g. execution of switching operations

The summary information displayed in the message field shall give a rapid display of alarm/message of the system in which a fault has occurred and alarm annunciation lists in which the fault is described more fully.

Each operational sequence shall be divided into single operation steps which are initiated by means of the function keys/WINDOW command by mouse. Operator prompting shall be designed in such a manner that only the permissible keys are available in the command field related to the specific operation step. Only those switching elements shall be accessed for which control actions are possible. If the operation step is rejected by the system, the operator prompting shall be supported by additional comments in the message field. The operation status shall be reset to the corresponding preceding step in the operation sequence by pressing one of the function keys. All operations shall be verified. Incorrect operations shall be indicated by comments in the message field and must not be executed.

The offer shall include a comprehensive description of the system. The above operation shall also be

possible via WINDOWS based system by mouse.

10.57.0 POWERSUPPLY

Power for the substation automation system shall be derived from station DC powersupplies.

Inverter of suitable capacity shall be provided for station HMI disturbance recorder evaluation unit and its peripheral devices e.g. printer etc. In the event of Power failure, necessary safeguard software shall be built for proper shutdown. Separate Inverters powered from separate station DC supplies shall be provided for Main & hot standby SAS system. Separate Inverter shall also be supplied for Remote HMI & Workstation only if applicable.

DOCUMENTATION

The following documents shall be submitted for employer's approval during detailed engineering:

(a) System Architecture Drawing
(b) Hardware Specification
(c) Functional Design Document
(d) Clear procedure describing how to add an IED/bay/diameter in future covering all major supplier
(e) VLAN architecture drawing

The following documentation to be provided for the system in the course of the project shall be consistent, CAD supported, and of similar look/feel. All CAD drawings to be provide in "dxf" format.

- Substation automation system architecture
- Block Diagram
- Guaranteed technical parameters, Functional Design Specification
- availability and reliability
- Calculation for power supply dimensioning
- I/O Signal lists
- Schematic diagrams
- List of Apparatus
- List of Labels
- Logic Diagram (hardware &software)
- Switchyard Panel Room layout drawing
- Control Room Lay-out
- Test Specification for Factory Acceptance Test(FAT)
- Test Specification for Site Acceptance Test(SAT)
- The SCD files of the station's project shall be submitted by the vendor during the FAT and after successful commissioning of SAS.
- A GOOSE matrix sheet with publisher and subscriber IEDs.
- Product Manuals (Installation, Configuration, maintenance, Troubleshooting, detailed diagnostics etc.)
- Assembly Drawing
- Operator's Manual
- Complete documentation of implemented protocols between various elements
- Listing of software and loadable in CDROM
- Other documents as may be required during detailed engineering

Two sets of hard copy and Four sets of CD ROM/USB drive containing all the as built

documents/drawings shall be provided.

10.58.0 TRAINING, SUPPORT SERVICES, MAINTENANCE AND SPARES

Training

Contractor personnel who are experienced instructors and who speak understandable English shall conduct training. The contractor shall arrange on its own cost all hardware training platform required for successful training and understanding in India. The Contractor shall provide all necessary training material. Each trainee shall receive individual copies of all technical manuals and all other documents used for training. These materials shall be sent to Employer at least two months before the scheduled commencement of the particular training course. Class materials, including the documents sent before the training courses as well as class handouts, shall become the property of Employer. Employer reserves the right to copy such materials, but for in-house training and use only. Hands-on training shall utilize equipment identical to that being supplied to Employer.

For all training courses, the travel (e.g., airfare) and per-diem expenses will be borne by the participants.

The Contractor shall quote training prices as indicated in BPS.

The schedule, location, and detailed contents of each course will be finalized during Employer and Contractor discussions.

Computer System Hardware Course

A computer system hardware course shall be offered, but at the system level only. The training course shall be designed to give Employer hardware personnel sufficient knowledge of the overall design and operation of the system so that they can correct obvious problems, configure the hardware, perform preventive maintenance, run diagnostic programs, and communicate with contract maintenance personnel. The following subjects shall be covered:

(a) System Hardware Overview: Configuration of the system hardware.
(b) Equipment Maintenance: Basic theory of operation, maintenance techniquesand diagnostic procedures for each element of the computer system, e.g., processors, auxiliary memories, LANs, routers and printers. Configuration of all the hardware equipment.
(c) System Expansion: Techniques and procedures to expand and add equipment such as loggers, monitors, and communication channels.
(d) System Maintenance: Theory of operation and maintenance of the redundant hardware configuration, failover hardware, configuration control panels, and failover switches. Maintenance of protective devices and power supplies.
(e) Subsystem Maintenance: Theory of design and operation, maintenance techniques and practices, diagnostic procedures, and where applicable) expansion techniques and procedures. Classes shall include hands-on training for the specific subsystems that are part of Employer's equipment or part of similarly designed and configured subsystems. All interfaces to the computing equipment shall be taught in detail.
(f) Operational Training: Practical training on preventive and corrective maintenance of all equipment, including use of special tools and instruments. This training shall be provided on Employer equipment, or on similarly configured systems.

Computer System Software Course

The Contractor shall provide a computer system software course that covers the following subjects:

(a) System Programming: Including all applicable programming languages and all stand-alone service and utility

packages provided with the system. An introduction to software architecture, Effect of tuning parameters (OS software, Network software, database software etc.) on the performance of thesystem.

(b) Operating System: Including the user aspects of the operating system, such as program loading and integrating procedures; scheduling, management, service, and utility functions; and system expansion techniques and procedures

(c) System Initialization and Failover: Including design, theory of operation, and practice

(d) Diagnostics: Including the execution of diagnostic procedures and the interpretation of diagnostic outputs,

(e) Software Documentation: Orientation in the organization and use of system software documentation.

(f) Hands-on Training: One week, with allocated computer time for trainee performance of unstructured exercises and with the course instructor available for assistance as necessary.

Application Software Course

The Contractor shall provide a comprehensive application software courses covering all applications including the database and display building course. The training shall include:

a) Overview: Block diagrams of the application software and data flows.Programming standards and program interface conventions.

b) Application Functions: Functional capabilities, design, and majoralgorithms. Associated maintenance and expansion techniques.

c) Software Development: Techniques and conventions to be used for thepreparation and integration of new software functions.

d) Software Documentation: Orientation in the organization and use of functional and detailed design documentation and of programmer and user manuals.

e) Hands-on Training: One week, with allocated computer time for trainee performance of unstructured exercises and with the course instructor available for assistance as necessary.

Requirement of training:

The contractor shall provide training for POWERGRID/AEGCL personnel comprehensively covering following courses.

S.No.	Name of Course
1	Computer System Hardware
2	Computer System Software
3	Application Software

10.59.0 Maintenance

Maintenance Responsibility during the Guaranteed Availability Period.

During Guaranteed Availability Period, the Contractor shall take continual actions to ensure the guaranteed availability and shall make available all the necessary resources such as specialist personnel, spare parts, tools, test devices etc. for replacement or repair of all defective parts and shall have prime responsibility for keeping the system operational. During guarantee period as specified in tender document, contractor shall arrange visit of SAS manufacturer's representative to site as per requirement to review the performance of system and in case any defect/shortcoming etc. is observed during the period, the same shall be set right by the contractor within 15 days.

RELIABILITY ANDAVAILABILITY

The SAS shall be designed so that the failure of any single component, processor, or device shall not render the system unavailable. The SAS shall be designed to satisfy the very high demands for reliability and availability concerning:

- Mechanical and electrical design
- Security against electrical interference(EMI)
- High quality components andboards
- Modular, well-tested hardware
- Thoroughly developed and tested modularsoftware
- Easy-to-understand programming language for application programming
- Detailed graphical documentation and application software
- Built-in supervision and diagnostic functions
- Security
  - Experience of security req uirements
  - Process know-how
  - Select before execute at operation
  - Process status representation as double indications
- Distributed solution
- Independent units connected to the local area network
- Back-up functions
- Panel design appropriate to the harsh electrical environment and ambient conditions
- Panel grounding immune against transient ground potentialrise

Outage terms

1) Outage
   The state in which substation automation system or a unit of SAS is unavailablefor Normal Operation as defined in the clause 9.1.1 due to an event directly related to the SAS or unit of SAS. In the event, the owner has taken any equipment/system other than Sub-station Automation System for schedule/forced maintenance, the consequent outage to SAS shall not be considered as outage for the purpose of availability.

2) Actual outage duration(AOD)
   The time elapsed in hours between the start and the end of an outage. The timeshall be counted to the nearest $1/4^{th}$ of an hour. Time less than $1/4^{th}$ of an hour shall be counted as having duration of $1/4^{th}$ of an hour.

3) Period Hours (PH)
   The number of hours in the reporting period. In a full year the period hour are 8760h (8784h for a leapyear).

4) Actual Outage hours(AOH)
   The sum of actual outage duration within the reporting period AOH =

$\sum$ AOD

5) Availability:
   Each SAS shall have a total availability of 99.98 % i.e. the ratio of total time duration minus the actual outage duration to total time duration.

10.51.0 Guarantees Required

The availability for the complete SAS shall be guaranteed by the Contractor. The contractor shall demonstrate their availability guaranteed by conducting the availability test on the total sub-station automation system as a whole after commissioning of total Sub- station Automation system. The test shall verify the reliability and integrity of all sub- systems. Under these conditions the test shall establish an overall availability of 99.98%. After the lapse of 1000 Hours of cumulative test time, test records shall be examined to determine the conformance with availability criterion. In case of any outage during the availability test, the contractor shall rectify the problem and after rectification, the 1000 Hours period start after such rectification. If test object has not been met the test shall continue until the specified availability is achieved.

The contractor has to establish the availability in a maximum period of three months from the date of commencement of the availability test.

After the satisfactory conclusion of test both contractor and employer shall mutually agree to the test results and if these results satisfy the availability criterion, the test is considered to be completed successfully. After that the system shall be taken over by the employer and then the guarantee period shall start.

10.52.0 Spares

Consumables:

All consumables such as paper, cartridges shall be supplied by the contractor till the SAS is taken over by the owner.

Availability Spares:

In addition to mandatory spares as listed in section project for SAS/BPS, the bidder is required to list the spares, which may be required for ensuring the guaranteed availability during the guaranteed availability period.

During the guaranteed availability period, the spare parts supplied by the Contractor shall be made available to the Contractor for usage subject to replenishment at the earliest. Thus, at the end of availability period the inventory of mandatory spares with the Employer shall be fully replenished by the Contractor. However, any additional spares required to meet the availability of the system (which are not a part of the above spares supplied by the Contractor) would have to be supplied immediately by the Contractor free of cost to the Employer.

The price of above availability spare, as assessed by the SAS vendor, shall be deemed to be included in the complete SAS price.

Special Tools for IEC 61850 based SAS:

The contractor shall supply a GOOSE Inspection and Simulation Tool. The tool(s) shall have the capability to sniff and inspect the GOOSE in the data network. The tool(s) shall also have the capability to extract the GOOSE information from .cid/.scd file(s) and simulate them.

For IEC 61850 based Process Bus Projects, the bidder also shall supply a SV (IEC 61850 Sampled Values) Inspection and Simulation Tool. The tool(s) shall have the capability to sniff and inspect the SV in the data network. The tool(s) shall also have the capability to extract the SV information from .cid/.scd file(s) and simulate them.

The price of above shall be deemed to be included in the complete SAS.

10.53.0 LIST OF EQUIPMENTS

Quantity of following equipment shall be decided by bidder in order to achieve guaranteed reliability and availability as declared by bidder.

i) Station HMI workstation
ii) Redundant Station HMI (in Hot-stand by mode)workstation
iii) Bay level units along with bay mimic for number of bays as detailed insection Project.
iv) Bay Level Unit for Auxiliary system (as per requirement)
v) Disturbance Recorder Work Station(Maintenance HMI)
vi) Engineering PC for Merging Units (applicable in case of Process Bus Projects)
vii) Colour Laser Printer – 1 No. (For Reports & Disturbance records)
viii) Dot matrix printers - (one each for Alarms and log sheets)
ix) All interface equipment for gateway to RCC and RSCC
x) Communication infrastructure between Bay level units, Station HMI, Printers, gateways, redundant LAN etc. as required
xi) Remote disturbance recorder workstation and remote HMI and along withone colour laser A4 printer (Remote HMI, only if specified in Section Project).
xii) Modems as per requirement.
xiii) Routers – 2Nos.
xiv) Merging Units (MU s) [applicable for Process Bus SAS], as per requirement.
xv) Switchgear Controllers (SGCs) [applicable for Process Bus SAS], as perrequirement.
xvi) Any other equipment as necessary.

Annexure-I

List of Analogue and Digital Inputs

Basic Monitoring requirements are:

- Switchgear status indication
- Measurements (U, I, P, Q, f)
- Event
- Alarm
- Oil & Winding temperature of transformer & reactor individual units
- Ambient temperature
- Status and display of 415V LT system, 220V & 48V D C system
- Status of display of Fire protection system and Air conditioning system.
- Acquisition of all counters in PLCC panels through potential free contacts from PLCC or independently by counting the receive/send commands.
- Acquisition of alarm and fault record from protection relays
- Disturbance records
- Monitoring the state of batteries by displaying DC voltage, charging current and load current etc.
- Tap-position of Power Transformer
- Temperature measured with Optical Temperature sensor (being provided by Transformer/Reactor manufacturer)
- Dissolved Hydrogen/multi-gas & Moisture Content monitor of Transformer
- Status and display of LT transformer & its associated switchgear for station auxiliary supply

List of Inputs

The list of input for typical bays is as below:-

Analogue inputs

i) For Each line Current
   - R phase
   - Y phase
   - B phase

   Voltage
   - R-Y phase
   - Y-B phase
   - B-R phase

ii) For each transformer/reactor

   Current
   - R phase
   - Y phase
   - B phase

WTI (Winding Wise)

OTI
Multi-gas DGA parameters
Tap position (for transformer only)

iii) For TBC and bus coupler Current

R phase Y phaseB phase

iv) Common

a) Voltage for Bus-I, Bus-II and Transfer bus wherever applicableVoltage

R-Y phase Y-B phaseB-R phase

b) Frequency for Bus-I and Bus-II
c) Ambient temperature(switchyard)
d) Switchyard Panel Room Temperature.
e) LT system

i) Voltage R-Y, Y-B, B-R of Main Switch Board section-I
ii) Voltage R-Y, Y-B, B-R of Main Switch Board section-II
iii) Voltage R-Y, Y-B, B-R of Diesel Generator
iv) Current from LT transformer-I
v) Current from LT transformer-II
vi) Current from Diesel Generator
vii) Voltage of 220VDCDB-I
viii) Voltage of 220VDCDB-II
ix) Current from 220V Battery set-I
x) Current from 220V Battery set-II
xi) Current from 220V Battery charger-I
xii) Current from 220V Battery charger-I
xiii) Voltage of 48VDCDB-I
xiv) Voltage of 48VDCDB-II
xv) Current from 48V Battery set-I
xvi) Current from 48V Battery set-II
xvii) Current from 48V Battery charger-I
xviii) Current from 48V Battery charger-I

Digital Inputs
The list of input for various bays/SYSTEM is as follows:

1. Line bays
   i) Status of each pole of CB.
   ii) Status of Isolator, Earth switch
   iii) CB trouble
   iv) CB operation/closing lockout
   v) Pole discrepancy optd
   vi) Trip coil faulty
   vii) LBB optd
   viii) Bus bar protn trip relay optd
   ix) Main bkr auto recloser operated
   x) Tie/transfer auto reclose operated
   xi) A/r lockout
   xii) Tie/transfer bkr a/r lockout
   xiii) Direct trip-I/II sent
   xiv) Direct trip-I/II received
   xv) Main I/II blocking

xvi) Main I/II-Inter trip send
xvii) Main I/II-Inter trip received
xviii) O/V STAGE – I operated
xix) O/V STAGE – II operated
xx) FAULT LOCATORFAULTY
xxi) MAIN-I/II CVT FUSEFAIL
xxii) MAIN-I PROTN TRIP
xxiii) MAIN-II PROTN TRIP
xxiv) MAIN-I PSB ALARM
xxv) MAIN-I SOTF TRIP
xxvi) MAIN-I R-PH TRIP
xxvii) MAIN-I Y-PH TRIP
xxviii) MAIN-I B-PH TRIP
xxix) MAIN-IS TART
xxx) MAIN-I/II Carrier aided trip
xxxi) MAIN-I/II fault in reverse direction
xxxii) MAIN-I/II ZONE-2TRIP
xxxiii) MAIN-I/II ZONE-3TRIP
xxxiv) MAIN-I/II weak end infeed optd
xxxv) MAIN-II PSB alarm
xxxvi) MAIN-II SOTFTRIP
xxxvii) MAIN-II R-PHTRIP
xxxviii) MAIN-II Y-PHTRIP
xxxix) MAIN-II B-PH TRIPxl)
xl) MAIN-I start
xli) MAIN-II aided trip
xlii) MAIN-I/II fault in reverse direction
xliii) Back-up o/c optd
xliv) Back-up e/f optd
xlv) 220V DC-I/II source fail
xlvi) SPEECH CHANNELFAIL
xlvii) PLCC Protection Channel-I FAIL
xlviii) PLCC Protection Channel-IIFAIL

2. Transformer bays (HV Side)

i) Status of each pole of CB,
ii) Status of Isolator, Earth switch
iii) CB trouble
iv) CB operation/closing lockout
v) Pole discrepancy optd
vi) Trip coil faulty
vii) LBB optd
viii) Bus bar protn trip relay optd
ix) REF OPTD
x) DIF OPTD (Phase Wise)
xi) OVERFLUX ALARM (MV)
xii) OVERFLUX TRIP(MV)
xiii) OVERFLUX ALARM (HV)
xiv) OVERFLUX TRIP(HV)
xv) HV BUS CVT ½ FUSEFAIL
xvi) MV BUS CVT ½ FUSEFAIL
xvii) OTIALARM/TRIP
xviii) PRD OPTD (each PRD)
xix) OVERLOADALARM
xx) BUCHOLZTRIP
xxi) BUCHOLZ ALARM
xxii) OLTC BUCHOLZALARM

xxiii) OLTC BUCHOLZTRIP
xxiv) OIL LOW ALARM
xxv) back-up O/C (HV) optd
xxvi) back-up E/F (HV) optd
xxvii) 220V DC-I/II source fail
xxviii) TAPMISMATCH
xxix) GR-A PROTNOPTD
xxx) GR-B PROTNOPTD
xxxi) back-up O/C (MV) optd
xxxii) back-up E/F(MV) optd
xxxiii) Healthiness of each Protection Relay through watchdog contact.

3. Transformer bays (MVSide)

i) Status of each pole of CB, Isolator, Earth switch
ii) CB trouble
iii) CB operation/closing lockout
iv) Pole discrepancy optd
v) Trip coil faulty
vi) LBB optd
vii) Bus bar protn trip relay optd
viii) Back-up impedance relay
ix) 220V DC-I/II source fail
x) GR-A PROTN OPTD
xi) GR-B PROTN OPTD

4. Line/Bus Reactor bays(as applicable):

i) Status of each pole of CB, Isolator, Earthswitch
ii) CB trouble
iii) CB operation/closing lockout
iv) Pole discrepancy optd
v) Trip coil faulty
vi) LBB optd
vii) Bus bar protn trip relay optd
viii) REFOPTD
ix) DIF OPTD (Phase wise)
x) Line/ BUS CVT ½ FUSE FAIL
xi) OTIALARM/TRIP
xii) PRD OPTD
xiii) BUCHOLZ TRIP
xiv) BUCHOLZ ALARM
xv) OIL LOW ALARM
xvi) Back-up impedance relay
xvii) 220V DC-I/II source fail
xviii) GR-A PROTN OPTD
xix) GR-B PROTN OPTD

5 Bus barProtection

i) Bus bar main-I trip
ii) Bus bar main-II trip
iii) Bus bar zone-I CT open
iv) Bus bar zone-II CT open
v) Bus transfer CT sup. Optd
vi) Bus transfer bus bar protn optd
vii) Bus protection relay fail

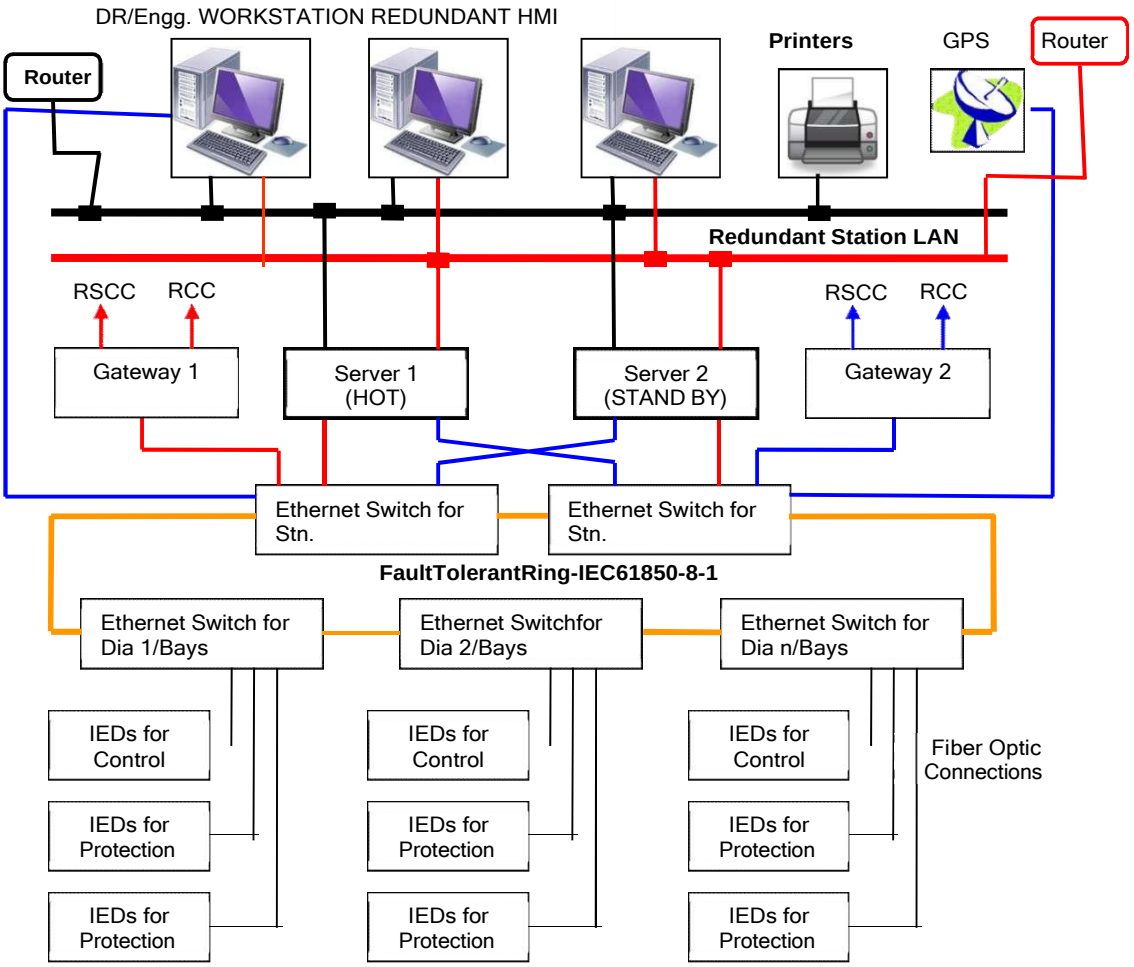
6. Auxiliary system
   i) Incomer-I On/Off
   ii) Incomer-II On/Off
   iii) 415V Bus- I/IIU/V
   iv) 415v bus coupler breaker on/off
   v) DG set bkr on/off
   vi) Alarm/trip signals as listed in Section: DG set
   vii) LT transformer-I Bunchholz Alarm &trip
   viii) LT transformer-II Buchloz Alarm &trip
   ix) LT transformer-I WTI Alarm &trip
   x) LT transformer-II WTI Alarm &trip
   xi) LT transformer-I OTI Alarm &trip
   xii) LT transformer-II OTI Alarm &trip
   xiii) PLCC exchange fail
   xiv) Time sync. Signal absent
   xv) Alarm/trip signals as listed in Section: Battery and Battery charger
   xvi) 220v DC-I earth fault
   xvii) 220v DC-II earth fault
   xviii) Alarm/trip signals as listed in Section: Fire protection system

7. Switchyard Panel Room:

   i) AC Compressor 1ON/OFF
   ii) AC Compressor 2ON/OFF
   iii) Fire Detection 1ON/OFF
   iv) Fire Detection 2On/OFF
   v) Switchyard Panel Room Temperature High Alarm

The exact number and description of digital inputs shall be as per detailed engineering requirement. Apart from the above mentioned digital inputs, minimum of 200 inputs shall be kept for employer's/owner's use in future for new substations. For extension substations, minimum 04 nos. digital inputs per bay shall be kept for future use.

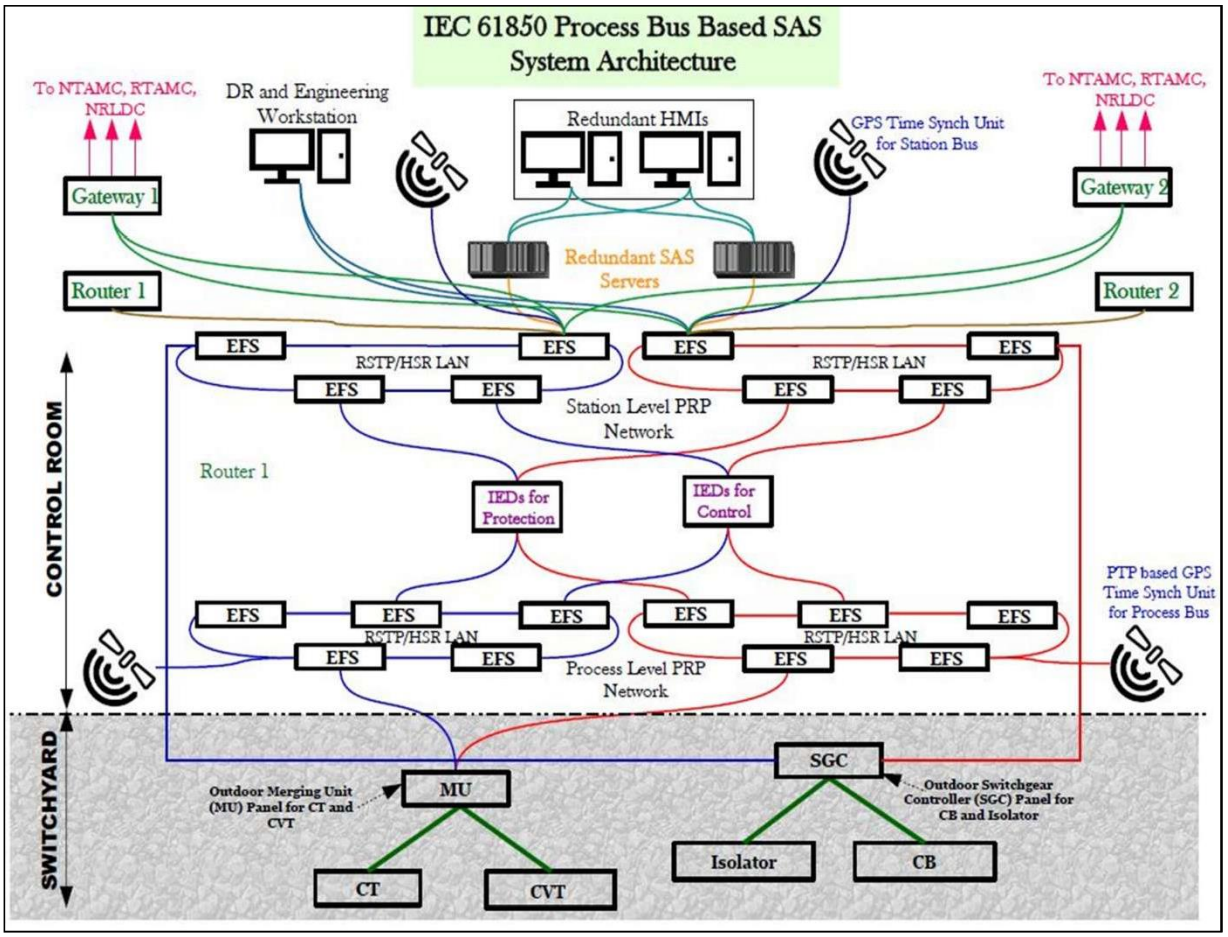
TYPICAL ARCHITECTURAL DRAWING OF
SUBSTATION AUTOMATION SYSTEM (Without Process Bus)



Note:

1. The redundant managed bus (station LAN) shall be realized by high speed optical bus usingindustrial grade components and shall be as per IEC61850.
2. Inside the sub-station, all connections shall be realized as per IEC 61850protocol.
3. For gateway, it shall communicate with Remote Supervisory Control Centre (RSCC) on IEC 60870- 104 protocol.Thenumberofportsrequiredshallbeasperclauseno.1.1and3.3ofthisspecification.
4. The printer as required shall be connected to station bus directly and can be managed either fromstation HMI, HMI view node or disturbance recorder workstation.
5. The above layout is typical. However if any contractor offers slightly modified architecture based on their standard practice without compromising the working, the same shall be subject to approval during detailedengineering.
6. RCC means NTAMC/RTAMC. Similarly, RSCC could be SLDC for state ownedsubstations/bays.

TYPICAL ARCHITECTURAL DRAWING OF
SUBSTATION AUTOMATION SYSTEM (with Process Bus)



Appendix-I

List of IO Points to be transmitted to RSCC

a) MW and MVAR for all lines , transformers ,reactors and Capacitors
b) Voltage of all buses
c) Frequency of all 400Kv and 765kVBuses
d) Frequency of one 220KvBus
e) All Breakers
f) All isolators
g) Tap Position for all transformers
h) Master protection signal for all feeders, transformers Units and Bus Bar
i) Loss of Voltage signal for Bus bar
j) All the points identified in point (e), (h) and (i) above as GPS Time stamped.
k) Temperature value per substation.
l) Any other point decided during detailed engineering

SECTION-11

TECHNICAL SPECIFICATION OF POWER AND CONTROL CABLES

11.1.0 GENERAL REQUIREMENT

Aluminium conductor PVC insulated armoured power cables shall be used for various other applications in switchyard area/control room except for control/protection purposes.

For all control/protection/instrumentation purposes PVC insulated armoured control cables of minimum 2.5 sq. mm Size with stranded Copper conductors shall be used.
Cables shall be laid conforming to IS: 1255.
While preparing cable schedules for control/protection purpose following shall be ensured:

- Separate cables shall be used for AC & DC.
- For different cores of CT & PT separate cable shall be used.
- At least one (1) core shall be kept as spare in each copper control cable of 4C, 5C or 7C size whereas minimum no. of spare cores shall be two (2) for control cables of 10 core or higher size.

For control cabling, including CT/VT circuits, 2.5 sq.mm.size copper cables shall be used per connection. However, if required from voltage drop/VA burden consideration additional cores shall be used. Further, for potential circuits of energy meters separate connections by 2 cores of 2.5sq.mm size shall be provided.

Standard technical data sheets for cable sizes up to and including 1100V are enclosed at **Clause 11.3.0**. Cable sizes shall be offered /manufactured in accordance with parameters specified in standard technical data sheets. Technical data sheet for any other cores/sizes required during detailed engineering shall be separately offered for Employer's approval by the contractor/supplier.

11.2.0 TECHNICAL REQUIREMENTS

11.2.1 General

The cables shall be suitable for laying in racks, ducts, trenches, conduits and underground buried installation with uncontrolled back fill and chances of flooding by water.

The XLPE insulated cables shall be capable of withstanding a conductor temperature of 250°C during a short circuit without any damage. The PVC insulated cables shall be capable of withstanding a conductor temperature of 160°C during a short circuit.

The Aluminium/Copper wires used for manufacturing the cables shall be true circular in shape before stranding and shall be uniformly good quality, free from defects. All Aluminium used in the cables for conductors shall be of H2 grade. In case of single core cables, armours shall be of H4 grade Aluminium.

The fillers and inner sheath shall be of non-hygroscopic, fire-retardant material, shall be softer than insulation and outer sheath shall be suitable for the operating temperature of the cable.

Progressive sequential marking of the length of cable in metres at every one metre shall be provided on the outer sheath of all cables.

Strip wire armouring method shall not be accepted for any of the cables. For control, cables only round wire armouring shall be used.

The cables shall have outer sheath of a material with an oxygen index of not less than 29 and a temperature index of not less than 250°C.

All the cables shall pass fire resistance test as per IS:1554 (Part-I)

The normal current rating of all PVC insulated cables shall be as per IS: 3961.

Repaired cables shall not be accepted.

Allowable tolerance on the overall diameter of the cables shall be plus or minus 2 mm.

11.2.2 XLPE Power Cables

The XLPE (90°C) insulated cables shall be of FR type, C1 category conforming to IS: 7098 (Part-I) and its amendments read along with this specification. The conductor shall be stranded aluminium circular/sector shaped and compacted. In multicore cables, the core shall be identified by red, yellow, blue and black coloured strips or colouring of insulation. A distinct inner sheath shall be provided in all multicore cables. For XLPE cables, the inner sheath shall be of extruded PVC of type ST-2 of IS: 5831. When armouring is specified for single core cables, the same shall consist of aluminium wires/strips. The outer sheath shall be extruded PVC of Type ST-2 of IS: 5831 for all XLPE cables.

11.2.3 PVC Power Cables

The PVC (70°C) insulated power cables shall be of FR type, C1 category, conforming to IS: 1554 (Part-

11.2.3.1.1 and its amendments read along with this specification and shall be suitable for a steady conductor temperature of 70°C. The conductor shall be stranded aluminium. The Insulation shall be extruded PVC to type-A of IS: 5831. A distinct inner sheath shall be provided in all multicore cables. For multicore armoured cables, the inner sheath shall be of extruded PVC. The outer sheath shall be extruded PVC to Type ST-1 of IS 5831 for all cables.

11.2.4 PVC Control Cables

The PVC (70°C) insulated control cables shall be of FR type C1 category conforming to IS: 1554 (Part-1) and its amendments, read along with this specification. The conductor shall be stranded copper. The insulation shall be extruded PVC to type A of IS: 5831. A distinct inner sheath shall be provided in all cables whether armoured or not. The over sheath shall be extruded PVC to type ST-1 of IS: 5831 and shall be grey in colour.

Cores shall be identified as per IS: 1554 (Part-1) for the cables up to five (5) cores and for cables with more than five (5) cores the identification of cores shall be done by printing legible Hindu Arabic Numerals on all cores as per clause 10.3 of IS 1554 (Part-1).

11.3.0 CABLE DRUMS

Cables shall be supplied in returnable wooden or steel drums of heavy construction. Wooden drum shall be properly seasoned sound and free from defects. Wood preservative shall be applied to the entire drum. Drums offered shall conform to relevant standards. Drum drawings are not required to be submitted for approval.

Standard lengths for each size of power and control cables shall be 500/1000 meters. The cable length per drum shall be subject to a tolerance of plus or minus 5% of the standard drum length. The owner shall have the option of rejecting cable drums with shorter lengths. Maximum, One (1) number non standard length of cable size(s) may be supplied in drums for completion of project.

A layer of water proof paper shall be applied to the surface of the drums and over the outer most cable layer.

A clear space of at least 40 mm shall be left between the cables and the lagging.
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 stencilled 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 PVC/Rubber caps so as to eliminate ingress of water during transportation and erection.

Cables shall be supplied in returnable wooden or steel drums of heavy construction. Wooden drum shall be properly seasoned sound and free from defects. Wood preservative shall be applied to the entire drum. *Drums offered shall conform to relevant standards. Drum drawings are not required to be submitted for approval.*

11.4.0 TYPE TESTS

All cables shall conform to all type, routine and acceptance tests listed in the relevant IS.

All cables shall conform to all type, routine and acceptance tests listed in the relevant IS.

Following type tests (on one size in a contract) as per IS: 7098 (Part 1) – 1988 including its amendments shall be carried out as a part of acceptance tests on XLPE insulated power cables for working voltages up to and including 1100 V:

a) Physical tests for insulation
   i) Hot set test
   ii) Shrinkage test
b) Physical tests for outer sheath
   i) Shrinkage test
   ii) Hot deformation
   iii) Heat shock test
   iv) Thermal stability

Contractor shall submit type test reports for the following tests

a) Water absorption (gravimetric) test.
b) Ageing in air oven
c) Loss of mass in air oven
d)Short time current test on power cables of sizes 240 sqmm and above on
   i) Conductors.
   ii) Armours.
e) Test for armouring wires/strips.

f) Oxygen and Temperature Index test.
g) Flammability test.

11.4.1 PVC INSULATED POWER & CONTROL CABLES (For working voltages up to and including 1100V)-

Following type tests (on one size in a contract) as per IS: 1554 (Part 1) -1988 including its amendments shall be carried out as a part of acceptance tests on PVC insulated power & control cables for working voltages up to and including 1100 V:

a) Physical tests for insulation and outer sheath
   i) Shrinkage test
   ii) Hot deformation
   iii) Heat shock test
   iv) Thermal stability
b) High voltage test (water immersion test only a.c. test as specified in this section.

Contractor shall submit type test reports for the following

a) High voltage test (water immersion d.c. test as per clause no. 16.3.2 of IS: 1554 (Part 1) - 1988).
b) Ageing in air oven.
c) Loss of mass in air oven.
d)Short time current test on power cables of sizes 240 sqmm and above on
   i) Conductors.
   ii) Armours.
e) Test for armouring wires/strips.
f) Oxygen and Temperature Index test.
g) Flammability test.

11.5.0 DATA SHEET FOR CABLES

(A) Power Cables

(B)

Sl. No.	**Description**	**3 ½ C 300mm$_2$**	**Other Power Cables**	
			70 mm$_2$, 35 mm$_2$, 25mm$_2$, 16 mm$_2$	**6 mm$_2$& 4mm$_2$**
1	Applicable Standard	IS: 7098/PT-I & its referred standards	IS: 1554/PT-I& its referred standards	
2	Type Designation	A2XWY	AYFY	AYWY
3	Rated Voltage(volts)	1100	1100	1100
4	Type & Category	FR & C1	FR & C1	FR & C1
5	Suitable for earthed or unearthed system	Suitable for both		
	Conductor			
	a) Material	Stranded Aluminium as per IS : 8130		
	b) Grade	H 2 (Electrolytic grade)		
	c) Number of wires (No.)	As per IS 8130		

6	d) Form of Conductor	Stranded compacted circular/sector shaped	Stranded compacted circular/sector shaped	Non- compacted Stranded circular
	e) Direction of lay of stranded layers	Outermost layer shall be R.H lay & opposite in successive layers		
7	Insulation			
	a) Composition of insulation	Extruded XLPE as per IS-7098 Part (1)	Extruded PVC type A as per IS-5831	Extruded PVC type A as per IS-5831
	b) Thickness of insulation(mm)	As per applicable Standard		
8	Inner Sheath material	Extruded PVC type ST-2 as per IS-5831	Extruded PVC type ST-1 as per IS- 5831	
9	Type and material of armour	Gal. Steel wire	Gal. Steel strip	Gal. Steel wire
10	Outer Sheath (PVC)	ST-1 & FR	ST-2 & FR	ST-2 & FR
11	Overall diameter of cable	As per applicable Standard		

(B) Control Cables

Sl. No.	Description	Particulars
1	Applicable Standard	IS: 1554/PT-I & its referred standards
2	Type Designation	YWY
3	Rated Voltage(volts)	1100
4	Type & Category	FR & C1
5	Suitable for earthed or unearthed system	Suitable for both
6	Conductor	
	a) Material	Plain annealed High Conductivity stranded Copper (as per IS 8130)
	b) Grade	Electrolytic
	c) Number of wires(No.)	As per IS 8130
	d) Form of Conductor	Non-compacted Stranded circular
	e) Direction of lay of stranded layers	Outermost layer shall be R.H lay
7	Insulation	
	a) Composition of insulation	Extruded PVC type A as per IS-5831
	b) Thickness of insulation(mm)	As per applicable Standard
8	Inner Sheath material	Extruded PVC type ST-1 as per IS-5831
9	Type and material of armour	Gal. Steel wire
10	Outer Sheath (PVC)	ST-1 & FR
11	Overall diameter of cable	As per applicable Standard
12	No. of Cores	As per Bill of Materials

SECTION-12

TECHNICAL SPECIFICATION OF PLCC EQUIPMENTS

12.1.0 GENERAL

All the PLCC equipment covered under the package shall conform to the requirements of the latest edition of the relevant IEC/IS Specifications or equivalent National Standards.

12.2.0 Standard And Drawing

The IEC/IS Specifications and international publication relevant to the equipment covered under this specification shall include but not be limited to the list given at Annexure - 'C' of Section - GTR:

12.2.1 Location of Equipment

The PLCC Equipment and Line traps as specified shall be installed at the respec- tive ends of the transmission lines. The Contractor shall be responsible forcoordinating the equipment supplied by him with the already existing carrier equipment at the respective sub-stations. Contractor shall also be responsible for collecting all the necessary information/data from the respective sub-stations/concerned State Electricity Boards for the installation of the equipment.

12.2.2 Frequency Planning

For planning frequency and output power of carrier terminals Bidders may plan for a minimum receive signal to noise ratio of 25 dB for the speech channels without companders. The noise power in 2.1 kHz band (300-2400 Hz) may be taken as -13 dBm referred to the coupling point of the H.T. line. An additional minus two and a half dB may be assumed for psophometric factor. As far as coupling loss (phase to phase) is concerned the Bidders may assume the same as 6dB at one coupling end for evaluating SNR. For protection channels the minimum SNR shall not be less than 15 dB under adverse weather. A safety margin of 9 dB shall be taken over and above these SNR values in order to cater for variations in line attenuation from the computed value as inhand reserve. Frequency and output power of PLC terminals for protection shall be planned such that the protection signal is received with full reliability even when one of the phase is earthed or is on open circuit on the line side causing an additional minimum loss of 6 dB.

The Bidder shall indicate the noise power in the bandwidth used for protection signaling and shall submit the SNR calculations for speech as well as protection channels on all the line section given in at the proposed frequencies. Sample calculations for SNR requirement and power allocation over different channels must be furnished alongwith the bid. Maximum permissible line attenuation shall be clearly brought out in these calculations. Further, Bidder shall submit details of frequency planning done (including computer studies carried out and facilities available) for PLCC links on EHV lines in the past in the relevant schedule of DRS. Bidder must enclose one copy of computer study result done in the past along with the Bid.

Successful Bidder shall be fully responsible for the coordination required with concerned State Electricity Boards for finalising the frequency plan.

12.2.3 Proposed Arrangement

The power line carrier communication equipment required by the OWNER is to provide primarily efficient, secure and reliable information link for carrier aided distance protection and direct tripping of remote-end breaker and also for speech communication between 765/400/220 kV sub-stations. It shall include separate carrier terminals of multipurpose type for speech and protection purposes. All carrier terminals including those for protection shall be suitable for point to point speech communication also.

For security reasons each 765/400/220kV transmission line shall be protected by Main-I and Main-II protections as given below :

Main-I Numerical Distance protection with permissive inter-tripping.

Main-II Distance protection of a different measuring technique than that of relay under Main I.

132kV transmission lines shall have Main I protection same as above alongwith backup overcurrent and earth fault protections.

The requirement of carrier information on each link covered under this specification is as below :

a) One protection channel for Main-I and another for Main-II distance protection schemes. Further these channels will also be used as main and back-up channel for direct circuit breaker inter-tripping for 765kV/ 400kVlines.

   In case of 400KV/220 KV/132 KV lines ,speech and data channel can also be used for protection wherever possible.

b) One speech channel with a facility to superimpose data signals upto1200Baud.

   However, the number of channels for protection signaling , speech anddata communication for SAS and Load dispatch centre shall be as per the BOQ given in price schedule.

The equipment for protection signals shall have high degree of reliability and speed. It shall be guaranteed to function reliably in the presence of noise impulse caused by isolator or breaker operation. The equipment shall be suitable for direct tripping of remote end breaker for fault in unswitched 765kV/400 kV ShuntReactor & Operation of Buchholz relays of reactor etc. It shall also be possible to effect direct tripping of breaker at one end when the other end breaker opens out either manually or by relays such as Bus fault relay etc.

The time intervals between receipt of a trip command on the transmit side, its transmission over the carrier link, reception at the far end and giving command to the trip relays at the distant end shall not exceed 20 mS. for permissive inter- tripping and 30 m sec. for direct inter-tripping even for the longest line section. The above timings are inclusive of operating time for auxiliary relays and interposing relays, if any, included in the PLCC equipment.

The requirement of protection signaling channel is such that security againstincorrect signals being received shall be at least two to three orders higher than reliability against a signal not being received.

For reasons of security and reliability, phase to phase coupling for 765kV/400 kVS/C , D/C & 220kV S/C lines shall be employed. Inter-circuit coupling shall be used for 220/132kV D/C lines and phase to ground coupling shall be used for 132 KV S/C lines. Double differential coupling shall also be considered fordouble circuit lines. Bidders must furnish detailed write-up on methods of coupling and recommend suitable coupling mode for double-circuit lines along- with the bids. Coupling mode shall, however, be fully confirmed by Contractor after conducting detailed computer study taking into account the transpositions of 765kV/400 kV lines for optimum coupling mode over these line sections. The coupling arrangement shall be fully optimized by the Contractor after conducting detailed study of every line section individually, taking into account the temperature variations, transpositions, earth

resistivity, conductor configuration, carrier channels requirements, security and reliability criteria and other relevant details. The line attenuation shall be calculated for complete range of frequencies. The earth resistivity data, existing frequency networks and other relevant details of each line will be furnished to the Contractor for carrying out the computer studies and frequency planning. The Contractor shall complete the computer studies wherever required and submit the frequency plan and optimum coupling details within a period of one month from the date of receipt of above data.

The 765kV/400 kV transmission lines may be transposed.

The transmission tower configuration and conductor details shall be forwarded after the award to enable the contractor to make his own computer study assessment of the carrier path based on wave propagation over transposed lines with each transposition point acting as “Modal Converter”.

The parameters of the equipment quoted shall be such that the mode of wave propagation on 765kV/400 kV power line (with transpositions indicated) shall not impose any limitation on the efficient and reliable performance of informationlink from protection or communication point of view.

The Contractor shall have to check and prove through the results of his computer studies that attenuation due to transpositions in the EHV lines is within limits and the offered equipment will perform satisfactorily.

The Bidder shall submit curves illustrating ‘incorrect tripping’ and “Failure to trip” probability plotted against corona noise level, in the presence of impulse noise due to switching of isolator and circuit breaker etc. Details of field tests and laboratory tests for successful operation of his equipment, under such adverse conditions shall be furnished by the Bidder. These are to be related to end-to-end signaling and shall take into account the type of communication link e.g. account shall be taken of transpositions in the phase to phase coupled H.T. line. Details of field tests and laboratory tests for successful operation of the equipment under the above circumstances shall be submitted by the Bidder illustrating the above parameters.

12.2.4 LINE TRAP

Line trap shall be broad band tuned for its entire carrier frequency range. Resistive component of impedance of the line trap within its carrier frequency blocking range shall not be less than 450 ohms for 765kV/400 kV system and 570ohms for 220kV and 132 kV systems..

Line trap shall be provided with a protective device in the form of surge arrestors which shall be designed and arranged such that neither significant alteration in its protective function nor physical damage shall result from either temperature rise or the magnetic field of the main coil at continuous rated current or rated short time current. The protective device shall neither enter into operation nor remain in operation, following transient actuation by the power frequency voltage developed across the line trap by the rated short time current.

The lightning arrestor shall be station class current limiting active gap type. Its rated discharge current shall be 10 kA. Coordination, however, shall be done by taking 20 kA at 8/20 micro-sec. discharge current into account. Bidder has to furnish full justification in case the use of gap-less metal oxide arrestor is recommended by them.

The lightning arrestor provided with the line trap of each rating shall fully comply with the requirements of IS:3070 Part-I/IEC-60099-I Part-I. It shall conform to type tests as applicable and type test

certificate for the same shall be submitted by the Bidder.

The lightning arrestor provided with the line trap shall be subject to routine and acceptance tests as per IEC-60099-1 (Part-I).

The line trap on 765kV & 400 kV lines shall show no visual corona discharge at a voltage of 508kV(rms) and 320 KV (rms) power frequency falling voltage. Suitable corona rings may be incorporated in the line trap. Radio interference voltage for 420/245/132 kV shall not exceed 500 micro volts at 280/163/97 kV (rms) respectively. For 765kV, RIV shall not exceed 1000 micro volts at 508kV(rms).

Line trap shall be equipped with the bird barriers.

Line trap shall conform to IEC 60353 (latest) fulfilling all the technical requirements. The rated short time current for 1 Second shall be 31.5/40/50/63 kA as per requirement. The mH. rating shall be 0.25/0.5/1.0 mH depending on frequency plan.

The Bidder shall indicate continuous current rating of the line trap at 65 deg. C ambient.

Reports for the following type tests on each type of line trap shall be submitted as per clause 9.2 of GTR .

1. Measurement of Inductance of the main coil.
2. Measurement of temperature rise.
3. Insulation test.
4. Short time current test.
5. Corona Extinction Voltage test (procedure for this shall be mutuallyagreed).
6. Radio Interference Voltage measurement test (procedure for this shall bemutually agreed).

The Bidder must enclose with his bid the reports of type and routine tests conducted on similar equipment earlier as per IEC-60353.

Welding

All the welding included in the manufacture of line traps shall be performed by personnel and procedure qualified in accordance with ASME-IX and all the critical welds shall be subject to NDT as applicable.

Line Trap Mounting

The Line Trap shall be suitable for outdoor pedestal or suspension mounting and shall be mechanically strong enough to withstand the stresses due to maximum wind pressure of 260 kg/square meter.

For pedestal mounting, each line trap shall be mounted on a tripod structure formed by three insulator stacks arranged in a triangular form. All the accessories and hardware, mounting stool including bolts for fixing the line trap on insulators shall be of non-magnetic material and shall be supplied by the Contractor.

For suspension mounting, Contractor shall be required to coordinate the mounting arrangement with the existing arrangement. Non-magnetic suspension hook/link of adequate length and tensile

strength to provide necessary magnetic clearance between the line trap and suspension hardware shall be supplied by the Contractor.

Terminal Connectors

The line traps shall be suitable for connecting to 4" IPS Aluminium tube or 3" IPS Al. tube or ACSR single/twin/Quad bundle conductor with horizontal or vertical take off. Necessary connector shall be supplied by the Contractor.

Terminal Connectors shall conform to IS:5561.

No part of clamp or connector (including hardware) shall be of magnetic material.

Clamps and connectors shall be designed corona controlled. Visual Corona extinction voltage shall not be less than 508kV(rms) & 320kV(rms) for 765kV and 420kV respectively. All nuts and bolts shall be suitably shrouded.

Radio interference Voltage for 420/245/132 kV shall not exceed 500 microvolts at 280/163/97 kV (rms) respectively. For 765kV, RIV shall not exceed 1000micro volts at 508kV(rms).

Clamps/connectors shall be designed for the same current ratings as line trap and temperature rise shall not exceed 35 deg. C over 50 deg. C ambient. No current carrying part shall be less than 10 mm thick.

Clamps/connectors shall conform to type test as per IS:5561. Type Test reports shall also be submitted for following additional type tests :

a) Visual Corona Extinction Test
b) Radio Interference Voltage Measurement

Bidders are required to submit alongwith their bid typical drawings clearly indicating the above mentioned features of the line traps, line trap mounting arrangement and terminal connectors. For suspension mounted line traps, Bidder shall submit drawings showing single point as well as multipoint (normally 3 point) suspension arrangements.

12.2.5 COUPLING DEVICE

The coupling devices shall be interposed between the capacitor voltagetransformer and coaxial line to the PLC transmitter/receiver, and in conjunction with the capacitor voltage transformer shall ensure :

a) Efficient transmission of carrier frequency signals between the carrierfrequency connection and the power line.

b) Safety of personnel and protection of the low voltage parts and installation, against the effects of power frequency voltage and transient over voltages.

The coupling device, in conjunction with the CVT shall from an electric filter of band pass type :

a) It shall match characteristic impedance of H.T. line to impedance of the carrier frequency connection.

b) Galvanic isolation between primary and secondary terminals of the coupling device shall be performed by the above mentioned transformer.

c) Power frequency currents derived by the CVT may be drained to the earth by a separate inductance termed drain coil of suitable rating.

d) Voltage surges coming from the power line at the terminals of the coupling device shall be limited by a non-linear surge arrestor of suitable rating in the primary side. Requirement of a gas type voltage arrestor in secondary side of the coupling device shall have to be fully justified, but in any case the input circuit of PLC. equipment shall have protective devices in the form of zener diodes and surge suppressers.

   The surge arrester shall have power frequency spark over voltage coordinated with the equipment ahead of it.

e) For direct and efficient earthing of its primary terminals, the coupling device shall be equipped with an earthing switch. The Earth Switch shall be available for earthing of CVT-HT terminals, when the coupling filter units are removed from circuit for maintenance/ replacement. The design shall take due regard of requirements for safety in accordance with the Indian Electricity Rules.

Two numbers 'phase to earth' type coupling filters shall be used to achieve'phase to phase'/ 'inter-circuit coupling'. Connection between secondaries of the two phase to earth type coupling device shall be through a balancing transformer/hybrid such that reliable communication shall be ensured even when one of the coupled phase is earthed or open circuited on the line side.

Coupling device shall conform to IEC-60481 and shall have the following carrier frequency characteristics as applicable to a phase to earth type coupling device:

a)	Nominal line side impedance	i) 240 ohms for 765kV and 400 kV Quad/triple bundle conductor line. ii) 320 ohms for 400kV twin bundle conductor line. iii) 400 ohms for 220/132 kV line
b)	Nominal equipment (unbalanced)side impedance	75 ohms
c)	Composite loss	Not more than 2 dB
d)	Return Loss	Not less than 12 dB
e)	Bandwidth	Shall suit the frequency plan between 36 and 501 kHz
f)	Nominal peak	Not less than 650 Watt.envelope power(for Inter-modulation product 80 dB down)

The coupling device shall be suitable for outdoor mounting. Temperature ofmetallic equipment mounted outdoor is expected to rise upto 65 deg. C during the maximum ambient temperature of 50 deg. C specified. The equipment offered by the Bidder shall operate satisfactorily under these conditions.

The H.T. Terminal of coupling device shall be connected to H.F. Terminal of the CVT by means of 6 mm sq. copper wire with suitable lugs & taped with 11 kV insulation by the contractor.

Coupling device shall have at least two terminals for carrier equipment connection. Bidder shall confirm that such a parallel connection to coupling device directly will not result in any additional attenuation.

The coupling device including the drainage coil, surge arrester and earthing switch shall conform to type tests and shall be subject to routine tests as per IEC- 60481/IS:8998.

Routine tests shall include but not be limited to the following :

i) Composite loss and return loss tests on coupling device.

ii) Turns ratio test and insulation tests on the balancing transformer.

iii) Milli volt drop test, power frequency voltage test and mechanicaloperation test on earthing switch.

iv) Power frequency spark over test for lightning arrester as per relevantIS/IEC.

Reports for the following type tests on coupling device shall be submitted as perclause 9.2 of GTR .

1.)Return loss test.

2.)Composite loss test.

3.)Distortion and inter modulation test .

4.)Impulse voltage test.

5)Tests on Arrestors

Bidder shall furnish, alongwith his bid copies of all type and routine test conducted earlier on similar coupling device in accordance with relevant standards.

12.2.6 High Frequency Cable

High frequency cable shall connect the coupling device installed in the switchyardto the PLC terminal installed indoor.

The cable shall be steel armoured and its outer covering shall be protected against attack by termites. Bidder shall offer his comments on method employed by him for earthing of screen and submit full justification for the same with due regard to safety requirements.

Bidder must enclose in his bid a detailed construction drawing of the cable being offered, with mechanical and electrical parameters.

Impedance of the cable shall be such as to match the impedance of the PLC terminal on one side and to that of the coupling device on the other side over the entire carrier frequency range of 40-500 kHz.

Conductor resistance of cable shall not exceed 16 ohms per Km at 20°C.

The cable shall be designed to withstand test voltage of 4 kV between conductor and outer sheath for one minute.

Bidder shall specify attenuation per Km of the cable at various carrier frequencies in the range of 40 to 500 kHz. The typical attenuation figures for H.F. cable shall be in the range of 1 to 5 dB/km in the frequency range of 40-500 kHz.

The H.F. cable shall conform to type tests and be subjected to routine tests as per IS 11967(Part 2/Sec 1): 1989/IS 5026:1987.

All HF cables within the scope of this specification shall be laid and termination shall be carried out by the Contractor.

The cables shall be supplied wound on drums containing nominal length of 500 meters each. However, exact requirement of drum lengths shall be finalised during detailed engineering to avoid joint in HF cable and its wastage.

12.2.7 Power Line Carrier Terminal

As already indicated the information link shall be provided for speech, protection, telex and data services.

PLC terminal shall use Amplitude Modulation and shall have single side band transmission mode. These shall be equipped for fixed frequency duplex working.

Characteristic input and output parameters of the SSB PLC terminals shall be asper IEC-60495, unless otherwise specified.

The salient features are detailed out below :

a)	Mode of transmission	Amplitude Modulation single side band with suppressed carrier or reduced carrier.
b)	Carrier frequency	40 to 500 kHz range
c)	Nominal carrier frequency	4.0 kHz band in either direction of transmission
d)	Power output (PEP)	20/40/80 Wattat HF terminal
e)	Frequency difference VF between a pair of PLC Terminals	Frequency difference between a pair of signal at the transmitting and receiving ends will not exceed 2 Hz with suppressed carrier. With reduced carrier frequency difference shall be zero. This shall include permissible ambient temperature variation and supply frequency and voltage variation of (+) 15% and (-) 10%.
f)	Automatic gain control	For 40 dB change in carrier frequency signal level within the regulation range, change in VF receive levels of both speech and other signals shall be less than 1dB.
g)	Supply voltage	48 V DC + 15%, - 10%. (Positive pole earthed)

All the PLC terminals shall be of multipurpose type. The Bidder shall confirm that the total transmission time for teleprotection shall not exceed 20 ms for permissive and 30 ms for direct tripping signals. Speech and teleprotection channels shall independently fulfill the SNR requirements out of the power allocated to its channel from the total power of the PLC terminals.

Detailed calculation for SNR requirement and power allocation over differentchannels should be furnished alongwith the bid.

In the input circuit of the PLC terminal protective devices shall be provided in theform of zener diodes or surge suppressers in order to eliminate any surge transfer through the coupling device or the surge induced in the connecting path of H.F. cable.

To improve voice transmission characteristics for the system, compressors and expanders shall be provided. The companders shall have at least 2:1 compression ratio with a corresponding expansion ratio of 1:2. The operating range of compander shall be compatible with the audio power levels specified for 4 wire operation. The improvement gained by companders shall however not be taken into account for power allocation and shall be in-hand reserve.

Sudden changes in input level to the receiver shall not cause false tripping. The Bidder shall clearly indicate in his offer the methods adopted to ensure above phenomenon. The receiver design shall also provide protection against false tripping from random noise.

Fail-safe devices shall be provided, so that a malfunction in one unit or subassembly cannot cause damage elsewhere in the system. All plug-in equipment shall be fitted with features to prevent improper insertion. The electrical cables shall not be routed across sharp edges or near sources of high temperature. The adjustments, which are susceptible to misadjustment from accidental contact/vibration, shall be equipped with suitable locking devices.

The PLC set shall be designed to give guaranteed performance from 0 deg. C to50 deg. C ambient temperature. The thermal capability of the equipment shall be so designed that the equipment remains operational successfully upto 60 deg. C ambient temperature. Any ventilation fans provided for circulation of air insidethe cabinets shall conform to relevant Indian Standards.

The terminals shall be provided with built-in indicating instrument to facilitate checking of important voltages and current values and signal levels in different parts of the PLC Terminals. Protection fuses shall be provided in all important circuits and fuses shall be so mounted as allow their easy inspection and replacement. All test points shall be easily accessible.

The carrier set shall be provided with suitable supervision and alarm facilities. Individual parts of the carrier set should be accessible from front, making it possible to place the carrier cabinets side-by-side. All components and parts of thecarrier set shall be suitably tropicalised.

PLC terminals shall be housed in floor mounting sheet metal cabinets, suitable for mounting on concrete plinth as well as channel frame by means of nuts and bolts or welding. All the panels shall be properly earthed to the OWNER's earthing grid by the Contractor. Contractor shall submit detailed drawings for earthing connections.

All the panels shall be protected against moisture ingress and corrosion during storage. Panels shall be properly dried before they are installed and energized

Bidder shall indicate measures adopted to prevent ingress of moisture duringoperation.

All cabinets having PLC terminals shall be provided with lamps of sufficient wattage for interior illumination with switch. Each panel shall be provided with 240 V AC single phase socket with switch to accept 5 & 15A standard Indian plugs.

A name plate shall be provided on the front door of each cabinet indicating channel function, transmitter frequency and direction etc.

Reports for the following type tests for PLC Terminals shall be submitted as perclause 9.2 of GTR .

Tests to determine various characteristics of PLC terminals as per IEC –60495.

a) Voltage variation

b) Carrier frequency range band.

c) Frequency accuracy

d) Transmit/Receive frequency difference.

e) Automatic gain control

f) Harmonic distortion

g) Selectivity

h) Output impedence, Return loss &Tapping

i) Return loss, Afinputs/Outputs

j) Balance to ground

k) Limiter action

l) Spurious emission

m) Carrier frequency levels and levels

n) Attenuation distortion

o) Noise generated within terminal

p) Near and far end cross talk

q) Group delay distortion

r) Conducted noise

s) Telephone signaling channel

t) Speech levels

u) Voltage withstand test

v) Insulation test

Heat Soaking of panels

All the solid state equipment/system panels shall be subjected to the Heat Soakingas per the following procedure :

All solid state equipment shall be burn-in for minimum of 120 hours continuously under operation condition. During the last 48 hours of testing, the ambient temperature of the test chamber shall be 50°C. Each PLC panel shall be complete with all associated sub-systems and the same shall be in operationduring the above test. During the last 48 hours of the above test, the temperature inside the panel shall be monitored with all the doors closed. The temperature of the panel interior shall not exceed 65°C.

12.2.8 SPEECH COMMUNICATION

PLC equipment offered shall provide telephone communication between the stations where the transmission lines are terminating. The equipment shall be suitable for providing the following facilities:

a) It shall be possible for subscriber at any of the stations to contact the subscriber at all other stations connected in the system as shown in the specification drawing by dialing his call number. To achieve this a 24lines EPAX with 4 wire interface & remote subscriber units shall beprovided/available at different stations.
b) The equipment shall contain all normal facilities like ring back tone, dial tone, engage tone & priority tone, and suitable pulses to establish and disconnect communication between subscribers.
c) The equipment shall be provided with necessary alarm circuits and fuses etc.
d) The equipment shall be of 4 kHz bandwidth on either direction and be suitable for providing superimposed data and teleprinter facilities at a laterdate without major modifications and high cost. The Bidder shall clearly indicate in his bid the provision made in his proposal for future development and the extent to which such additional facilities can be added at a later date.
e) The system shall be completely automatic with definite number allocated for each telephone. The numbering scheme for telephones, exchange and tie lines shall be developed by the Bidder and indicated in the bid. Final numbering scheme shall be fully coordinated with the existing/ proposed future systems by the Contractor.
f) Arrangement for over-riding facilities shall be provided by means of priority keys wherever specified. The over-riding facility shall enable cutting-in ongoing calls with the priority key and ask the concerned partiesto finish their conversation. The wanted number should then get automatically connected without having to redial the number.
g) All the carrier telephone conversations shall be secret and it should not be possible for anybody to over hear the conversation going on between any two parties excepting those provided with over-riding facilities.
h) The necessary cables for connecting all the telephone instruments ordered for at each sub-station (including wiring and termination) shall be provided by the Contractor. These telephone

instruments shall be located within control room building at respective sub-station.

i) The cabinets housing the equipment for EPAX, four wire E/M interface & remote subscriber units (four wire) shall have mounting arrangement similar to that for PLC terminals.
j) All the terminals for speech shall be with Transit Band Pass Filter suitable for tuning at site and shall be wired for addition of VFTs in future.
k) Equipment for speech communication must be fully compatible with OWNER's existing equipment. Any interfaces required for proper matching and connection with the OWNER's existing equipment shall be provided by the Contractor.
l) Terminals for protection shall be suitable for speech between two ends of each transmission line or on tandem operation basis with back to back connection at the intermediate stations.
m) Each PLC terminal for speech as well as protection purposes shall be provided with a plug-in type service telephone and buzzer. Further, 4 wire remote telephone instruments (parallel to service telephone) shall also be provided on one PLC terminal for protection for each link. These instruments shall be located in respective Switchyard control room to enable the operator to make emergency calls on point-to-point basis. Each such instrument shall be equipped with a buzzer and 'press-to-call' key and shall not require any additional power supply units.

12.2.9 Electronic Private Automatic Exchange (EPAX)

The 24 line Electronic Private Automatic Exchange (EPAX) wherever specified shall be connected to minimum six trunk routes thorough PLCC channels (speech panel) with Four-wire E/M' interface unit. This 4-wire interface unit either shall form an integral part of the 'EPAX' system or be suitable for mounting/housing in the carrier panel. The exchange will have its own ringing current and tone generator etc. The exchange shall be suitable for working on 48 V DC Power Supply (positive pole earthed).

The exchange shall be fully automatic, solid state, and of modular construction and shall have multiple switching routes (minimum 4-routes).

'EPAX' shall also be provided with two (2) additional interface units and operate exclusively with OWNER's leased subscriber lines, of Department of Telecommunication (DOT) and compatible with 2 wire full duplex, voice grade mode of operation.

The details of communication protocol, for interfacing of the 'DOT' leased lines, shall be coordinated by the Contractor, with the licensing authority (DOT).

12.2.10 Remote End Four Wire 'E/M' Interface & Subscriber Unit or Equivalent EPAX (4x4)

The remote end four wire 'E/M' interface & subscriber units, wherever specified, shall be of electronic type and be suitable for working on fixed frequency power line carrier systems with E & M signaling. This shall be housed in the carrier set and be fully wired to the power line carrier terminal equipment.

This unit shall receive and register various signals, on PLCC Channels, from remote end exchanges or other remote end subscriber units and associated four wire interface unit.

The four wire interface unit shall be equipped for routing transit calls and shall be supplied pre-wired to handle calls for minimum eight directions, in a form suitable for transmission over PLCC.

The bidder shall also indicate the total number of trunk-line capacity, available with each four-wire

interface unit.

The unit shall be suitable for connecting two-wire telephone sets. Further, the associated telephone cables for locating two subscriber lines, within the control room is in the scope of this specification.

12.2.11 Network Protection Equipment (Protection Coupler)

The Bidder shall offer voice frequency transmission equipment which shall work on frequency shift or coded signal principle for transmission/reception of protection signals as single purpose channel. The equipment shall be suitable for connection to the power line carrier terminal.

The voice frequency transmission equipment shall not only be insensitive to corona noise but shall also remain unaffected by impulse type noise which are generated by electrical discharge and by the opening and closing of circuit breakers, isolators, earthing switches etc. The equipment shall also be made immune to a field strength of 10V/m expected to be caused by portable radio transmitters in the range of 20-1000 MHz. In his offer, bidder shall clearly explain as to what measures have been taken to make the equipment insensitive to corona noise, white noise and to impulse noise of an amplitude larger than the wanted signal and submit full field test and laboratory test reports. The guarantee on design data shall not be acceptable.

The equipment shall be unaffected by spurious tripping signals. The Bidder shall submit proof as to how this is achieved satisfactorily.

The equipment shall be suitable for transmission of direct and permissive trip signal as well as blocking signals for protective gear of power system. The equipment shall be operated in the audio frequency range in speech band or above speech band as superimposed channel in 4 kHz band of SSB carrier. The equipment shall operate with full duplex frequency shift mode of operation or by switching between two frequencies in case of coded signals . The protection signaling equipment shall be of solid state design, modular in construction and have a proven operating record in similar application over EHV systems. Details regarding application of the equipment over 765kV/400kV/220kV systems shall be submitted along with the bid. Each protection signaling equipment shall provide:

i) Transmission facilities for minimum three protection signals.

ii) Reception facilities for minimum three protection signals.

The equipment shall be designed for remote tripping/ blocking on permissive basis and direct tripping for reactor fault and others. The overall time of PLC,

VFT and transmission path for permissive trip/blocking shall be 20 m. Sec. or less and for direct tripping 30 m. Sec. or less even for the longest line section.

Operating time lower than specified above may be preferred provided they fulfill the requirements of security and reliability as mentioned below :

False - trip probability 1 0^{-5} (Noise burst of any amplitude)

Fail to trip probability 10^{-2} for S/N 6 dB in 3.1 kHz Band(white Noise Measurement)

It may be emphasized that specified time, as mentioned above is composed of the following :

a) Back-to-back signal delay in frequency shift or coded signals protectionequipment.

b) Back-to-back delay in PLC terminal.

c) Delay in transmission line.

d) Operation time of interposing relay, if any, in frequency shift or codingequipment.

Reference is invited in this regard to the guide lines expressed in CIGREPublication "Teleprotection" report by Committee 34 and 35.

The following transfer criteria shall be provided by the equipment:

a) Transmit side

One number potential free NO (normally open) contact of protective relays (To be supplied by the OWNER) of under noted rating for each of the following functions:

i) Permissive trip command

ii) Direct trip commandContact Rating:

Maximum voltage	: 660 Volts
Maximum current rating	: 5 amps
Maximum power rating	: 1250 W/VA

b) Receive Side

Voice frequency transmission equipment for network protection shall be provided with one potential free NO (normally open) contact of the under noted rating for each of the following functions:

i) Permissive trip command

ii) Direct trip commandContact Rating:

Rated voltage	:250 Volts DC
Rated current	:0.1 A DC
Other Parameters	:As per IEC-60255-25

c) Alarm

In addition, the voice frequency protection terminal shall provide at least one number potential free change over contact of the following rating for alarm purposes.

Rated voltage	:	250 volts DC
Rated current	:	0.1 A DC
Other Parameters	:	As per IEC-60255-25

The Contractor shall submit drawings showing inter-connection between PLCC and protection panels

for approval by the OWNER.

It has to be ensured that under no circumstances protection channel should share the power. Each protection channel shall be able to transmit power for which system is designed. For example, a 40 W PLC terminal shall transmit 40 Watt (max.) for protection channel alone in the event of fault. Speech and super-imposed data channels, in the same protection terminal must get disconnected momentarily during the operation of protection channels.

The equipment shall be constructed such that in permissive line protection system, operational reliability of the protection channel may be checked over the carrier link by means of a loop test. It shall be possible to carry out the above test from either end of the carrier link. During healthy condition of the transmission line,the loop test shall not initiate a tripping command. In the event of a system fault, while loop test is in progress, protection signal shall over-ride the test signal.

The equipment shall be complete with built in counters for counting the numberof trip commands sent and number of trip commands received.

Reports for the following tests as per clause 9.2 of GTR shall be submitted forapproval for protection coupler and the relays associated with PLCC equipmentfor network protection signaling equipment and interface unit with protective relay units if any :

1) Protection coupler (As per IEC 60834 -1)

   a) Power supply variation

   b) Power supply interruption

   c) Reflected noise

   d) Reverse polarity

   e) Interference by discrete frequency

   f) Transmission time

   g) Interference by frequency deviation. (Wherever applicable)

   h) Alarm function

   i) Security

   j) Dependability

   k) Voltage withstand test

   l) Insulation test.

   m) Electrical fast transient test (along with carrier terminal)

   n) HF disturbance test (along with carrier terminal)

o) Electro static discharge test (along with carrier terminal)

p) Radiated electromagnetic field susceptibility test (along with carrier terminal)

q) Environment test (as per IS 9000)

2) Relays.

a) Impulse voltage withstand test as per Clause 5.1 of IS:8686 (for atest voltage appropriate to Class III as per Clause 3.2 of IS:8686).

b) High Frequency Disturbance test as per Clause 5.2 of IS:8686 (fora test voltage appropriate to Class III as per Clause 3.2 of IS:8686).

12.2.12 Mandatory Testing & Maintenance Equipment

Print testing kit for PLCC terminal, E/M interface & subscriber unit, Protection coupler & EPAX - comprising of following items of reputed make in addition to any other special items required for testing and maintenance of this equipment packed in a carrying brief case:

1. Screw driver set with multi up fixing feature
2. Nose pliers
3. Cutting pliers
4. Ordinary Pliers
5. Adjustable wrench
6. Soldering iron with tip earthed operated with isolated (step down) transformer having provision forinterchangeable taps

   a) 150 watts -1 No.

   b) 35 Watts - 1 No

   c) 10 watts - 1 No.

.

7. Desoldering pump
8. Print extender
9. Print puller
10. Large selection of test leads
11. Solder wire
12. Large selection of plugs, jacks & pistol probes compatible with equipmentsupplied

13. Dummy load

14. Interface card/print for Tx to Rx loop-back

15. Test oscillator/tone generator with indicating meters - either built in orseparate

16. ESD wrist band

17. ESD conducting mat

12.2.13 LIST OF COMMISSIONING TESTS

The following tests shall be carried out on complete system/subsystem duringcommissioning:

1. Composite loss and return loss on coupling device using dummy load.

2. Composite loss (Attenuation) for HF Cable coupling device.

3. End to end attenuation measurement for verification of optimum couplingmode. Test shall be done for all combinations.

4. End to end return loss for optimum coupling mode.

   a. open behind line trap.

   b. grounded behind line trap.

5. If end to end return loss for optimum coupling mode is not satisfactory,same shall be measured for other coupling modes also.

6. Adjustment of Tx/Rx levels on PLCC equipment as per test schedule.

7. AF frequency response (end to end) for the entire 4 kHz Bandwidth forspeech and teleoperation channels.

8. Measurement of noise in 2 kHZ bandwidth with and without line energised.
9. SNR (test-one) with line energised noting down weather conditions.

10. Transmission time for teleprotection and other data channels.

11. Observation of Tx/Rx levels (test-tone) for each channel at both ends by sequential switching on/off parallel channels using dummy load and also with the transmission line.

12. Observation of end to end and trunk dialing performance.

13. Observation of end-to-end protection signaling (command sent & received) in conjunction with protective relays, noting down transmission/receipt of unwanted commands under switching operations inthe switchyard during protective relay testing.

Notes

1. All measurements for link attenuation, composite loss and return loss shallbe carried out for the entire range of carrier frequencies with specific attention to the frequencies.

   i. within coupling device bandwidth.

   ii. within line trap bandwidth, and

   iii. operating frequencies.

Following tests shall be carried out independently at each and

   i. Composite loss & return loss for coupling device.

   ii. Attenuation test for HF cable + coupling device.

   iii. Levels and other local adjustments (on dummy load).Final adjustment shall be on end to end basis.

   iv. Test for loading by parallel channels with dummy load. This test can be done alongwith tests for coupling device.

   v. Protection signaling under local loop test (dummy load).

2. Necessary test instruments required for all the above tests shall be brought by commissioning engineers of the contractor.

12.2.14 TECHNICAL PARTICULARS FOR MODULAR COUPLING DEVICE

TABLE-II		
Sl No	**Description**	**COUPLIND DEVICE**
1	Carrier Frequency Range	78-500 kHz
2	Maximum temperature limit for satisfactory operation of coupling device mounted outdoor	65^0 C
3	Composite loss	≤ 1 dB
4	Return loss	≥ 12 dB
5	Nominal line side impedance	240/320 ohms (Phase to earth)
6	Nominal carrier equipment side impedance	75ohms unbalanced and 150 ohm balanced
7	Nominal Peak Envelop power with Distortion and Inter-modulation Products 80 dB Down)	1000 watts for frequency≥100 kHz
8	Power frequency Impedance between primary terminal and Earth Terminals of	Less than 20 ohm

	Coupling Device	
9	Maximum number of PLC terminals that can be connected in parallel	
	(a) 20 W (P.E.P) PLC Terminals	(a) 8 to 12 nos.
	(b)40 W (P.E.P.) PLC Terminals	(b) 6 to 8 nos.
	(c) 100 W (P.E.P.) PLC Terminals	(c) 4 to 6 nos.
10	1 Minute Power Frequency Insulation level between Primary and Secondary Terminals of Coupling Device	10 KV rms
11	Impulse (1.2/50 micro-sec) withstand level between Primary and Secondary Terminals of Coupling Device	10 kV peak
12	Drainage Coil :	
13	(a) Inductance	0.2 to 0.7 mH
	(b) Continuous power frequency current	≤ 1.5 Arms
	(c) Short time rating for 0.2 sec	≤ 50 A
14	Lighting Arrestor :	
15	(a) Type of construction	Non linear resistor type with spark gap
	(b) Rated Voltage	660 V
	(c) Rated discharge current	5 KA_{peak}
	(d) Maximum permissible short time current	30 kA peak
	(e) Impulse spark over voltage (max)	3300 V_{peak}
16	Earthing Switch	
	(a) Rated Current	300 A_{rms}
	(b) Rated Voltage	10kV
	(c) Short time current	16 kA, 1 sec

SECTION 13

TECHNICAL SPECIFICATIONS OF BAY MARSHALLING KIOSK

13.1.0 BAY MARSHALLING KIOSK

(One) number of bay marshalling **kiosk** shall be **provided for each 220 kV bay** under present scope. In addition to the requirements specified elsewhere in the specification, the bay marshalling kiosk shall have two distinct compartments for the following purpose: -

(i) Incoming: To receive **2(two)** incoming 415V, 3 phase, 63Amps, AC supply with auto changeover and MCB unit and

(ii) Outgoing:

(a) To distribute **4(four)** outgoing 415V, 16 Amps 3 phase AC supplies to be controlled by MCB.

(b) To distribute **3(three)** outgoing 240V, 16 Amps single phase supplies to be controlled by MCB.

(c) To distribute **3(three)** outgoing 240V, 10 Amps single phase supplies to be controlled by MCB

13.1.1 The steel sheet thickness of BMK shall be minimum 3.15 mm and painting shall be as per Clause 2.15.0.

13.1.2 The BM shall be protective Class of IP 55.

13.1.3 The BMK shall have a minimum of 700 mm clearance to switchyard floor.

SECTION 14

TECHNICAL SPECIFICIATIONS FOR PAINTING

14.1.0 PAINITNG

14.1.1 All surfaces of ferrous materials used for construction of outdoor equipment and enclosures such as instrumenttransformer main tanks and equipment, marshalling boxes, kiosk, operating boxes, metallicenclosures etc. shallbe cleaned and painted as given below if not specified otherwise in respectiveSections.

The quality of paint such that its colour should not fade even if it is exposed to temperature up to 1200 degree C.

Description	Surface preparation	Primer coat	Intermediate undercoat	Finish coat	DFT	Colour Shade
CT & PT Main tanks of CT, PT and other oil filled equipment, etc. (External surface)	Shot Blast cleaning Sa 2½ (ISO 8501-1)	Epoxy base zinc primer (30-40 mm)	Epoxy high build micaceous iron oxide (75 mm)	Aliphatic Polyurethane 2 coats (25 mm/coat)	Minimum 155 mm	Shade No. 631 of IS:5
do (Internal surfaces)	Shot Blast cleaning Sa 2½ (ISO 8501-1)	Hot oil resistant, non-corrosive varnish or paint or epoxy			Minimum 30 mm	Glossy white or paint
Marshalling boxes, operating	Chemical/Shot Blast cleaning Sa	Epoxy base zinc primer (30-40 mm)				

14.1.2 All paints shall be carefully selected to withstand heat, rain and extremes of weather. The paint shall not scale off or crinkle or be removed by abrasion due to normal handling.

14.1.3 In case finish paint chips off or crinkle during transit or installation, the contractor shall arrange for repainting transformer at site at his cost. The paint for repainting/touch up shall be supplied by the contractor.

14.1.4 The paint work done shall be guaranteed for a minimum period of 5 years from the date of receipt of the equipment.

14.1.5 1(One) coat of additional paint to the exposed exterior surfaces shall be given at site prior to commissioning in presence of the Employer's representative.

SECTION 15

TECHNICAL SPECIFICATION FOR CONSTRUCTION WORKS IN SUBSTATIONS

15.1.0 GENERAL

15.1.1 The intent of this Section of the Specification is to cover requirements which are to be followed in construction of switchyards including civil works in the switchyard.

15.1.2 *The work shall be generally carried out as per approved drawings.*

15.1.3 *The Contractor shall be required to prepare his own drawings based on project with modifications as and if required and shall submit those for Employer's scrutiny*.

15.2.0 SURFACE PREPARATION AND STONE SPREADING

15.2.1 Before taking up PCC base (pro-1:4:8) and stone filling at the location in the construction site, the area shall be thoroughly de-weeded including removal of roots as directed by the Engineer-in-Charge.

15.2.2 After all the structures, equipment & earthing system are erected and after construction of cable trenches, the surface of the switchyard area shall be maintained, rolled/ compacted to the lines and grades as decided by Engineer-in-Charge. De-weeding including removal of roots shall be done before rolling is commenced. Engineer-in-Charge shall decide final formation level so as to ensure that the site appears uniform devoid of undulations. The final formation level shall however be very close to the formation level indicated in the drawing using half ton roller with suitable water sprinkling arrangement to form a smooth and compact surface.

15.2.3 A base layer of PCC of 80 mm thickness with proportion of 1:4:8 shall be provided before spreading of crushed rocks. PCC base shall be done in panels of 4 m x 4 m with expansion gap of 25 mm between panels. The gap shall be filled with bitumen. Each panel shall be provided with four (4) numbers of PVC pipes (per panel) of 100 mm dia of length 450 mm for soaking of water. The pipes will be provided with gratings at the top and the same will be flushed with the PCC top.

15.2.4 Over the PCC layer, a surface course of minimum 100mm thickness of 20mm nominal size river pebbles or (single size ungraded) broken stone shall be spread.

15.3.0 CABLE TRENCHES AND CABLE TRAYS

15.3.1 Construction of cable trenches with pre-cast removal R.C.C cover (with lifting arrangement) as per drawings supplied with the Bid Documents shall be carried out by the Contractor.

15.3.2 The Contractor shall provide embedded steel plates of adequate size on the walls of concrete cable trench for supports for cable trays. Insert plates will be provided at an interval of 2000mm.

15.3.3 If asked for, the cable trench walls shall be designed for following loads: -

15.3.3.1 Dead load of 155 kg/M length of cable support (tray) + 75 kg on one tier at the end.

15.3.3.2 Triangular earth pressure + uniform surcharge pressure of 2T/m2.

15.3.4 RCC cable trench cover shall be designed for self-weight of slab + UDL of 2000 kg/m2 + a concentrated load of 200 kg at center of span on each slab panel.

15.3.5 Cable trench inside the Control Room shall be covered with 6 mm thick chequered plates with lifting arrangement.

15.3.6 Cable trench crossing the road/rails shall be designed for class AA. Loading of IRC/relevant IS Code and should be checked for transformer loading.

15.3.7 Trenches shall be drained. Necessary sumps be constructed and sump pumps if necessary, shall be supplied. Cable trenches shall not be used as storm water drains.

15.3.8 All metal parts inside the trench shall be connected to the earthing system.

15.3.9 Cables from trench to equipment shall run in hard conduit pipes.

15.3.10 Trench wall shall not foul with the foundation. Suitable clear gap shall be provided.

15.3.11 The trench bed shall have a slope of 1/500 along the run and 1/250 perpendicular to the run.

15.3.12 All the construction joints of cable trenches i.e., between base slab to base slab and the junction of vertical wall to base slab as well as from vertical wall to wall and all the expansion joints shall be provided with approved quality PVC water stops of approx. 230 x 5 mm size for those sections where the ground water table is expected to rise above the junction of base slab and vertical wall of cable trenches.

15.3.13 Cable trenches shall be blocked at the ends if required with brick masonry in cement sand mortar 1:6 and plaster with 12 mm thick 1:6 cement sand mortar.

15.3.14 Cable Trays

(i). The cable trays shall be of G.S. sheet and minimum thickness of sheet shall be 2 mm.

(ii). The Contractor shall perform all tests and inspection to ensure that material and workmanship are according to the relevant standards. Contractor shall have to demonstrate all tests as per specification and equipment shall comply with all requirements of the specification.

a) Test for galvanising (Acceptance Test)

The test shall be done as per approved standards.

b) Deflection Test: (Type Test)

A 2.5 metre straight section of 300mm, wide cable tray shall be simply supported at two ends. A uniform distributed load of 76 kg/m shall be applied along the length of the tray. The maximum deflection at the mid-span shall not exceed 7mm.

15.4.0 FOUNDATION AND RCC CONSTRUCTION

15.4.1 General

15.4.1.1 Work covered under this Clause of the Specification comprises the design and construction of foundations and other RCC constructions for switchyard structures, equipment supports, trenches, drains, jacking pad, control cubicles, bus supports, transformer, marshalling kiosks, auxiliary equipment and systems, buildings, tanks, boundary wall or for any other equipment or service and any other foundation required to complete the work.

15.4.1.2 Concrete shall conform to the requirements mentioned in IS: 456 and all the tests shall be conducted as per relevant Indian Standard Codes as mentioned in Standard field quality plan appended with the specification.

A minimum grade of M20 concrete shall be used for all structural/load bearing members as per latest IS 456.

15.4.1.3 If the site is sloppy, the foundation height will be adjusted to maintain the exact level of the top of the structures to compensate for such slopes.

15.4.1.4 The switchyard foundation's plinths and building plinths shall be minimum 300 mm and 500 mm above finished ground level respectively.

15.4.1.5 Minimum 75 mm thick lean concrete (1:4:8) shall be provided below all underground structures, foundations, trenches, etc., to provide a base for construction.

15.4.1.6 Concrete made with Portland slag cement shall be carefully cured and special importance shall be given during the placing of concrete and removal of shuttering.

15.4.1.7 The design and detailing of foundations shall be done based on the approved soil data and subsoil conditions as well as for all possible critical loads and the combinations thereof. The Spread footings foundation or pile foundation as may be required based on soil/sub-soil conditions and superimposed loads shall be provided.

15.4.1.8 If pile foundations are adopted, the same shall be cast-in-situ driven/bored or pre cast or under reamed type as per relevant parts of IS Code 2911. Only RCC piles shall be provided. Suitability of the adopted pile foundations shall be justified by way of full design calculations. Detailed design calculations shall be submitted by the bidder showing complete details of piles/pile groups proposed to be used. Necessary initial load test shall also be carried out by the bidder at their cost to establish the piles design capacity. Only after the design capacity of piles has been established, the Contractor shall take up the job of piling. Routine tests for the piles shall also be conducted. All the work (design & testing) shall be planned in such a way that these shall not cause any delay in project completion.

15.4.2 Design

15.4.2.1 All foundation shall be of reinforced cement concrete. The design and construction of RCC structures shall be carried out as per IS: 456 and minimum grade of concrete shall be M-20.

Higher grade of concrete than specified above may be used at the discretion of Contractor without any additional financial implication to the Employer.

15.4.2.2 Limit state method of design shall be adopted unless specified otherwise in the specification.

15.4.2.3 For detailing of reinforcement IS: 2502 and SP: 34 shall be followed. Cold twisted deformed bars (Fe- 415 N/mm2) conforming to IS: 1786 shall be used as reinforcement. However, in specific areas, mild steel (Grade-I) conforming to IS: 432 can also be used. Two layers of reinforcement (on inner and outer face) shall be provided for wall and slab sections having thickness of 150 mm and above. Clear cover to reinforcement towards the earth face shall be minimum 40 mm.

15.4.2.4 RCC water retaining structures like storage tanks, etc., shall be designed as uncracked section in accordance with IS: 3370 (Part I to IV) by working stress method. However, water channels shall be designed as cracked section with limited steel stresses as per IS: 3370 (Part I to IV) by working stress
method.

15.4.2.5 The procedure used for the design of the foundations shall be the most critical loading

combination of the steel structure and or equipment and or superstructure and other conditions, which produces the maximum stresses in the foundation or the foundation component and as per the relevant IS Codes of foundation design. Detailed design calculations shall be submitted by the bidder showing complete details of piles/pile groups proposed to be used.

15.4.2.6 Design shall consider any sub-soil water pressure that may be encountered following relevant standard strictly.

15.4.2.7 Necessary protection to the foundation work, if required shall be provided to take care of any special requirements for aggressive alkaline soil, black cotton soil or any other type of soil which is detrimental/ harmful to the concrete foundations.

15.4.2.8 RCC columns shall be provided with rigid connection at the base.

15.4.2.9 All sub-structures shall be checked for sliding and overturning stability during both construction and operating conditions for various combinations of loads. Factors of safety for these cases shall be taken as mentioned in relevant IS Codes or as stipulated elsewhere in the Specifications. For checking against overturning, weight of soil vertically above footing shall be taken and inverted frustum of pyramid of earth on the foundation should not be considered.

15.4.2.10 Earth pressure for all underground structures shall be calculated using co-efficient of earth pressure at rest, co-efficient of active or passive earth pressure (whichever is applicable).
However, for the design of sub-structures of any underground enclosures, earth pressure at rest shall be considered.

15.4.2.11 In addition to earth pressure and ground water pressure etc., a surcharge load of 2T/Sq.m shall also be considered for the design of all underground structures including channels, sumps, tanks, trenches, sub-structure of any underground hollow enclosure, etc., for the vehicular traffic in the vicinity of the structure.

15.4.2.12 Following conditions shall be considered for the design of water tank in pumps house, channels, sumps, trenches and other underground structures:
15.4.2.12.1 Full water pressure from inside and no earth pressure and ground water pressure and surcharge pressure from outside (application only to structures, which are liable to be filled up with water or any other liquid).
15.4.2.12.2 Full earth pressure, surcharge pressure and ground water pressure from outside and no water pressure from inside.
15.4.2.12.3 Design shall also be checked against buoyancy due to the ground water during construction and maintenance stages. Minimum factor of safety of 1.5 against buoyancy shall be ensured ignoring the superimposed loadings.

15.4.2.13 The foundations shall be proportioned so that the estimated total and differential movements of the foundations are not greater than the movements that the structure or equipment is designed to accommodate.

15.4.2.14 The foundations of transformer and circuit breaker shall be of block type foundation. Minimum reinforcement shall be governed by IS: 2974 and IS: 456.

15.4.2.15 The tower and equipment foundations shall be checked for a factor of safety of 2.0 for normal condition and 1.50 for short circuit condition against sliding, overturning and pull out. The

same factors shall be used as partial safety factor overloads in limit state design also.

15.4.3 Admixtures & Additives

15.4.3.1 Only approved admixtures shall be used in the concrete for the Works. When more than one admixture is to be used, each admixture shall be batched in its own batch and added to the mixing water separately before discharging into the mixer. Admixtures shall be delivered in suitably labelled containers to enable identification.

15.4.3.2 Admixtures in concrete shall conform to IS: 9103. The water proofing cement additives shall conform to IS: 2645. Employer shall approve concrete Admixtures/Additives.

15.4.3.3 The Contractor may propose and the Employer may approve the use of a water-reducing set retarding admixture in some of the concrete. The use of such an admixture will not be approved to overcome problems associated with inadequate concrete plant capacity or improperly planned placing operations and shall only be approved as an aid to overcoming unusual circumstances and placing conditions.

15.4.3.4 The water reducing set-retarding admixture shall be an approved brand of Ligno- sulphonate type admixture.

15.4.3.5 The water proofing cement additives shall be used as required/advised by the Employer.

15.5.0 SUBMISSION

15.5.1 The following information shall be submitted for review and approval to the Employer as far as Civil Works are concerned:

15.5.1.1 Design criteria shall comprise the codes and standards used, applicable climatic data including wind loads, earthquake factors maximum and minimum temperatures applicable to the building locations, assumptions of dead and live loads, including equipment loads, impact factors, safety factors and other relevant information.

15.5.1.2 Structural design calculations and drawing (including constructions / fabrication) for all reinforced concrete and structural steel structures.

15.5.1.3 Any other data, drawings and information required to be submitted as per various clauses of the specification.

Approval of the above information shall be obtained before ordering materials or starting fabrication or construction as applicable

15.6.0 BUS BARS AND BUS BAR SUPPORTS

15.6.1 The bus bars shall be outdoor strung bus bars with ACSR conductor supported on lattic.

15.6.1.1 If asked for, the substation steel structures shall be designed as per ***Section-3*** of this specification.

SECTION 16

TECHNICAL SPECIFICATIONS FOR SUPPLY OF CONSTRUCTION MATERIALS

16.1.0 SUPPLY OF CONSTRCUTION MATERIALS BY THE CONTRACTOR

16.1.1 The contractor has to make his own arrangements for procurement, supply and use of construction materials like cement, M.S. rounds, H.B.G. metal and sand.

16.1.2 Cement

The contractor has to make his own arrangements for the procurement of cement to required specifications required for the work subjected to the follows:

16.1.2.1 The contractor shall procure cement (approved BSI marked of PPC of Grade 53), required for the works only from reputed cement factories (Main producer) acceptable to the Engineer-in-Charge. The contractor shall be required to be furnished to the Engineer in-Charge bills of payment and test certificates issued by the manufacturers to authenticate procurement of quality cement from the approved cement factory.

The contractor shall make his own arrangement for adequate storage of cement.

16.1.2.2 The contractor shall procure cement in standard packing of all 50 kg per bag from the authorized manufacturers. The contractor shall make necessary arrangement at his own cost to the satisfaction of Engineer-in-Charge for actual weighment of random sample from the available stock and shall conform with the specification laid down by the Indian Standard Institution or other standard foreign institutions laid down by the Indian Standard Institution or other standard foreign institutions as the case may be. Cement shall be got tested for all the tests as directed by Engineer-in-Charge at least one month in advance before the use of cement bags brought and kept on site Stores. Cement bags required for testing shall be supplied by the contractor free of cost. If the tests prove unsatisfactory, then the charges for cement will be borne by the Contractor.

16.1.2.3 The Contractor should store the cement of 60 days requirement at least one month in advance to ensure the quality of cement so brought to site and shall not remove the same without the written permission of the Engineer-in-Charge. The Contractor shall forthwith remove from the works area any cement that the Engineer-in-Charge may disallow for use, an account of failure to meet with required quality and standard.

16.1.2.4 The contractor shall further, at all times satisfy the Engineer-in-Charge on demand, by production of records and books or by submission of returns and other proofs as directed, that the cement is being used as tested and approved by Engineer-in-Charge for the purpose and the Contractor shall at all times, keep his records up to date to enable the Engineer-in-Charge to apply such checks as he may desire.

16.1.2.5 Cement which has been unduly long in storage with the contractor or alternatively has deteriorated due to inadequate storage and thus become unfit for use in the works will be rejected by the department and no claim will be entertained. The Contractor shall forthwith remove from the work area, any cement the Engineer-in-Charge may disallow for use on work and replace it by cement complying with the relevant Indian Standards.

16.1.3 Steel

The Contractor shall procure mild steel reinforcement bars, high yield strength deformed (HYSD) bars, rods and structural steel, etc., required for the works, only from the main or secondary producers manufacturing steel to the prescribed specifications of Bureau of Indian Standards or equivalent and licensed to affix ISI or other equivalent certification marks and acceptable to the Engineer-in-Charge. Necessary ISI list certificates are to be produced to Engineer-in-Charge before use on works. The unit weight and dimensions shall be as prescribed in the relevant Indian Standard specification for steel.

16.2.0 SUPPLY OF CONSTRCUTION MATERIALS BY THE EMPLOYER

16.2.1 As it is a single responsibility contract supply, and/or arrange all materials and services including construction and testing equipment to complete the works in all respects described in the specification, shall be under the scope of the Contractor unless otherwise specifically mentioned elsewhere in the bidding document.

16.3.0 MISCELLANEOUS GENERAL REQUIREMENTS

16.3.1 Dense concrete with controlled water cement ratio as per IS-code shall be used for all underground concrete structures such as pump-house, tanks, water retaining structures, cable and pipe trenches etc. for achieving water-tightness.

16.3.2 All joints including construction and expansion joints for the water retaining structures shall be made water tight by using PVC ribbed water stops with central bulb. However, kicker type (externally placed) PVC water stops shall be used for the base slab and in other areas where it is required to facilitate concreting.

The minimum thickness of PVC water stops shall be 5 mm and minimum width shall be 230 mm.

16.3.3 All steel sections and fabricated structures which are required to be transported on sea shall be provided with anti-corrosive paint to take care of sea worthiness.

16.3.4 A screed concrete layer not less than 100 mm thick and of grade not weaker than M10conforming to IS:456-1978 shall be provided below all water retaining structures. A sliding layer of bitumen paper or craft paper shall be provided over the screed layer to destroy the bond between the screed and the base slab concrete of the water retaining structures.

16.3.5 Bricks having minimum 75 kg/cm2 compressive strength can only be used for masonry work. Contractor shall ascertain himself at site regarding the availability of bricks of minimum 75kg/cm2 compressive strength before submitting his offer.

16.3.6 Angles 50 x 50 x 6 mm (minimum) with lugs shall be provided for edge protection all round cut outs/ openings in floor slab, edges of drains supporting grating covers, edges of RCC cable/pipe trenches supporting covers, edges of manholes supporting covers, supporting edges of manhole pre-cast cover and any other place where breakage of corners of concrete is expected.

16.3.7 Anti- termite chemical treatment shall be given to column pits, wall trenches, foundations of buildings, filling below the floors etc. as per IS: 6313 and other relevant Indian Standards.

16.3.8 Items/components of equipment/materials/components etc. not explicitly covered in the specification but required for completion of the project shall be deemed to be included in the scope.

SECTION-17

SPECIFICATION FOR DESIGN AND FABRICATIONOF SUBSTATION STEEL STRUCTURES

17.1.0 SCOPE

17.1.1 This section covers the design parameters and specification for fabrication and galvanizing, of steel structures, bolts & nuts, tower accessories etc. for Substations covered under this Bid Document.

17.2.0 MATERIALS

17.2.1 Structural Steel

The structures shall be of structural steel conforming to any of the grade, as appropriate, of IS 2062 (latest edition) Steel conforming IS 8500 may also be used.

Medium and high strength structural steels with known properties conforming to any other national or international standards may also be used.

17.3.0 Bolts

Bolts used shall conform to IS12427 or bolts of property class 4.6 conforming to IS 6639 may also be used.

High strength bolts, if used (only with steel conforming to IS 8500) shall conform to property class 8.8 of IS 3757.

Foundation Bolts shall conform to IS 5624. Step bolts shall conform to IS 10238

17.3.1 Nuts

Nuts shall conform to IS 1363 (Part 3). The mechanical properties shall conform to property class 4 or 5 as the case may be as specified in IS 1367 (Part 6) except that the proof stress for nuts of property class 5 shall be as given in IS 12427.

Nuts to be used with high strength bolts shall conform to IS 6623.

17.3.2 Washers

Washers shall conform to IS 2016. Heavy washers shall conform to IS 6610. Spring washers shall conform to type Bof IS 3663

Washers to be used with high strength bolts and nuts shall conform to IS 6649.

17.3.3 Galvanisation

Structural members, plain and heavy washers shall be galvanized in accordance with the provisions of IS 4759.

Spring washers shall be hot dip galvanized as per service grade 4 of IS 4759 or IS 1537.

17.3.4 Other Materials

Other materials used in the construction of the supporting structures shall conform to appropriate Indian Standards wherever available.

17.4.0 DESIGN PARAMETERS

17.4.1 Switchyard structures such as columns, beams and equipment mounting structures shall be designed as per drawing provided along with this bidding document.

Note: Structures with earth peak shall assume to have four earth wires for design purpose in normal condition.

17.4.2 Spans: -

Following Spans shall be considered in design of all structures as applicable: -

a). Line gantries (structures to terminate lines):

(i)For 33 KV Switchyard: 50 Meter, wind & weight span.

b). All other Structures

(i) For 33 KV Switchyard: 20 Meter, wind & weight span.

17.4.3 Deviation Angle

The design of line gantries shall only be checked for a maximum deviation angle of 300 from normal at centre of gantries to Dead End Tower.

For protection against direct lightning G.I. wires of size 7/3.66 mm conforming to IS 2241 shall be considered for all switch yards.

17.5.0 DESIGN DRAWINGS

17.5.1 The relevant drawings for all the towers, beams and equipment mounting structures shall be furnished by the CONTRACTOR to the Purchaser which shall include structural/fabrication drawings, Bill of Materials including nuts and bolts.

17.5.2 The structural drawings, Bill of materials and shop fabrication drawings for all the structures shall be submitted in four copies and will be finally approved by the Purchaser. The fabrication shall be taken up from the approved shop drawings.

The overall responsibility of fabricating structure members correctly lies with the CONTRACTOR only and the CONTRACTOR shall ensure that all the members can be fitted while erecting without any undue strain on them.

17.6.0 ACCESSORIES

17.6.1 Step Bolts

Each column/tower shall be provided with step bolts conforming to IS: 10238 of not less than 16mm diameter and 175mm long spaced not more than 450mm apart and extending from 2.5 meters above the ground level to the top. Each step bolt shall be provided with two nuts on one end to fasten the bolt securely to the tower and button head at the other end to prevent the feet from slipping away. The step bolts shall be capable of withstanding a vertical load not less than 1.5 KN.

17.6.2 Insulator Strings and Conductor Clamps Attachments

17.6.2.1 Single suspension and tension insulator string assemblies shall be used for stringing busbars. For the attachment of Suspension Insulator string, a suitable strain plate of sufficient thickness for transferring the load to the tower body shall be provided. To achieve requisite clearances, if the design calls for providing extra D-shackles, link plate etc. before connecting the insulator string the insulator string the same shall be supplied by the CONTRACTOR.

17.6.2.2 At tension points strain plates of suitable dimensions placed on the beams, shall be provided for taking the hooks or D-shackles of the tension insulator strings. To achieve requisite

clearances, if the design calls for providing extra D-shackles, link plate etc. before connecting the insulator string the same shall be supplied by the CONTRACTOR.

17.6.3 Earth wire Clamps Attachment

i. **Suspension Clamp**

The detailed drawing shall be submitted by the CONTRACTOR for Purchaser's approval. The CONTRACTOR shall also supply U- bolts, D-shackles wherever required.

ii. **Tension Clamps**

Earth-wire peaks of tension towers shall be provided with suitable plates to accommodate the shackle of tension clamps. The CONTRACTOR shall also supply the U-bolts wherever required and take Purchaser's approval for details of the attachments before the mass fabrication.

17.7.0 FABRICATION

17.7.1 The fabrication of substation steel structures shall be in conformity with the following:

17.7.1.1 Except where hereinafter modified, details of fabrication shall conform to IS: 802 (Part-II) or the relevant international standards.

17.7.1.2 The tower structures shall be accurately fabricated to connect together easily at site without any undue strain on the bolts.

17.7.1.3 No angle member shall have the two leg flanges brought together by closing the angle.

17.7.1.4 The diameter of the hole shall be equal to the diameter of bolt plus 1.5mm.

17.7.1.5 The structure shall be designed so that all parts shall be accessible for inspection and cleaning. Drain holes shall be provided at all points where pockets of depression are likely to hold water.

17.7.1.6 All identical parts shall be made strictly inter-changeable. All steel sections before any work are done on them shall be carefully levelled, straightened and made true to detailed drawings by methods which will not injure the materials so that when assembled, the adjacent matching surfaces are in close contact throughout. No rough edges shall be permitted in the entire structure.

17.7.1.7 Minimum Thickness of Tower Members shall be as follows: -

ITEM	***Minimum thickness in mm***
Leg members & main chords of beams in compression	5
Other members	4

17.7.2 Drilling and Punching

17.7.3 Before any cutting work is started, all steel sections shall be carefully strengthened and trued by pressure and not by hammering. They shall again be trued after being punched and drilled.

17.7.3.1 Holes for bolts shall be' drilled or punched with a jig but drilled holes shall he preferred. The punching may be adopted for thickness up to 16mm. Tolerances regarding punch holes are as follows:

17.7.3.1.1 Holes must be perfectly circular and no tolerances in this respect are permissible.

17.7.3.1.2 The maximum allowable difference in diameter of the holes on the two sides of plates or angle is 0.8mm. i.e. the allowable taper in punched holes should not exceed 0.8 mm on diameter.

17.7.3.1.3 Holes must be square with the plates or angles and have their walls parallel.

17.7.3.2 All burrs left by drills or punch shall be removed completely. When the tower members are in position the holes shall be truly opposite to each other. Drilling or reaming to enlarge holes shall not be permitted.

17.7.4 Erection mark

3.6.3.1 Each individual member shall have erection mark conforming to the component number given to it in the fabrication drawings. The mark shall be marked with marking dies of 16mm size before galvanizing and shall be legible after galvanizing.

17.8.0 GALVANIZING AND PAINTING

17.8.1 Galvanizing of the various members of the structures shall be done only after all works of sawing, shearing, drilling, filling, bending and matching are completed. Galvanizing shall be done by the hot dip process as recommended in IIS: 2629 or other such authoritative international standards and shall produce a smooth, clean and uniform coating of not less than 61 0 gm per square meter. The preparation for galvanizing and the galvanizing process itself must not affect adversely the mechanical properties of the treated materials. No manual Galvanization process will be accepted.

17.8.2 All assembly bolts shall be thoroughly hot dip galvanised after threading. Threads shall be of a depth sufficient to allow for the galvanized coating, which must not be excessive at the root of the threads, so that the nut shall turn easily on the completed bolts without excessive looseness. The nut threads shall not be galvanised, but oiled only.

17.8.3 The outside surface shall be galvanised. Sample of galvanised materials shall be supplied to the galvanised test set out in IIS 729 or other such authoritative international standards.

17.9.0 EARTHING

17.9.1 To keep provision in the structures for earthling, holes shall be drilled on two diagonal opposite legs of the towers/columns/mounting structures. The holes shall be suitable for bolting 65 mm X 1 2 mm GII strips and shall be such that the lower hole is about 350 mm above the ground level, clear of the concrete muffing, for connecting the earthling strip.

17.10.0 TEST AND TEST CERTFICATE

17.10.1 Each consignment ready for transportation shall be offered to ASEB for inspection before dispatch giving a minimum time of not less than 30 days. Samples of fabricated structure materials shall be subjected to following tests:

17.10.1.1 Steel: The structural steel shall conform to IS 226 and IS 8500, BS 4360-1068 or ISO / R 630 other such authoritative international standards. Manufacturer's test certificate shall be submitted for all used steel.

17.10.1.2 Galvanizing: The galvanizing shall be as per IS 2633 or BS 729 other such authoritative international standards. Zinc coating over the galvanized surfaces shall not be less than 610 gm per square meter.

17.10.1.3 Bolts and nuts: Manufacturer's test certificate as per standard practice shall be submitted.

17.11.0 TEST AT CONTRACTOR'S PREMISES

17.11.1 The CONTRACTOR shall fabricate one specimen structure of each type as soon as possible after placement of order and before starting the bulk fabrication of the structures ordered. It shall be assembled on a foundation as nearly similar as practicable to site and tested with suitable test loads as per specified broken wire condition, multiplied by the corresponding factor of safety to ensure that the design and fabrication complies with the requirements. Each structure shall be capable of withstanding the above-mentioned tests without any injury or any permanent deflection at any part. If any member is found to be weak or damaged the design

should be suitably modified and the tower re-tested.

17.11.1.1 After the first lot of the structures manufactured, the members forming one structure of each type shall be selected at random from the lots of similar members and assembled in exactly the same manner as to be done at site. The structure then shall be set on foundation as nearly similar as practicable to site and tested with equivalent test load for which the structure has been designed.

17.11.1.2 No structure or any member thereof, which failed under the test shall be supplied.

SECTION 18

TECHNICAL SPECIFICATIONS FOR ABT METERS

18.1.0 RECORDING METERS SAMAST (ABT COMPLIANT TRIVECTOR METERS)- shall be as per philosophy of CTUIL/ Grid India

18.2.0 Basic Features of Interface Energy Meters

a) The energy metering system specified herein shall be used for tariff metering for bulk, inter-utility power flows, in different States of India. Static composite meter shall be installed at interface points as a self-contained device for measurement of Voltage (V), Frequency (f), Active (Wh) and Reactive (VArh) energy exchanged in each successive 5 min time block. All meters shall be compliant to IS 15959 and its latest amendments.

b) Each meter shall have a unique identification code, which shall be marked permanently on its front, as well as in its memory. All meters supplied to as per this specification shall have their identification code starting with "IEM", whichshall not be used for any other supplies. "IEM" shall be an eight digit running serial number, further followed by "A" and "B" for the use with CT secondary of 1A and 5A respectively. This shall be mutually agreed between the buyer and the vendor. Note: The secondaries of all the CT cores will be 1A.

c) The meters shall be suitable for communication with external device like modem, DCU, etc. which shall be able to communicate with CDCS for local/remote data transfer. The meter shall compulsorily have at least 1 optical port for taking reading through Hand Held Unit (HHU).

d) Auxiliary Supply to IEM- The meters shall normally operate with the power drawn from DC auxiliary power supply (Range 110V to 220V DC) to reduce the Voltage Transformer (VT) burden. In addition, there shall be provision to operate the meter from the Voltage Transformer (VT) secondary circuit having a rated secondary line-to-line voltage of 110V, and current transformers (CTs) having a rated secondary current of 1 A or 5A. Any further transformers/ transactions/ transducers required for their functioning shall be in-built in the meters. Necessary isolation and/or suppression shall also be built-in, for protecting the meters from surges and voltage spikes that occur in the VT and CT circuits of extra high voltage switchyards. The reference frequency shall be 50Hz. Also, the meter shall have suitable tolerance (up to 15% either side) for DC supply.

e) The meters shall safely withstand the usual fluctuations arising during faults etc. In particular, VT secondary voltages 115% of Vref applied continuously and 190% of Vref for 3.0 seconds, and CT secondary current 150% of Iref applied continuously and 30 times of Iref applied for 0.5 seconds shall not cause any damage to or maloperation of the meters.

f) The meters shall continue to function for the remaining healthy phase(s), in case one or two phases of VT supply fails. In case of a complete VT supply failure, the computation of average frequency shall be done only for the period during which the VT supply was available in the 5-minute block. Any time block contraction or elongation for clock correctionshall also be duly accounted for.

g) The total burden imposed by a meter for measurement and operation shall be defined as per IS 14697. An automatic backup for continued operation of the meter's calendar-clock, and for retaining all data stored in its memory, shall be provided through a long-life battery, which shall be capable of supplying the required power for

at least 2 years. Themeters shall be supplied duly fitted with the batteries, which shall not require to be changed for at least 10 years, as long as total VT supply interruption does not exceed two years. The battery mounting shall be designed to facilitate easy battery replacement without affecting PCB of the meter.

h) The meters shall fully comply with all stipulations in IS 14697 except those specifically modified by this specification.The reference ambient temperature shall be 27°C.

i) Each meter shall have a test output device (visual), as per clause 6.11 of IS 14697.1999, for checking the accuracy of active energy (Wh) measurement. The preferred pulsing rate is twenty (20) per Wh for CT sec-1A and four (4) per Wh for CT sec –5A. It shall be possible to couple this device to suitable testing equipment also.

j) **Exception Management**- The three line-to-neutral voltage shall be continuously monitored and in case any of these falls below defined threshold (70% of Vref), meter shall have suitable indication on LED/ LCD. The meter shall also have provision for low voltage event logging in meter memory in case of any phase voltage going below a defined threshold. The time blocks in which such a voltage failure occurs/persists shall also be recorded in the meter's memory with a symbol "*" if 3 Phase RMS voltage applied to the IEM is in between 5% to 70% of Vref and if Voltage is less than 5% of Vref, meter should record Zero voltage symbol "Z".

k) **Time Accuracy** - Each meter shall have a built-in calendar and clock, having an accuracy of 10 seconds per month or better. The calendar and clock shall be correctly set at the manufacturer's works. The date (year-month-day) and time (hour-min.-sec.) shall be displayed on the meter front on demand. Meter shall have the intelligence to synchronize the time with GPS (Local GPS/CDCS GPS/ NAVIC) signal and from PC using software. Limited time synchronization through meter communication port shall be possible at site. When an advance or retard command is given, twelve subsequent time blocks shall be contracted or elongated by five seconds each. All clock corrections shall be registered in the meter's memory and suitably shown on print out of collected data.

l) A touch key or push button shall be provided on the meter front for switching on the display and for changing from one indication to the next. The display shall switch off automatically about one minute after the last operation of touch key/push button. When the display is switched on, the parameter last displayed shall be displayed again, duly updated.

m) The whole system shall be such as to provide a print out (both from the local PC, and from remote central computer) of the following format:

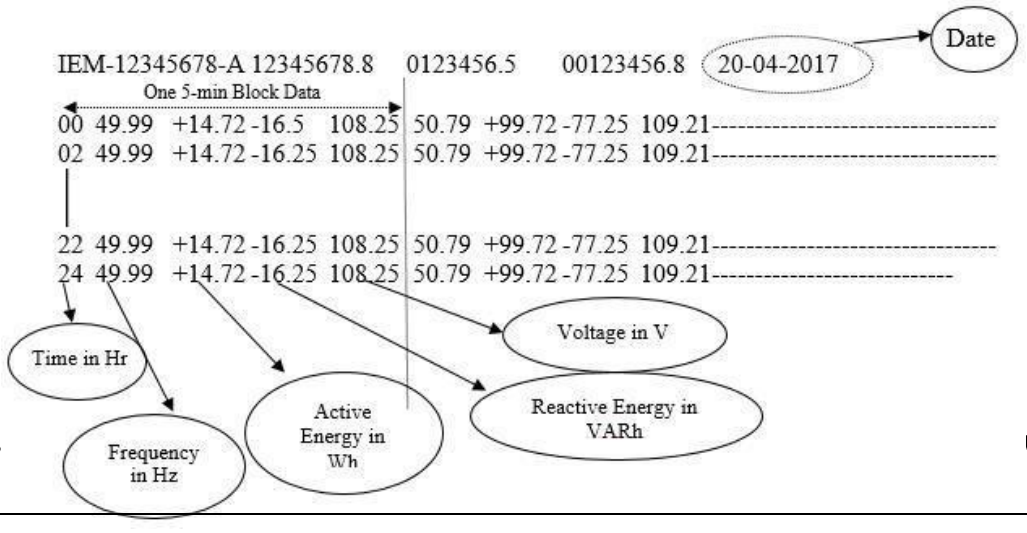


Figure 1: Standard Raw Data Format for IEM

There are 4 values in one 5 min time block. The first row shall contain the meter data for 2 hours, i.e., 24 time blocks, 00 hrs to 02:00 hrs. Similarly, the 2nd row shall contain the data for the next 2 hours and henceforth.

The above data shall be available in text file format (file extension as per IEEE standard/.txt) exportable to Excel. Indication of time retard or advance to be provided without disturbing the proposed format. Each 5-min block data consists of Frequency (in HZ), Active energy (in Wh), Reactive energy (in VARh) and Voltage (in V). All 5 minute Whand VARh figures in. NPC/output report shall be rounded off upto third decimal.

n) The portable hand held unit (HHU)/ Common meter reading instrument (CMRI)/ Data Collecting Device (DCD) shall be having IS-15959:2011 compatibility for standardized parameters. The optical coupler for tapping data stored in the SEMs memory shall be compatible universally across different make of SEMs.

18.3.0 Constructional Features

18.3.1.1 The meters shall be supplied housed in compact and sturdy, metallic or moulded cases of non-rusting construction and/or finish. The cases shall be designed for simple mounting on a plane, vertical surface such as a control/relaypanel front. All terminals for CT and VT connections shall be arranged in a row along the meter's lower side. Terminals shall have a suitable construction with barriers and cover, to provide a secure and safe connection of CTs and VTs leads through stranded copper conductors of 2.5 sq. mm. size.

18.3.1.2 All meters of the same model shall be totally identical in all respects except for their unique identification codes. They shall also be properly sealed and tamper evident, with no possibility of any adjustment at site, except for transactions allowed in IS 15959.

18.3.1.3 The meters shall safely withstand, without any damage or mal operation, reasonable mechanical shocks, earthquake forces, ambient temperature variations, relative humidity etc. in accordance with IS-14697. They shall have an IP-51 category dust-tight construction, and shall be capable of satisfactory operation in an indoor, non-air conditioned installation.

18.3.1.4 Either the meters shall have built-in facility (e.g., test links in their terminals) for in-situ testing, or a separate test block shall be provided for each meter.

18.3.2 Measurement

i. The active energy (Wh) measurement shall be carried out on 3-phase, 4-wire principle, with an accuracy as per class 0.2S (IS 14697).
ii. The meter shall compute the net active energy (Wh) sent out from the substation bus bars during each successive 5 min block, and store it in its memory up to fourth decimal with plus sign if there is net Wh export and with a minus sign if there is net Wh import. Further Wh data in. NPC/output report shall be rounded upto third decimal.
iii. The meter shall count the number of cycles in VT output during each successive 5 min block, and divide the same by 300 (60 sec/min x 5min) to arrive at the average frequency. The frequency data shall be stored in the meter's memory in Hertz up to third decimal. Further Frequency data in. NPC/output report shall be rounded off upto second decimal.
iv. The meter shall continuously compute the average of the RMS values of the three line-to-neutral VT secondary voltages as a percentage of 63.51 V, and display the same on demand. The accuracy of the voltage measurement/computation shall be at least 0.5%, a better accuracy such as 0.2% in the 95-105% range being desirable. The voltage data shall be stored in the meter's memory in volts up to third decimal. Further voltage data in. NPC/output report shall be rounded off upto second decimal.

v. The Reactive energy (VARh) measurement shall be carried out on 3-phase, 4-wire principle, with an accuracy of 0.5S as specified in IS 14697. The meter shall compute the net Reactive energy (VARh) sent out from the substation bus bars during each successive 5 min block, and store it in its memory up to fourth decimal with plus sign if there is net VARh export and with a minus sign if there is net VARh import. It shall also display on demand the net VARh sent out during the previous 5 min block. Further VARh data in. NPC/output report shall be rounded off upto third decimal.

vi. The meter shall also integrate the reactive energy (VARh) algebraically into two separate registers, one for the period for which the average RMS voltage is above 103.0%, and the other for the period for which the average RMS voltage is below 97.0 %. The current reactive power (VAR), with a minus sign if negative, and cumulative reactive energy (VARh) readings of the two registers (>103% and <97%) shall be displayed on demand. The readings of the two registers at each midnight shall also be stored in the meter's memory. When reactive power is being sent out from substation bus bars, VAR display shall have a plus sign or no sign and VARh registers shall move forward. When reactive power flow is in the reverse direction, VAR display shall have negative sign and VARh registers shall move backwards. Generally, the standard PT ratios are 33kV/110V, 132kV/110V, 220 kV /110 V, 400 kV /110 V and 765 kV / 110 V. However, at the time of commissioning the vendor may confirm the same from site and configure the meter accordingly to ensure correct recording of reactive energy.

vii. For CT secondary rating of 5A, all computations, displays and memory storage shall be similar except that all figures shall be one fifth of the actual, worked out from CT and VT secondary quantities.

viii. Further, the meter shall continuously integrate and display on demand the net cumulative active energy sent out from the substation bus bars up to that time. The cumulative Wh reading at each midnight shall be stored in the meter's memory. The register shall move backwards when active power flows back to substation bus bars.

ix. Errors for different power factors shall be as defined in IS14697.

x. For reactive power (VAR) and reactive energy (VARh) measurements, IS14697 shall be complied with. The accuracy of measurement of reactive energy shall be as per class 0.5S.

xi. The harmonics shall be filtered out while measuring Wh, V and VARh, and only fundamental frequency quantities shall be measured/computed.

xii. Data security shall be ensured as per IS 15959 (three layers of security).

18.3.3 Memory/ Storage

i. Each meter shall have a non-volatile memory in which the following shall be automatically stored:

ii. Average frequency for each successive 5 min block, in Hertz up to third decimals.

iii. Net Wh transmittal during each successive 5 min block, up to fourth decimal, with plus sign if there is net Wh export and with a minus sign if there is net Wh import.

iv. Net VARh transmittal during each successive 5 min block, up to fourth decimal, with plus sign if there is net VARh export and with a minus sign if there is net MVARh import.

v. Cumulative Wh transmittal at each midnight, in eight digits including one decimal.

vi. Cumulative VARh transmittal for voltage high condition, at each midnight in eight digits including one decimal.

vii. Cumulative VARh transmittal for voltage low condition, at each midnight, in eight digits including one decimal.

viii. Average RMS voltage for each successive 5min block.

ix. Date and time blocks of failure of VT supply on any phase, as a star (*)/ (Z) mark.

x. The meters shall store all the above listed data in their memories for a period of fifteen (15) days. The data older than fifteen (15) days shall be erased automatically

xi. The software provided at CDCS, i.e., SLDC, will manage all functionalities of collection of data through DCUs, validate the data, store the data in a database, and manage the complete system. Software will also have a

scheduler for scheduling the task of collection of data periodically. The periodicity of data collection shall be user defined.

18.3.4 Display

Each meter shall have digital display for indication of the following (one at a time), on demand:

i. Meter serial no. and model: IEM12345678A or IEM12345678B
ii. Date (year month day /yyyy mm dd): 20160311 d
iii. Time (hour min sec /hh mm ss): 195527 t
iv. Cumulative Wh reading: 1234567.8 C
v. Average frequency of the previous block: 49.89 F
vi. Net Wh transmittal during the previous block: 28.75 E
vii. Net VARh transmittal during the previous block: 18.75 R
viii. Average % Voltage: 99.2 U
ix. Reactive power (VAR): 106.5 r
x. Voltage - high VARh register reading: 1234567.5 H
xi. Voltage - low VARh register reading: 1234567.4 L
xii. Low battery indication
xiii. The three line-to-neutral voltages shall be continuously monitored and in case any of these falls below 70 %, a preferably flashing three LEDs (one LED/phase) provided on meter's front shall become steady. They shall go off if all three voltages fall below 70 %. The LED shall automatically resume flashing when all VT secondary voltages are healthy again.
xiv. The two VARh registers (xv and xvi) shall remain stay-put while VT supply is unhealthy.

Any other better or more informative mechanism to display the above shall be preferred. The above shall be mutually agreed between the meter buyer and vendor.

Navigation keys to be provided at the meter front plate to navigate the display menu.

18.3.5 Communication

18.3.5.1 Each meter must have an optical port on its front for tapping all data stored in its memory through HHU. In addition to the above each meter shall also be provided with a RS-485, Ethernet and USB port on one of its sides, from where all the data stored in the meter's memory can also be transferred to CDCS (through DCU), local computer and external storage. The overall intention is to tap the data stored in the meter's memories at a scheduled time from any of the above mentioned ports or any other means and transmit the same to a remote central computer using suitable means of communication. It shall be possible to securely download the IEM data through an USB port via external storage thereby removing the requirement of a MRI (Meter Reading Instrument). It shall be ensured that data transfer through USB shall be unidirectional only i.e., from Meter to external storage device in an authentication process. Meter data shall be tamper-proof.

18.3.5.2 All meters shall be compatible with Optical port, RS-485 port, Ethernet port and USB / RS-232 port all together at a time and communicate independently. It shall also be possible to obtain a print out (hard copy) of all data collected from the meters, using the local PC. Data collection from any local laptop/PC shall be possible by installing data collection software. Entire project has to be based on Optic Fibre/GSM/4G/3G.

18.3.5.3 The Tenderer may design appropriate architecture for providing end to end metering solution. He is free to decide upon the best solution out of all the available options to ensure that data from all IEMs in ASSAM are

available atState Load Despatch Centre by the scheduled time. However, the entire responsibility of fully functional end to end metering system shall rest with the Tenderer in order to meet the performance levels as given in this document. The communication provider may adopt Optical Fibre/GSM/3G/4G communication technology or a combination of these technologies as per the site requirement adopting best available technology in the proposed area of implementation. The successful Tenderer shall be responsible for proper data exchange among IEM, DCU, CDCS, MDP and other operational/requisite software as part of fully functional metering system.

The operational testing of all the network elements has to be demonstrated by the Tenderer to the satisfaction of theutility.

18.3.5.4 The Tenderer shall provide the necessary software which would enable a local PC/ CDCS to:

i. Accept the data from the Optical/Ethernet/WAN and store it in its memory in user defined formats (text, csv, xls, etc.) in a user-defined file name (file name format must be ddmmyy substation name-utility name).
ii. Polling feature along with a task scheduler to run the data downloading software at a pre-designated date and time repeatedly or by manually selecting a meter. File naming for such downloaded data should also be in user-defined format. A detailed activity log shall also be available for each downloading operation.
iii. Upload/Import meter data (binary files) in the software for further processing. While uploading, there shall be provision to upload all selected files with single key-stroke.
iv. Convert the binary file(s) to text file(s). There should be provision to select multiple files based on filename, convert all selected files with single key-stroke and store the text files in the same location where binary files are stored.
v. Display the collected data on PC's screen in text format, with forward/backward rolling
vi. Print out in text format the data collected from one or more meters, starting from a certain date and time, as per
operator's instructions
vii. Transmit the collected data, in binary format, through an appropriate communication link to the central computer,
starting from a certain date and time, as per operator's instructions.
viii. Store the collected data in binary format, on a CD/Pen Drive. In addition to above, in general the software shall beable to convert IEMs data to existing format as well as in tabular (.csv) format as applicable.
ix. The above software shall further ensure that absolutely no tampering (except erasing of complete data with password protection) of the collected metering data is possible during its handling by the PC. The software shall be suitable for the commonly available PCs, (Windows) and shall be supplied to Owner in a compatible form to enableits easy loading into the PCs available (or to be installed by the Owner/others) at the various substations.
x. The Tenderer shall ensure data integrity checks on all metered data received from data collection systems.
xi. The quality of installation of the various equipment & power supply wiring to all field equipment shall be as per standards/ regulations/prevailing practices of the utility. The supply of electricity needed for operation and maintenance of entire Metering system shall be provided free of cost by the respective owners of the premises.

18.3.6 Climatic Condition

The meters to be supplied against this specification shall be required to operate satisfactorily and continuously under the following tropical conditions of hot, humid, dusty, rust and fungus prone environment.

Maximum ambient air temperature (°C)	55
Minimum ambient air temperature (°C)	(-) 5
Average Daily ambient air temperature (°C)	32
Maximum Relative Humidity (%)	95

Minimum Relative Humidity (%)	10
Maximum altitude above sea level (m)	1000
Average Annual Rainfall (mm)	1200
Maximum Wind Pressure (Kg/sq.m)	195
Isoceraunic Level (days per year)	50
Seismic Level (Horizontal Accn. In g)	0.3

18.3.7 Quality Assurance

The quality control procedure to be adopted during manufacturing of the specified equipment shall be mutually discussed and finalized in due course, generally based on the established and proven practices of the manufacturer. The software shall be user friendly which can be easily installed in any PC/Laptop irrespective of operating system of the PC/Laptop, and shall be certified for ensuring data handling capabilities. The same shall be demonstrated by the party during technical evaluation. During demonstration party shall bring standard meter. Thereafter software shall be offered for technical compatibility before taking up further necessary action in the procurement process.

18.3.8 Testing

18.3.8.1 All equipment, after final assembly and before dispatch from manufacturer's works, shall be duly tested to verify that is suitable for supply to the Owner. Routine and acceptance tests shall be carried out on the meters in line with IS 14697.

18.3.8.2 Any meter which fails to fully comply with the specification requirements shall be liable to be rejected by the Owner. However, the Owner may purchase such meters at a reduced price in case of marginal non-compliance, at his sole discretion.

18.3.8.3 Acceptance Tests for PC Software and data down loading using meter communication ports- All IEMs after final assembly and before despatch from Tenderer's/Manufacturer's works shall be duly tested to verify that they are suitable for downloading data using meter communication ports shall be subjected to the following acceptance test.

18.3.8.4 Downloading Meter Data from the Meter(s) to PC via optical port.

18.3.8.5 Downloading meter data through USB port and RS 232.

18.3.8.6 Downloading meter data to DCU/CDCS through Ethernet as well as RS 485 port.

18.3.8.7 Compatibility with PC Software.

18.3.8.8 Functioning of Time synchronisation, advance and retard time commands.

18.3.8.9 Per meter downloading time verification.

18.3.9 Copy of Certificate shall be submitted.

18.3.10 Type Tests

One (1) meter in a batch shall be subjected to the complete range of type tests as per IS14697 and IS15959, after final assembly. In case of any failure to pass all specified tests, the Tenderer shall arrange to carry out the requisite modifications/replacements in the entire lot of meters at his own cost. After any such modifications and final assembly, two (2) meters selected out of the lot by the Owner's representative shall be subjected to the full range of type tests. The lot shall be accepted by the Owner only after successful type testing.

The meters used for type testing shall be separately identified, duly marked, and supplied to the Owner in case they are fully functional and as good as other (new) meters, after necessary touching up/refurbishing. In case this is not possible, the Tenderer shall provide their replacements at no extra cost to Owner.

The Tenderer shall arrange all type testing specified above, and bear all expenses for the same. Copy of Test certificate shall be submitted to SLDC.

18.3.11 ANOMALY DETECTION FEATURES

18.3.11.1 The meter shall have features to detect and log the occurrence and restoration of following anomalies, along with

date and time of event: 6.1.1. Phase wise Missing Potential – The meter shall detect missing potential (1 or 2 phases) provided the line current is above a specified threshold. The voltage at that stage would be below a specified threshold.

18.3.11.2 Phase wise Current Circuit Reversal – The meter shall detect reversal of polarity provided the current terminals are reversed. This shall be recorded for 1 or 2 phase CT reversal.

18.3.11.3 Voltage Unbalance – The meter shall detect voltage unbalance if there is unbalance in voltages.

18.3.11.4 Current Unbalance – The meter shall detect current unbalance if there is unbalance in load conditions. Meter should ensure true system conditions before going for current unbalance checks.

18.3.11.5 CT Miss – The meter shall detect current miss if the current is below a defined threshold, provided the phase voltage is above a specified threshold. Snapshots of phase wise voltage, phase wise active current and phase wise powerfactor shall be provided with above specified anomaly events. Further, each meter module shall record the followingevents along with total duration:

18.3.11.6 Power On/Off – The meter shall detect power off if both the auxiliary supplies fail. The event shall be recorded on the next power up. At the same time power on event shall be recorded. No snapshot shall be logged with this event.

18.3.11.7 Feeder Supply Fail -This event shall be logged when feeder supply, i.e., all the voltages goes below certain threshold. No snapshot shall be logged with this event.

18.3.11.8 Last three hundred & fifty (350) events (occurrence + restoration), in total, shall be stored in the meter memory on first in first out basis.

18.3.11.9 There shall be five separate compartments for logging of different type of anomalies:

Compartment No. 1	100 events of missing potential
Compartment No. 2	100 events of CT reversal
Compartment No. 3	100 events of power failure/ Power on-off
Compartment No. 4	50 events of transaction related changes as per ICS Category B

18.3.11.10 Once one or more compartments have become full, the last anomaly event pertaining to the same compartment shall be entered and the earliest (first one) anomaly event should disappear. Thus, in this manner each succeeding anomaly event shall replace the earliest recorded event, compartment wise. Events of one compartment/ category should overwrite the events of their own compartment/ category only. In general persistence time of 5 min. for occurrence and restoration respectively need to be supported in meter.

18.3.11.11 Anomaly count should increase as per occurrence (not restoration) of anomaly events. Total no. of counts shall beprovided on BCS.

18.3.12 Installation and Commissioning

18.3.12.1 The Tenderer shall be responsible for total installation and commissioning of the meters (along with test blocks, if supplied separately) as per Owner's advice, including unpacking and inspection on receipt at site, mounting the meters on control and relay panels at an appropriate viewing height, connection of CT and VT circuits including any required rewiring, functional testing, commissioning and handing over. The Tenderer's personnel shall procure/carry the necessary tools, equipment, materials and consumables (including insulated wires, lugs, ferrules, hardware etc.)

18.3.12.2 As part of commissioning of DCDs the Tenderer shall load the software specified in clause 5(d) into the PCs at the respective substations, and fully commission the total meter reading scheme. He shall also impart the necessary instructions to substation engineers. At least 2-hour training session shall be arranged for substation staff and SLDCs. Also, an operating manual (pdf as well as hard copy) of the meter containing all

details of the meter, various data downloading features, etc. shall be made available at site and SLDC.

18.3.12.3 At the time of commissioning, the meters lying in stores shall be time synchronized through GPS signal before installation in the panel to avoid the large time mismatch.

8.12.12.1 The meter shall be supplied with latest/compatible software (shall be compatible with old & new meters data download handling). Any new software as required to be installed within warranty period are to be done by party or through remote support to client.

8.12.12.2 The total arrangement shall be such that one (1) operation (click on "data down load from meter" button on software) can carry out the whole operation in about five (5) minutes per meter or preferably faster.

8.12.12.3 The layout of software front end/user interface has to be approved by RLDC during technical evaluation/demonstration. However, a standard template sheet will be provided along with TENDER for reference.

8.12.12.4 Software for windows/office/antivirus to be supplied. Antivirus should not slow down processes and same will be demonstrated during technical demonstration.

8.12.12.5 Above specification is minimum only, any higher standard required for the purpose intended (meter data handling) would be assessed by vendor and would be supplied accordingly. The detailed architecture shall be approved during drawing approval stage.

8.12.12.6 Meter shall be accommodated in existing C&R panel of standard size (Alstom/ ER/ABB/Siemens) in kiosk or C&R panel with door closed. If required before Tendering, Tenderer may collect necessary data or else the scope is deemed to be included.

8.12.12.7 Step by Step procedure (on screen shot type and desktop video capture) shall be provided for

- Installation/Re-installation of Database handling software in to Laptop / PC
- Meter maintenance/site-testing procedure as per relevant IS/IEC standard
- Procedure for data downloading from Meter by HHU/Laptop/Desktop PC.

As on date of delivery, the supplied meters shall comply with all statutory regulation as required under CERC/CEA/IEGC as applicable and the same should be declared by the vendor during delivery along with warranty certificate.

18.3.13 STANDARDS TO BE COMPLIED WITH

Standards to be complied

S.No	Reference	Reference Title
	Detail	
1	IS-15959:2011	Data Exchange for Electricity Meter Reading Tariff &
		Load Control – Companion Specification
2	IS-14697:1999	Specifications for AC Static Transformer operated Watt
		Hour & VAR-Hour meters, class of 0.2S and 0.5S
3	IEEE 830-1998	IEEE Recommended Practice for Software
		Requirements Specifications

18.3.14 System Security& Cyber Security

18.3.14.1 The Contractor shall document and implement a Cyber Security Policy in line with CERT-In latest guidelines (http://www.cert-in.org.in) to secure the system and the Contractor shall keep updating the Security settings as per the revised guidelines of CERT-In at time to time. Below listed basic strategies shall

be followed by the Contractor for making the entire Control Centre immune to Cyber-attacks.

18.3.14.2 All the Hardware, OS and application software shall be hardened.

18.3.14.3 Network partition and DMZ through use of Firewall as required maximizing the security of ABT, OA AND MIS System while facilitating access for data and information to all stake holders.

18.3.14.4 All default user id & passwords shall be changed.

18.3.14.5 All log in/log out and cable plug in/plug out shall also be logged in the System.

18.3.14.6 Prevent unauthorized users from reading or writing data or files, executing programs or performing operationswithout appropriate privileges

18.3.14.7 Document all user sign on procedure

18.3.14.8 Record all network traffic for detecting unauthorized activity, unusual activity and attempts to defeat system security (Contractor to propose and document what constitutes normal activity/traffic)

18.3.14.9 Vendor has to identify and list the entire network and other protocols that communicate with physical systems andlimit what is not required.

18.3.14.10 Network Zoning shall be implemented as per the proposed architecture given in Fig.1. However, the Contractor may suggest other methods of network architecture without compromising the security of the System.

18.3.14.11 No user shall be allowed to access remote network zones other than the adjacent zone.

18.3.14.12 Latest Cyber Security Guidelines of CERT-In specified at (http://www.cert-in.org.in) shall be followed.