NEPAL ELECTRICITY AUTHORITY

(An Undertaking of Government of Nepal)
Project Management Directorate

KATHMANDU VALLEY SUBSTATION AUTOMATION PROJECT

(A Component of
Power Transmission and Distribution Efficiency Enhancement Project)

BIDDING DOCUMENT
FOR

Procurement of Plant for
Design, Supply, Installation, Integration, Testing and Commissioning of Substation Automation System (SAS) for Existing Grid Substations in Kathmandu Valley

Single-Stage, Two-Envelope
Bidding Procedure

Issued on:	**19 April 2019**
Invitation for Bids No.:	**PMD/PTDEEP/KVSAP–075/76 – 01**
ICB No.:	**PMD/PTDEEP/KVSAP–075/76 – 01**
Employer:	**Nepal Electricity Authority**
Country:	**Nepal**

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CHAPTER 1 – PROJECT SPECIFICATION REQUIREMENT (PSR)

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CHAPTER 1-Project Specification Requirement

1.0 GENERAL

1.1.1 Nepal Electricity Authority is establishing Substation Automation System (SAS) in the existing Grid Substations at Kathmandu Valley. Through SAS implementation, NEA aims to mirror the benefits such as reduced operating staffs in the substations, taking the operating decisions more accurately and quickly, and improve the quality of service provided to consumers, while maintaining acceptable levels of risk and reliability. The project is funded by ADB.

Nepal Electricity Authority intends to carry out the following services in Turn key mode of Contract:

Engineering, Design, supply, install, testing, commissioning, operate and maintain the Substation Automation System (SAS) in the existing Grid Substations at Kathmandu Valley. Power Grid Corporation of India Ltd. (PGCIL) is the project supervision consultant for the project.

1.1.2 Associated Substations:

The following substations are envisaged under Substation Automation Project:-

Substations

1. Suichatar 132/66/11 kV Substation
2. Matatirtha 132/33/11 kV Substation
3. Balaju 132/66/11 kV Substation
4. Bhaktapur 132/66/11 kV Substation
5. Chapali 132/66/11 kV Substation
6. Lamosangu 132/66/11 kV Substation
7. Panchkhal 66/11 kV Substation
8. Banepa 132/66/11 kV Substation
9. New Patan 66/11 kV Substation
10. Baneshwor 66/11 kV Substation
11. Lainchaur 66/11 kV Substation
12. New Chabel 66/11 kV Substation

13. K-3 66/11 kV Substation

2.0 INTENT OF SPECIFICATION

2.1 The specification includes design, engineering, manufacture, fabrication, testing at manufacturer's works, delivery, unloading at site, storage, erection, testing and commissioning at site of the Substation Automation System (SAS) in the existing Grid Substations at Kathmandu Valley. Scope includes automation of 132 kV bays, 66 kV, 33 kV and 11 kV bays of 13 substations under Kathmandu Grid Division, NEA including the construction of Master Control Center (MCC) at Baneshwor Substation and the integration of all 132kV / 66 kV /33 kV /11 kV bays with MCC and Load Dispatch Center (LDC), NEA, Replacements and Retrofitting of old Control & Relay Panels and Indoor Switchgear Panels, Replacement and Retrofitting of old isolators, other electrical and mechanical auxiliary systems on turnkey basis.

2.2 It is the intent of this specification to describe primary features, materials, and design & performance requirements and to establish minimum standards for the work.

2.3 The specification is not intended to specify the complete details of various practices of manufactures/ bidders, but to specify the requirements with regard to performance, durability and satisfactory operation under the specified site conditions.

3.0 SCOPE

3.1 The scope of this specification covers the following substation automation works in Kathmandu Valley.

3.1.1 Works associated with 132/66/11 kV Substations under the scope of the Project

a. Complete Substation Automation System (SAS) for substations including hardware and software, (including protection relays for main and backup protection as and when required) and other accessories and metering and indication facilities for the substation & remote control stations along with associated equipment for 132 kV / 66 kV/ 33 kV / 11 kV bays of 12 substations as specified in 1.1.2 (which excludes Baneshwor 66 kV /11 kV Substation)

b. Supply and replacement of 132 kV /66 kV/33 kV isolators as per the BPS, after modification of existing foundations and steel supporting structures. The number of isolators to be replaced is as specified in the BPS (Bid Price Schedule). Dismantling of the replaced isolators and storing the dismantled material / equipment in the substation stores or any other places as specified by the employer shall be in the scope of the contractor. Cost of dismantling and storing deemed to be included in the installation and other services in BPS.

c. Supply and replacement of 132kV / 66kV / 33kV Control & Relay Panels and 11 kV Indoor Switchgear Panels. Number of Panels to be replaced is specified in BPS. Dismantling of the replaced panels and storing the dismantled material / equipment in the substation stores or any other places as specified by the employer shall be in the scope of the contractor. Cost of dismantling and storing deemed to be included in the installation and other services in BPS.

d. Retrofitting of existing Control & Relay Panels and Indoor Switchgear Panels including replacement of protection relays for main and backup protection as and where required and other accessories, metering and indication facilities for the substation & remote control stations along with associated equipment.

e. Construction of Master Control Center (MCC) in Baneshwor Substation for monitoring and controlling of all 132 kV /66 kV /33 kV /11 kV bays of 14 (fourteen) existing substations under Kathmandu Grid Division, NEA and 7 (seven) under-construction substations at Kathmandu Valley.

f. Integration of all 132 kV /66 kV /33 kV /11 kV Bays of all substations under present scope with MCC. All the bays shall be controllable from local substations as well as from remote MCC at Baneshwor substation.

g. Integration of all 132/66/11 kV Bays of all substations under present scope with the SCADA of SIEMENS (SINAUT Spectrum) at Load Dispatch Centre, Kathmandu including supply of Hardware, Software, accessories etc.

h. 132 kV/ 66 kV/ 33 kV/ 11kV XLPE cable along with termination kit and other accessories for temporary supply arrangement while replacing isolators or indoor switchgears.

i. The control and power cables in the BPS are intended to be used with the replaced equipment. The communication cables and other cables required for Automation works are to be included with the respective cost. The existing cables if available can be reused, if the cables are in good condition.

j. The scope includes supply and installation of miscellaneous equipment like switches etc to be used for control and supply of new Isolators and other equipment, where such facilities are not available.

k. Temporary arrangement of the materials and equipment for the control and protection of the associated line(s) and transformer(s) while bypassing the control and relay panels shall be in the scope of the contractor and cost of the arrangement deemed to be included in the retrofitting works.

l. Air Conditioning System

m. 1.1 kV grade Power & Control cables along with complete accessories. Earthling of Isolators, Panels and other equipment with existing earthmat of the substations

n. Visual Monitoring System for watch and ward of present scope as per Annexure-III. The design of the system shall be such that the common system shall be able to accommodate for all feeders/equipment including future, 220/132/66/33/11 kV system.

o. Design, engineering, manufacture, testing, supply including transportation, insurance & storage at site of mandatory spares.

p. Any other equipment/material required for completing the specified scope, shall be included in the scope of supply and the offer should be complete & comprehensive.

BASIC REQUIREMENT OF MASTER CONTROL CENTER AT BANESHWOR SUBSTSTION

1. The scope of work includes construction of Master Control Center at Baneshwor substation complete with server room, control room with monitoring screen, air-conditioning.
2. The control center building shall be built over existing RCC structure building at Baneshwor Substation. The construction shall be PES (Pre-engineered structure or RCC).
3. The control center is to be designed such as to Supervise, monitor and control all substation within Kathmandu Valley. There is 14 substation in operation in Kathmandu valley, 5 substation under construction and 3 substation is proposed.
4. The existing substation is equipped with the SAS system of ABB, India make. The contractor is required to provide all necessary servers, hardware, software, switches etc which are required for satisfactory completion of work and for future requirement. The contractor is required to provide all necessary document, design to prove the capacity of the equipment provided.

The bidders are advised to visit the substations sites and acquaint themselves with the infrastructure and also the design philosophy. Before proceeding with the construction work of the substations, the Contractor shall fully familiarize himself with the site conditions and General arrangements & scheme etc. Though the Owner shall endeavor to provide the information, it shall not be binding for the Owner to provide the same. The bidder shall be fully responsible for providing all equipment, materials, system and services specified or otherwise which are required to complete the construction and successful commissioning, operation & maintenance of facilities under the scope in all respects.

The complete design **(unless specified otherwise in specification elsewhere)** and detailed engineering shall be done by the Contractor based on conceptual tender drawings. Drawings enclosed with tender drawings are for information only.

3.2 The Contractor shall also be responsible for the overall co-ordination with internal/external agencies; Supplier of Owner's supplied equipment, project management, training of Owner's manpower, loading, unloading, handling, moving to final destination for successful erection, testing and commissioning of the substation/switchyard.

3.3 Any other items not specifically mentioned in the specification but which are required for erection, testing and commissioning and satisfactory operation of the substation are deemed to be included in the scope of the specification unless specifically excluded.

3.4 Owner has standardized its technical specification for various equipment and works for different voltage levels. Items, which are not applicable for the scope of this package as per schedule of quantities described in BPS, the technical specification for such items should not be referred to.

4.0 SPECIFIC EXCLUSIONS

The following items of work are specifically excluded from the scope of the specifications for all substations:

(a) Owner's quarters, site office.

(b) Cutting and clearing of trees and bushes in yard

5.0 PHYSICAL AND OTHER PARAMETERS

5.1 Location of the Substations –

Suichatar Substation, Matatirtha Substation, Balaju Substation, Bhaktapur Substation, Chapali Substation, New Patan Substation, Baneshwor Substation, Lainchaur Substation, New Chabel Substation and K-3 Substation are located at Kathmandu Valleys whereas Banepa, Panchkhal and Lamosangu Substations are approximately 25 km, 40 km and 100 km respectively road distance from Kathmandu Valley along the Araniko Highway.

5.2 Meteorological data :-

a) Altitude above sea level :

1420m from MSL

b) Ambient Air Temperature :

45ºC(max)/ 0 ºC(min)

c) Average Humidity (in %) :

95 (max), 40(min)

d) The substation locations are lying in the wind speed Zone 4 i.e. 47m/s.

e) Seismic Requirement for Substations: 0.5g (Horizontal peak acceleration value).

However, for design purposes, ambient temperature should be considered as 50 degree centigrade and Relative humidity 100% for both the substation.

5.3 The fault level of all equipment to be supplied under present scope shall be as indicated below:

S.NO.	Voltage Level	Fault Level
1	220kV	40kA for 1 Sec
2	132kV	31.5kA for 1 Sec
3	33kV	25kA , 3 sec
4	11kV	25kA , 3 sec

6.0 SCHEDULE OF QUANTITIES

The requirements of various items/equipment are indicated in Bid price Schedules. All equipment/items for which bill of quantity has been indicated in BPS (Bid price Schedules) shall be payable on unit rate basis/quoted rate basis. During actual execution, any variation in such quantities shall be payable as per relevant clauses incorporated in Letter of award.

Wherever the quantities of items/works are not indicated, the bidder is required to estimate the quantity required for entire execution and completion of works and incorporate their price in respective Bid price schedules. For erection hardware items, Bidders shall estimate the total requirement of the works and indicate module-wise lump sum price bay wise and include the same in relevant Bid price schedules. For module identification, Bidder may refer typical drawings enclosed with the specifications. Any material/works for the modules not specifically mentioned in the description in BPS, as may be required shall be deemed to be included in the module itself.

The detailed bill of quantities of the mandatory spares is as per BPS.

Bidder should include all such items in the bid proposal sheets, which are not specifically mentioned but are essential for the execution of the contract. Item which explicitly may not appear in various schedules and required for successful commissioning of substation shall be included in the bid price and shall be provided at no extra cost to Owner.

7.0 BASIC REFERENCE DRAWINGS

7.1 Single line diagram and general arrangements are enclosed with the bid documents for reference, which shall be further engineered by the bidder.

7.2 The reference drawings, which form a part of the specifications, are given at Annexure-I. The bidder shall maintain the overall dimensions of the substation, phase to earth clearance, phase to phase clearance and sectional clearances. The enclosed drawings give the basic scheme. In case of any discrepancy between the drawings and text of specification, the requirements of text shall prevail in general. However, the Bidder is advised to get these clarified from Owner.

7.3 The auxiliary transformers/ Station Service Transformers/ Station supply/ AC and Distribution Boards of the existing substations shall be used to feed the substation auxiliaries under the scope of the Project.

8.0 ORDER OF PRECEDENCE OF DIFFERENT PARTS OF TECHNICAL SPECIFICATION

For the purpose of present scope of work, technical specification shall consist of following parts and they should be read in conjunction with each other.

1.	Chapter 1 : Project Specification Requirement	Rev. 00 (NEA)
2.	Chapter 2 : General Technical Requirement	Rev. 00 (NEA)
3.	Chapter 3 : Switchgear	Rev. 00 (NEA)
4.	Chapter 4 : Air Conditioning System	Rev. 00 (NEA)
5.	Chapter 5 : Switchyard Erection	Rev. 00 (NEA)
6.	Chapter 6 : Control & Relay Panels	Rev. 00 (NEA)
7.	Chapter 7 : Substation Automation System	Rev. 00 (NEA)
8.	Chapter 8 : Power and control cables	Rev. 00 (NEA)

9.	Chapter 9 : SCADA centralized control system	Rev. 00 (NEA)
10.	Chapter 10: AMC	Rev. 00 (NEA)

In case of any discrepancy between Chapter 1-PSR, Chapter 2-GTR and other technical specifications on scope of works, Chapter 1-PSR shall prevail over all other chapters.

In case of any discrepancy between Chapter 2-GTR and individual chapters for various equipments, requirement of individual equipment chapter shall prevail.

9.0 SPARES

Mandatory Spares

The Mandatory Spares shall be included in the bid proposal by the bidder. The prices of these spares shall be given by the Bidder in the relevant schedule of BPS and shall be considered for evaluation of bid. It shall not be binding on the Owner to procure all of these mandatory spares.

The bidder is clarified that no mandatory spares shall be used during the commissioning of the equipment. Any spares required for commissioning purpose shall be arranged by the Contractor. The unutilized spares if any brought for commissioning purpose shall be taken back by the contractor.

10.0 SPECIAL TOOLS AND TACKLES

The bidder shall include in his proposal the deployment of all special tools and tackles required for operation and maintenance of equipment. The special tools and tackles shall only cover items which are specifically required for the equipment offered and are proprietary in nature. However a list of all such devices should be indicated in the relevant schedule provided in the BPS. In addition to this the Contractor shall also furnish a list of special tools and tackles for the various equipment in a manner to be referred by the Employer during the operation of these equipment. The scope of special tools and tackles are to be decided during detail engineering and the list of special tools and tackles, if any shall be finalized**.**

11.0 FACILITIES TO BE PROVIDED BY THE OWNER

11.1 Owner shall make available the auxiliary HT power supply from NEA on chargeable basis at a single point in the Substation. The prevailing energy rates of the state shall be applicable. All further distribution from the same for construction and permanent auxiliary supply shall be made by the contractor. However, in case of failure of power due to any unavoidable circumstances, the contractor shall make his own necessary arrangements like diesel generator sets etc. at his own cost so that progress of work is not affected and Owner shall in no case be responsible for any delay in works because of non-availability of power.

11.2 Owner shall make available construction water supply at a single point in the substation. All further distribution for the same shall be made by the Contractor. In case of non-availability or inadequate availability of water for construction work, the contractor shall make his own arrangement at his own cost and the Owner shall in no case be responsible for any delay in works because of non-availability or inadequate availability of water.

12.0 SPECIFIC REQUIREMENT

a. The Bidders are advised to visit Substations site and acquaint themselves with the topography, infrastructure, etc.

b. The bidder shall be responsible for safety of human and equipment during the working. It will be the responsibility of the Contractor to co-ordinate and obtain Electrical Inspector's clearance before commissioning. Any additional items, modification due to observation of such statutory authorities shall be provided by the Contractor at no extra cost to the Owner.

The Contractor shall arrange all T&P (such as necessary supports, cranes, ladders, platforms etc.) for erection, testing & commissioning of the system at his own cost. Further, all consumables, wastage and damages shall be to the account of contractor.

c. Augmentation and integration work related to SCADA System

132/66/33/11kV bays of substations under present scope at both the substations shall be integrated by the contractor into existing SCADA system of Siemens 'SINAUT Spectrum"(version 4.3.2) installed at Master Station i.e. Nepal Electricity Authority Load Dispatch Centre (located in Siuchatar, Kathmandu). The integration shall include all hardware and software required at the Control Centre as well as necessary data base, display generation and upgrades for proposed control and monitoring of station and Network Analysis. The manufacturers of the existing SCADA system are:-

LDC facilities: Siemens Germany

The existing communication protocol used for SCADA at LDC Kathmandu is IEC 101. For the present scope of work no RTU is envisaged and the Data for SCADA purpose shall be obtained from the Substation Automation System (based on IEC 61850) using Gateway port with communication protocol IEC 101/104 as per requirement being provided under present contract.

d. In Chapter 2 GTR and other Technical specifications, the term “Purchaser” and/or “Employer” may be read as “Owner”.

e. Erection, testing and commissioning of Circuit breaker, Isolators, Substation automation system, Control and protection Panels & PLCC shall be done by the contractors under the supervision of respective equipment manufacturers. Charges for the above supervision shall be included by the bidder in the erection charges for the respective equipment in the BPS.

f. The Contractor shall impart the necessary training to Owner’s Personnel as per following details:-

- **Training at Manufacturer’s works**. The Contractor shall include in the training charges payment of per Diem allowance to NEA trainees @ USD 200 per day per trainee for the duration of training abroad towards accommodation, meals and other incidental expenses, and to and fro economy class air ticket from Nepal to place of training. The duration of training shall be excluding travelling period.

  The training shall be provided in the field of design, testing and maintenance at Manufacturer’s works as per following:-

  1. Control & Protection and Substation Automation System: 7 Days (4 Nos. Trainees)

- **On Job Training in Nepal:** The traveling and living expenses of Owner’s personnel for the training programme conducted in Nepal shall be borne by the Owner.

  The training shall be provided to Employer’s personnel in the field of erection, testing, operation and maintenance at substation site as per following:-

  1. Control & Protection: 5 Days.
  2. Substation Automation System: 5 days.

g. The reference of IS standard (i.e. Indian Standard) mentioned in the technical specification shall be read as equivalent IEC or BS or equivalent International Standard.

h. Non CFC refrigerant shall be utilized for Air conditioning system, offered for Control room building and switchyard panel room is under the scope of contract.

i. For equipment, all design parameters including air clearances, insulation coordination etc shall be corresponding to altitude of 1470 Meter from MSL in (accordance to IEC).

j. The contractor shall also supply necessary BCU for monitoring and control of auxiliary supply including operation of Isolators associated with Auxiliary transformer

k. LIST OF PREFERED SHORTLISTED MAKE/MANUFACTURER:

"It is preferred that the equipment be supplied from the manufacturers listed in ANNEXURE-II for mentioned equipments/items.

The bidders may offer equipment/brands other than those listed in ANNEXURE-III, that are better or equivalent with regard to quality and performance substantiated with appropriate documents.

l. The switchyard panel room as detailed in section Substation Automation System is not required for GIS station. The contractor shall place their panels i.e. Bay level units, relay and protection panels, Digital RTCC panels, DPC panels etc for 132/66 kV in respective GIS hall(s) or in a separate room in the GIS buildings. The room shall be air-conditioned and the supplier shall submit detailed heat load calculation during detailed engineering. Further, the temperature of enclosure /room shall be monitored through substation automation system by providing necessary temperature transducers.

13.0 PRECOMMISSIONING, COMMISSIONING, TRIAL-RUN & COMPLETION

As soon as the Facilities covered by these specifications are physically completed in all respects, the Pre commissioning, Commissioning, Trial-run and Completion of the Facilities, as mentioned below, shall be attained in accordance with the procedure given in the Conditions of Contract, Vol.-I of the Bidding Documents.

(i) Pre commissioning**:** As per relevant Chapters

(ii) Commissioning : Charging of the Facilities at rated voltage

Further, wherever appearing in these specifications, the words – 'commissioning checks', 'installation checks', 'site tests', 'performance guarantee tests for fire protection system', are to be considered as 'pre commissioning checks'.

(iii) Trial-run : Operation of the Facilities or any part thereof by the Contractor immediately after the Commissioning for a continuous period of 72(Seventy two) hours continuously. In case of interruption due to problem / failure in the respective equipment, the contractor shall rectify the problem and after rectification, continuous 72(Seventy two) hours period start after such rectification.

(iv) Completion : Upon successful completion of Trial-run.

'Guarantee Test(s)' and/or 'Functional Guarantees' are applicable only for Substation Automation System as specified in Chapter-'Substation Automation System.'

ANNEXURE - I

SUBSTATION STATIONS & TRANSMISSION LINE NETWORK UNDER KATHMANDU GRID DIVISION

SWITCHING STATIONS UNDER DISTRIBUTION CENTRES (DCS)

Legends

Circuit Breaker	Disconnecting Switch with Power Fuse	Current Transformer	Power House	XLPE Cable	11 kV line
Disconnecting Switch	Potential Transformer	Power Transformer	Lightning Arrestor	132 kV line	Under ground Cable
Draw Out Type Circuit Breaker	Capacitor Voltage Transformer	Station Service Transformer	Earthing Switch	66 kV line	Bus Bar

NEPAL ELECTRICITY AUTHORITY

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Daated :- 14/08/2016

Substations & Transmission line Network of Kathmandu Valley

ANNEXURE- II

LIST OF PREFERED (SHORTLISTED) MAKE

It is preferred that the following equipment be supplied from the manufacturers listed hereunder:

(i) M**ain Protection Relays, Control &Relay panel, Substation Automation System, from:** ABB, AREVA / ALSTOM, SIEMENS, Fuji, Reyrolle, Toshiba, Mitsubishi, GE or equivalent.

(ii) **Energy Meters from:** ELSTER (ABB), ACTARIS (Schlumburger), EDMI, SIEMENS or equivalent.

(iii) **Communication System:** NOKIA, NOKIA SIEMENS, SIEMENS, ABB, AREVA/ALSTOM or equivalent

The bidders may offer equipment/brands other than those listed above that are better or equivalent with regard to quality and performance substantiated with appropriate documents. The bidder is required to submit all technical information, brochures, test reports of the proposed equipment for assessing equivalence with the shortlisted vendor during the bid submission.

EXISTING RTU BASED SCADA & ITS DATA ACQUISITION

1.0 GENARAL INFORMATION

1.1 Remote Terminal Units

The Load Dispatch Centre (LDC) controls and monitors the network of Integrated Nepal Power System (INPS) via RTUs located at its various outstations.

In addition to the above, two local RTUs have been installed at the LDC: one to handle local-control-center status inputs and analog inputs and outputs; and the other for training, maintenance and testing purposes.

Manufacturers of existing SCADA system are:

LDC facilities: SIEMENS, Germany

RTU facilities: ABB, Germany

1.2 Data acquisition principles for existing Substation

The existing substations are provided with RTU for interfacing of the following supervisory controls and data acquisitions:

Remote Control

- Remote control of all 220/132/33kV circuit breakers.

Status indications

- Status indications of all 220/132kV circuit breakers, busbar and line isolators.
- Status indications of all 33kV line feeders.

Table 1.4 : Alarms to be acquired from each type of bay

Type of Alarm	Line Bay	Transformer Bay	Coupler Bay	Busbar	Station
Main protection trip	MPT	MPT	MPT		
Back-up protection trip	BPT	BPT	BPT		
Bay fault	BFA	BFA	BFA		
Circuit breaker fault	CBF	CBF	CBF		
Auto-recloser operated	ARO				
Temperature Alarm		TAL			
Temperature Trip		TTR			
Buchholz alarm		BAL			
Buchholz Trip		BTR			
General transformer/reactor talarm		GTA			
General transformer/reactor Trip		GTT			
Busbar Voltage status				BVS	
Station urgent fault					SUF
Station none-urgent fault					SNF
Station Control disabled					SCD
RTU alarm					RTU
Communication alarm					COM
Total	**5**	**10**	**4**	**1**	**5**

Measurements

- ❖ Busbar voltages (separate for each busbar and section) of all 220/132/33 kV Busbars.
- ❖ Active/reactive power for
  - All 220kV & 132kV Line feeders.
  - All 220kV, 132kV and 33kV Transformer feeders.
- ❖ Single phase current measurements for all 33kV lines participating in load shedding Scheme.

Technical Specification for Visual Monitoring System

Visual monitoring system for watch and ward of Substation premises :

Visual monitoring system (VMS) for effective watch and ward of sub station premises covering the areas of entire switchyard, Control Room cum Administrative building, Fire fighting pump house, stores and main gate, shall be provided. The contractor shall design, supply, erect, test and commission the complete system including cameras, Digital video recorder system, mounting arrangement for cameras, cables, LAN Switches, UPS and any other items/accessories required to complete the system. To provide all the necessary licenses to run the system successfully shall be in the scope of contractor.

System with Color IP Cameras for VMS surveillance would be located at various locations including indoor areas and outdoor switchyard and as per the direction of Engineer-In-Charge. The VMS data partly/completely shall be recorded (minimum for 15 days) and stored on network video recorder.

The number of cameras and their locations shall be decided in such a way that any location covered in the area can be scanned. The cameras shall be located in such a way to monitor at least:

1. The operation of each and every isolator pole of the complete yard in case of AIS Sub-station.
2. The Operation of each bay bays of GIS Hall as Applicable.
3. All the Transformer and Reactors All the Entrance doors of Control Room Building and Fire-fighting Pump House, GIS Hall and Switchyard Panel room as applicable.
4. All the gates of switchyard.
5. Main entrance Gate
6. All other Major AIS Equipment (such as CB, CT, CVT, SA etc. as applicable)

   The cameras can be mounted on structures, buildings or any other suitable mounting arrangement to be provided by the contractor.

1.1 Technical requirements of major equipment of Visual Monitoring System.

1.1.1 The Video Monitoring system shall be an integrated system with IP network centric functional and management architecture aimed at providing high-speed manual/automatic operation for best performance.

1.1.2 The system should facilitate viewing of live and recorded images and controlling of all cameras by the authorized users.

1.1.3 The system shall use video signals from various types of indoor/outdoor CCD colour cameras installed at different locations, process them for viewing on workstations/monitors in the control Room and simultaneously record all the cameras after compression using **H 264/**MPEG 4 or better standard. Mouse/Joystick-Keyboard controllers shall be used for Pan, Tilt, Zoom, and other functions of desired cameras.

1.1.4 The System shall provide sufficient storage of all the camera recordings for a period of 15 days or more @ 25 FPS, at 4 CIF or better quality using necessary compression techniques for all cameras. It shall be ensured that data once recorded shall not be altered by any means. The recording resolution and frame rate for each camera shall be user programmable.

1.1.5 The surveillance VMS System shall operate on 230 V, 50 Hz single-phase power supply. System shall have back up UPS power supply meeting the power supply need of all the cameras in the stations including those which are installed at gate for a period of 2 hours. The bidder shall submit the sizing calculation for the UPS considering the total load requirement of Video Monitoring System.

1.2 System requirements:

a) System must provide built-in facility of watermarking or Digital certificate to ensure tamperproof recording.

b) All cameras may be connected through a suitable LAN which shall be able to perform in 765kV class sub-station environment without fail.

c) All camera recordings shall have Camera ID & location/area of recording as well as date/time stamp. Camera ID, Location/Area of recording & date/time shall be programmable by the system administrator with User ID & Password.

d) Facility of camera recording in real-time mode (25 FPS)/15/12.5/10 or lower FPS as well as in any desired combination must be available in the system.

e) Facility of Camera recording in HD (1280X720p), D1 , 4CIF , CIF, VGA, as well as in any combination i.e. any camera can be recorded in any quality.

f) System to have facility of **100%** additional camera installation beyond the originally planned capacity.

g) In order to optimize the memory, while recording, video shall be compressed using H **264/**MPEG-4 or better standard and streamed over the IP network.

h) System shall be triplex i.e. it should provide facility of Viewing, Recording & Replay simultaneously.

i) The offered system shall have facility to export the desired portion of clipping (from a specific date/time to another specific date/time) on CD or DVD. Viewing of this recording shall be possible on standard PC using standard software like windows media player etc.

j) System shall have provision of WAN connectivity for remote monitoring.

k) The equipment should generally conform to Electro magnetic compatibility requirements for outdoor equipment in EHV switchyards. The major EMC required for Cameras and other equipment shall be as under:

1. Electrical Fast Transient (Level 4) – As per IEC 61000-4-4
2. Damped Oscillatory (1 MHz and 100 KHz) (level 3) – As per IEC 61000-4-18

3. AC Voltage Dips & Interruption/Variation (class 3) – As per IEC 61000-4-11
4. Electrostatic Discharge (Level 4) – As per IEC 61000-4-2
5. Power Frequency Magnetic Field (level 4) – As per IEC 61000-4-8
6. Ripple on DC input Power Supply Port immunity test(level 4) - As per IEC 61000-4-17

Type test reports to establish compliance with the above requirement shall be submitted during detailed engineering.

1.2.1 VIDEO SURVEILLANCE APPLICATION SOFTWARE

a) Digital video surveillance control software should be capable to display and manage the entire surveillance system. It should be capable of supporting variety of devices such as cameras, video encoder, Servers, NAS boxes/Raid backup device etc.

b) The software should have inbuilt facility to store configuration of encoders and cameras.

c) The software should Support flexible 1/2/4/8/16/32 Windows Split screen display mode and scroll mode on the PC monitor.

d) The software should be able to control all cameras i.e. PTZ control, Iris control, auto / manual focus, and color balance of camera, Selection of presets, Video tour selection etc.

e) The software should have user access authority configurable on per device or per device group basis. The system shall provide user activity log with user ID, time stamp, action performed, etc.

f) The users should be on a hierarchical basis as assigned by the administrator. The higher priority person can take control of cameras, which are already being controlled by a lower priority user.

g) It should have recording modes viz. continuous, manual, or programmed modes on date, time and camera-wise. All modes should be disabled and enabled using scheduled configuration. It should also be possible to search and replay the recorded images on date, time and camera-wise. It should provide onscreen controls for remote operation of PTZ cameras. It should have the facility for scheduled recording. Different recording speeds (fps) and resolution for each recording mode for each camera should be possible.

h) The software for clients should also be working on a browser based system for remote users. This will allow any authorized user to display the video of any desired camera on the monitor with full PTZ and associated controls.

i) Retrieval: The VMS application should allow retrieval of data instantaneously or any date / time interval chosen through search functionality of the application software. In case data is older than 15 days and available, the retrieval should be possible. The system should also allow for backup of specific data on any drives like DVD’s or any other device in a format which can be replayed through a standard PC based software. Log of any such activity should be maintained by the system.

j) VMS shall provide the full functionality reporting tool which can provide reports for user login/logoff, camera accessibility report, server health check reports etc.

1.2.2 Network video recorder

The Network Video recorder shall include at least Server (min 3.0 GHZ, 4GB RAM, 3000GB HDD(min)), RAID 5 ,with suitable configuration along with Colored TFT 22" High resolution monitor, and Internal DVD writer. Windows XP/Vista/7 Prof. or VMS compatible operating system latest version with hardware like graphic cards, licensed Anti-virus etc.

Further the digital video recorder shall conform to the following requirements:

1.	Server Spec	Intel Quad Core (or better) 3.0 Ghz (min.) , 8 MB Cache , 4 GB memory , with suitable NVIDIA graphics card,3 TB HDD , Raid 5
2.	Recording and Display Frame Rate	Real-time 25 frames per second per channel , manual select
3.	Recording Resolution	(PAL): 1280X720 , 704(H) x 586(V) It should be possible to select lower resolutions
4.	Compression Method	H.264/MPEG-4 or better and latest
5.	Video Motion Detection Capable	Standard and built-in (selectable in menu)
6.	Monitoring Options	Split screen 1, 2, 4 , 8, 16, 32 or more cameras
7.	Playback Options	Search, still image capture
8.	Alarm/Event Recording Capable	To be provided with built-in external alarm input/ output ports minimum(8 in, 2 out)
9.	Network Operation Capable	To be provided by using WAN or LAN router
10.	Remote Internet Viewing Capable	Using WAN or LAN router
11.	HDD Storage Consumption	1GB ~ per hour / channel variable based on frame speed and resolution settings, as well as compression
12.	Operation	Triplex operation (simultaneous recording, playback, network operation)
13.	Number of Video Channel	32
14.	Audio Recording Capable	32
15.	Input Voltage	230V AC or equivalent with UPS as a back up for 30 minutes.

1.2.3 VMS Camera

a) The color IP camera for substation shall have PAN, TILT and ZOOM facilities so that it can be focused to the required location from the remote station through a controller. Whereas wireless IP cameras with PTZ controls are required for installation at gates of the POWERGRID premises as per the direction of Engineer-In-Charge

b) The IP Camera at the main gate can be fixed or PTZ based and shall be used for monitoring entry and exit

c) It should have sufficient range for viewing all the poles of isolators and other equipments with high degree of clarity.

d) The VMS camera shall be suitable for wall mounting, ceiling mounting and switchyard structure mounting.

e) It shall be possible to define at 128 selectable preset locations so that the camera gets automatically focused on selection of the location for viewing a predefined location.

f) The camera should be able to detect motion in day & night environments having light intensity of Color: 0.5 Lux; B&W:0.05 Lux

g) Housing of cameras meant for indoor use shall be of IP 42 or better rating whereas outdoor camera housing shall be of IP 66 or better rating. Housing shall be robust and not have the effect of electromagnetic induction in 765/400KV switchyard.

h) All camera recordings shall have Camera ID & location/area of recording as well as date/time stamp. Camera ID, Location/Area of recording & date/time shall be programmable by the system administrator with User ID & Password

i) Facility of camera recording in real-time mode (25 FPS)/15/12.5/10 or lower FPS as well as in any desired combination must be available in the system.

A. Outdoor IP Fixed Megapixel Camera Specifications (For Main Gate)

1.	Image Sensor	2-megapixel Progressive ,1 / 3" CMOS/CCD sensor, Minimum illumination 0.1 Lux
2.	Min Luminous	0.5LUX(Color) 0.05Lux(Black)
3.	Camera Enclosure Type	IP66 Grade
4.	Iris/Focus	Auto/Manual
5.	Video Compression	Dual Stream H.264 and MPEG 4 user selectable
6.	Support Dual-stream	primary/secondary stream, H.264/MPEG 4 optional
7.	Video Definition	Primary stream:1600x1200,1280x960,1280x720, Secondary stream:800x600,400x288,192x144
8.	Video Parameters	Brightness, hue, contrast, saturation and image quality
9.	Video Frame Rate	PAL: 1-25frames/second

		NTSC:1-30frames/second
10.	Video Compression BR	32Kbit/S - 6Mbit/S
11.	Video Output	One channel composite Streaming
12.	Supported Protocols	TCP, UDP, IP, HTTP, FTP, SMTP, DHCP, DNS,ARP, ICMP, POP3, NTP, IPsec, UpnP, RTP, RTCP
13.	Operating Temperature	-5 ~ +50℃
14.	Operating Humidity	10 ~ 90%

B. Outdoor IP66 PTZ HD Camera Specifications (For Switch Yards)

1.	Image sensor	1/3 type Solid State Progressive Scan CCD,WDR(High Definition)
2.	Security	Multiple user access with password protection
3.	Effective Pixels	**(PAL): Main Stream : 1280x720** Sub Stream : 640x360、320x280 selectable
4.	Compression	Dual Stream H.264 and MPEG 4 user selectable
5.	Signal System	50 Hz
6.	S/N (signal to noise) Ratio	Better than 50 dB
7.	Electronic Shutter	1/60 ~ 1/10,000 sec. automatic or better
8.	Scanning System	Progressive/interlace
9.	Low Light Sensitivity (lux)	Color: 0.5 Lux; B&W:0.02 Lux
10.	Lens	Minimum 10x (minimum) optical in High Definition (**The system shall be able to zoom the images on the monitor without any distortion to the maximum level of optical zoom)**
11.	Lens Size	Minimum 4.1~73.8 mm
12.	Lens Aperture	F1.6(wide)~F2.8(tele), f=4.1~41.0mm, 10X Zoom, Video Auto Focus Angle of View Horizontal : 52°(wide) , 2.8°(tele)
13.	PTZ Data Transfer Baud/Bit Rates Supported	Selectable 2400 bps / 4800 bps / 9600 bps
14.	Panning Range	Complete 360 degrees (horizontal)
15.	Pan Speed	Adjustable, 0.1 degrees / second ~ 250 degrees / second
16.	Tilting Range	Minimum 180° Tilt Rotation
17.	Tilt Speed	Adjustable, 0.1 degrees / second ~ 150 degrees / second
18.	In Built Storage	Camera should have inbuilt storage TF or SD format for recording and storing Pictures
19.	IP Class	IP66 Standard

20.	Working temperature	-0℃ ~ +50℃
21.	Working Humidity	10 ~ 90%

1.2.4 PTZ-Keyboards

The features of PTZ shall include:

- Fully functional dynamic keyboard/joystick controllers
- Controls all pan, tilt, zoom, iris, preset functions
- Control up to 255 units from a single keyboard
- Many preset options and advanced tour programming
- Compatible with all connected cameras

1.	Key Application	wired keyboard control operation of PTZ functions for weatherproof dome cameras
2.	Pan / Tilt / Zoom Protocol Languages Supported	Selectable
3.	PTZ Data Transfer Baud Rates Supported	selectable 1200 bps / 2400 bps / 4800 bps / 9600 bps
4.	Additional Features	dynamic joystick for smooth camera movements, preset location option for quick access to frequently monitored areas

CHAPTER 2- GENERAL TECHNICAL REQUIREMENT

TABLE OF CONTENTS

1.0 FOREWORD

1.1 The provisions under this chapter are intended to supplement general requirements for the materials, equipments and services covered under other chapters of tender documents and is not exclusive.

2.0 GENERAL REQUIREMENT

2.1 The contractor shall furnish catalogues, engineering data, technical information, design documents, drawings etc., fully in conformity with the technical specification during detailed engineering.

2.2 It is recognised that the Contractor may have standardised on the use of certain components, materials, processes or procedures different from those specified herein. Alternate proposals offering similar equipment based on the manufacturer's standard practice will also be considered provided such proposals meet the specified designs, standard and performance requirements and are acceptable to Purchaser.

2.3 Equipment furnished shall be complete in every respect with all mountings, fittings, fixtures and standard accessories normally provided with such equipment and/or needed for erection, completion and safe operation of the equipment as required by applicable codes though they may not have been specifically detailed in the Technical Specifications unless included in the list of exclusions. Materials and components not specifically stated in the specification and bid price schedule but which are necessary for commissioning and satisfactory operation of the switchyard/substation unless specifically excluded shall be deemed to be included in the scope of the specification and shall be supplied without any extra cost. All similar standard components/parts of similar standard equipment provided, shall be inter-changeable with one another.

3.0 STANDARDS

3.1 The works covered by the specification shall be designed, engineered, manufactured, built, tested and commissioned in accordance with the Acts, Rules, Laws and Regulations of Nepal/.relevant IEC standard or Acceptable International Standard.

3.2 The equipment to be furnished under this specification shall conform to latest issue with all amendments (as on the date of bid opening) of standard specified under Annexure-A of this chapter, unless specifically mentioned in the specification.

3.3 The Bidder shall note that standards mentioned in the specification are not mutually exclusive or complete in themselves, but intended to compliment each other.

3.4 The Contractor shall also note that list of standards presented in this specification is not complete. Whenever necessary the list of standards shall be considered in conjunction with specific IEC or equivalent international standard.

3.5 When the specific requirements stipulated in the specifications exceed or differ than those required by the applicable standards, the stipulation of the specification shall take precedence.

3.6 Other internationally accepted standards which ensure equivalent or better performance than that specified in the standards specified under Annexure-A / individual chapters for various equipments shall also, be accepted, however the salient points of difference shall be clearly brought out in the Additional information schedule of the bid along with English language version of such standard. The equipment conforming to standards other than specified under Annexure-A/

individual chapters for various equipments shall be subject to Purchaser's approval.

4.0 SERVICES TO BE PERFORMED BY THE EQUIPMENT BEING FURNISHED

4.1 The equipment furnished under this specification shall perform all its functions and operate satisfactorily without showing undue strain, restrike etc under such over voltage conditions.

4.2 All equipments shall also perform satisfactorily under various other electrical, electromechanical and meteorological conditions of the site of installation.

4.3 All equipment shall be able to withstand all external and internal mechanical, thermal and electromechanical forces due to various factors like wind load, temperature variation, ice & snow, (wherever applicable) short circuit etc for the equipment.

4.4 The bidder shall design terminal connectors of the equipment taking into account various forces that are required to withstand.

4.5 The equipment shall also comply to the following:

a) To facilitate erection of equipment, all items to be assembled at site shall be "match marked".

b) All piping, if any between equipment control cabinet/ operating mechanism to marshalling box of the equipment, shall bear proper identification to facilitate the connection at site.

4.6 Equipments and system shall be designed to meet the following major technical parameters as brought out hereunder.

4.6.1 System Parameter

220kV System

SL No	**Description of parameters**	**220 kV System**
1.	System operating voltage	220kV
2.	Maximum operating voltage of the system(rms)	245kV
3.	Rated frequency	50Hz
4.	No. of phase	3
5.		
i)	Full wave impulse withstand voltage (1.2/50 microsec.)	1050 kVp
ii)	Switching impulse withstand voltage (250/2500 micro sec.) dry and wet	-
iii)	One minute power frequency dry withstand voltage (rms)	-
iv)	One minute power frequency dry and wet withstand voltage (rms)	460kV
6.	Corona extinction voltage	156kV
7.	Max. radio interference voltage for frequency between 0.5 MHz and 2 MHz at 156kV rms for 220kV system	1000 micro-volt
8.	Minimum creepage distance (25mm/kV)	6125 mm
9.		
i.	Phase to phase	2100 mm

SL No	Description of parameters	220 kV System
ii.	Phase to earth	2100 mm
iii)	Sectional clearances	5000 mm
10.	Rated short circuit current for 1 sec. duration	40kA
11.	System neutral earthing	Effectively earthed

132kV & 11kVSystem

SL No	Description of parameters	132 kV System	22 kV System	11 kV System
1.	System operating voltage	132kV	22kV	11kV
2.	Maximum operating voltage of the system(rms	145kV	25kV	12kV
3.	Rated frequency	50Hz	50Hz	50Hz
4.	No. of phase	3	3	3
5.	Rated Insulation levels			
i)	Full wave impulse withstand voltage (1.2/50 microsec.)	650 kVp	150 kVp	75 kVp
ii)	One minute power frequency dry and wet withstand voltage (rms)	275kV	50kV	28kV
6.	Corona extinction voltage	105kV	-	-
7.	Max. radio interference voltage for frequency between 0.5 MHz and 2 MHz at 92KV rms for 132KV system	500 micro-volt	-	-
8.	Minimum creepage distance (25mm/kV)	3625 mm	625 mm	300 mm
9.	Min. Clearances			
i.	Phase to phase	1300 mm	290 mm	280 mm
ii.	Phase to earth	1300 mm	290 mm	140 mm
iii)	Sectional clearances	4000 mm	2800 mm	3000 mm
10.	Rated short circuit current	31.5 kA for 1 Sec	25 kA for 3 Sec	25 kA for 3 Sec
11.	System neutral earthing	Effectively earthed	Effectively earthed	Effectively earthed

Note :

1. The above parameters are applicable for installations up to an altitude of 1000m above mean sea level. For altitude exceeding 1000m, necessary altitude correction factor shall be applicable.
2. The insulation and RIV levels of the equipments shall be as per values given in the respective chapter of the equipments.

4.6.2 Major technical parameters of bushings / hollow column / support insulators are given below:

220kV System

S.N.	Parameters	**220 kV**
(a)	Max. System voltage Um(kV)	245
(b)	Impulse withstand voltage (dry & wet) (kVp)	± 1050
(c)	Power frequency withstand voltage (dry and wet) (kV rms)	460
(d)	Total creepage distance (min) (mm)	6125

The requirement of alternate long & short sheds stated in model technical specification shall not be applicable in case of 11 kV.

132kV, 22kV & 11kV System

S.N.	Parameters	**132 kV**	**22kV**	**11kV**
(a)	Max. System voltage Um(kV)	145	25	12
(b)	Impulse withstand voltage (dry & wet) (kVp)	± 650	± 150	± 74
(c)	Power frequency withstand voltage (dry and wet) (kV rms)	275	50	28
(d)	Total creepage distance (min) (mm)	3625	625	300

4.6.3 Major Technical Parameters

The major technical parameters of the equipments are given below. For other parameters and features respective technical chapters should be referred.

4.6.3.1

(A) For 245 kV & 145 kV Equipments

Rated voltage kV (rms)	245	145
Rated frequency (Hz)	50	50
No. of Poles	3	3
Design ambient temperature (°C)	50	50

Rated insulation levels :

1) Full wave impulse withstand voltage (1.2/50 micro sec.)

-	between line terminals and ground	± 1050 kVp	±650 kVp
-	between terminals with circuit breaker open	± 1050 kVp	±650 kVp
-	between terminals with isolator open	± 1200 kVp	±750 kVp

2) One minute power frequency dry and wet withstand voltage

-	between line terminals and ground	460 kV (rms)	275 kV (rms)
-	between terminals with circuit breaker open	460 kV (rms)	275 kV (rms)
-	between terminals with Isolator open	530 kV (rms)	315kV (rms)
Max. radio interference voltage (microvolts) for frequency between 0.5 MHz and 2 MHz in all positions of the equipments.		1000 (at 156 kV rms)	500 (at 92 kV rms)
Minimum creepage distance :-			
Phase to ground (mm)		6125	3625
Between CB Terminals (mm)		6125	3625
System neutral earthing		Effectively earthed	Effectively earthed
Seismic acceleration		- 0.5g horizontal -	
Rating of Auxiliary Contacts		10 A at 220/110 V DC (as applicable)	
Breaking capacity of Auxiliary Contacts		2 A DC with circuit time constant of not less than 20ms.	
Phase to phase spacing (mm)		4500 or 4000	3000 or 2700

Auxiliary Switch shall also comply with other clauses of this chapter.

(B) FOR 245 kV & 145 kV CT/CVT/SA

Rated voltage kV (rms)		245	145
Rated frequency (Hz)		50	50
No. of poles		1	1
Design ambient temperature (°C)		50	50
Rated insulation levels :			
1)	Full wave impulse withstand voltage (1.2/50 micro sec.)		
-	between line terminals and ground for CT and CVT	± 1050 kVp	±650 kVp
-	for arrester housing	± 1050 kV peak	±650 kVp
2)	One minute power frequency dry and wet withstand voltage		
-	between line terminals and ground for CT and CVT	460 kV rms	275 kV rms
-	for arrester housing	460 kV rms	275kV rms
Max. radio interference voltage (microvolts) for frequency between 0.5 MHz and 2 MHz in all positions of the equipment.		1000 for CT/CVT 500 for SA (at 156 kV rms)	500 (at 92 kV rms)

Minimum creepage distance :-		
Phase to ground (mm)	6125	3625
System neutral earthing	- Effectively earthed -	
Seismic acceleration	- 0.5g horizontal -	
Partial discharge for :-		
- Surge arrester at 1.05 COV	- Not exceeding 50 pc. -	
- for CT/CVT	- Not exceeding 10 pc. –	

(C) **For 33 kV, 22kV & 11kV Vacuum Circuit Breaker and Isolator**:

Rated voltage kV (rms)	36	25
Rated frequency (Hz)	50	50
No. of Poles	3	3
Design ambient temperature (°C)	50	50

Rated insulation levels :

1) Full wave impulse withstand voltage (1.2/50 micro sec.)

- between line terminals and ground	±170 kVp	±150 kVp	±75 kVp
- between terminals with circuit breaker open	±170 kVp	±150 kVp	±75 kVp
- between terminals with isolator open	±170 kVp	±150 kVp	±75 kVp

2) One minute power frequency dry and wet withstand voltage

- between line terminals and ground	70kV(rms)	50kV(rms)	28kV(rms)
- between terminals with circuit breaker open	70kV(rms)	50kV(rms)	28kV(rms)
- between terminals with Isolator open	70kV(rms)	50kV(rms)	28kV(rms)

Minimum creepage distance:			
Phase to ground (mm)	900	625	300
Between CB Terminals (mm)	900	625	300
System neutral earthing	Effectively earthed		
Seismic acceleration	0.5 g	0.5 g	
Rating of Auxiliary Contacts	10 A at 250 V DC		
Breaking capacity of Auxiliary Contacts	2 A DC with circuit time constant of not less than 20ms		

Auxiliary Switch shall also Comply with other clauses of Chapter-GTR.

(D) FOR 33kV, 22kV & 11kV CT/VT/SA

Rated voltage kV (rms)	36	25	12
Rated frequency (Hz)	50	50	11
No. of poles	1	1	1
Design ambient temperature (°C)	50	50	50
Rated insulation levels :			
1) Full wave impulse withstand voltage (1.2/50 micro sec.)			
- between line terminals and ground	±170 kVp	±150 kVp	±75 kVp
- for arrester housing	±170 kVp	±150 kVp	±75 kVp
2) One minute power frequency dry and wet withstand voltage			
- between line terminals and ground	70kV rms	50kV rms	28kV rms
- for arrester housing	70kV rms	50kV rms	28kV rms
Minimum creepage distance :			
Phase to ground (mm)	900	625	300
Between Terminals (mm)	900	625	300
System neutral earthing	- Effectively earthed -		
Seismic acceleration	0.5 g	0.5 g	
Cantilever strength of bushing	350 kg (minimum)		

(E) Technical Parameters of Bushings/Hollow Column Insulators/support insulators for 33kV, 22kV & 11kV:

(a) Rated Voltage (kV)	36	25	12
(b) Impulse withstand voltage (Dry & Wet) (kVp)	±170	±150 kVp	75
(c) Power frequency withstand voltage (dry and wet) (kV rms)	75	50	28
(d) Total creepage distance (mm)	900	625	300

(e) Pollution Class-III Heavy (as per IEC 71) and as specified in Section-2 for all class of equipment.

5.0 ENGINEERING DATA AND DRAWINGS

5.1 The list of drawings/documents which are to be submitted to the Purchaser shall be discussed and finalised by the Purchaser at the time of award.

The Contractor shall necessarily submit all the drawings/ documents unless anything is waived.

5.2 The Contractor shall submit 4 (four) sets of drawings/ design documents /data / detailed bill of quantity and 1 (one) set of test reports for the approval of the Purchaser. The contractor shall also submit the softcopy of the above documents in addition to hardcopy.

5.3 Drawings

5.3.1 All drawings submitted by the Contractor shall be in sufficient detail to indicate the type, size, arrangement, material description, Bill of Materials, weight of each component, break-up for packing and shipment, dimensions, internal & the external connections, fixing arrangement required and any other information specifically requested in the specifications.

5.3.2 Drawings submitted by the Contractor shall be clearly marked with the name of the Purchaser, the unit designation, the specifications title, the specification number and the name of the Project. Employer/Consultant has standardized few drawings/documents of various make including type test reports which can be used for all projects having similar requirements and in such cases no project specific approval (except for list of applicable drawings alongwith type test reports) is required. However, distribution copies of standard drawings/documents shall be submitted as per provision of the contract. All titles, noting, markings and writings on the drawing shall be in English. All the dimensions should be in SI units.

5.3.3 The review of these data by the Purchaser will cover only general conformance of the data to the specifications and documents, interfaces with the equipment provided under the specifications, external connections and of the dimensions which might affect substation layout. This review by the Purchaser may not indicate a thorough review of all dimensions, quantities and details of the equipment, materials, any devices or items indicated or the accuracy of the information submitted. This review and/or approval 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 and documents.

5.5 All manufacturing and fabrication work in connection with the equipment 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 make the equipment conform to the provisions and intent of the Contract and such changes will again be subject to approval by the Purchaser. Approval of Contractor's drawing or work by the Purchaser shall not relieve the contractor of any of his responsibilities and liabilities under the Contract.

5.6 All engineering data submitted by the Contractor after final process including review and approval by the Purchaser shall form part of the Contract Document and the entire works performed under these specifications shall be performed in strict conformity, unless otherwise expressly requested by the Purchaser in Writing.

5.7 Approval Procedure

The scheduled dates for the submission of the drawings as well as for, any data/information to be furnished by the Purchaser would be discussed and finalised at the time of award. The following schedule shall be followed generally for approval and for providing final documentation.

i)	Approval/comments/ by Purchaser on initial submission	As per agreed schedule

ii)	Resubmission (whenever required)	Within 3 (three) weeks from date of comments
iii)	Approval or comments	Within 3 (three) weeks of receipt of resubmission.
iv)	Furnishing of distribution copies (5 hard copies per substation and one scanned copy (pdf format) for Corporate Centre)	2 weeks from the date of approval
v)	Furnishing of distribution copies of test reports	
	(a) Type test reports (one scanned softcopy in pdf format per substation plus one for corporate centre & one hardcopy per substation)	2 weeks from the date of final approval
	(b) Routine Test Reports (one copy for each substation)	-do-
vi)	Furnishing of instruction/ operation manuals (2 copies per substation and one softcopy (pdf format) for corporate centre & per substation)	As per agreed schedule
(vii)	As built drawings (two sets of hardcopy per substation & one softcopy (pdf format) for corporate centre& per substation)	On completion of entire works

NOTE :

(1) The contractor may please note that all resubmissions must incorporate all comments given in the earlier submission by the Purchaser or adequate justification for not incorporating the same must be submitted failing which the submission of documents is likely to be returned.

(2) All drawings should be submitted in softcopy form, however substation design drawings like SLD, GA, all layouts etc. shall also be submitted in AutoCAD Version. SLD, GA & layout drawings shall be submitted for the entire substation in case of substation extension also.

(3) The instruction Manuals shall contain full details of drawings of all equipment being supplied under this contract, their exploded diagrams with complete instructions for storage, handling, erection, commissioning, testing, operation, trouble shooting, servicing and overhauling procedures.

(4) If after the commissioning and initial operation of the substation, the instruction manuals require any modifications/ additions/changes, the same shall be incorporated and the updated final instruction manuals shall be submitted by the Contractor to the Purchaser.

(5) The Contractor shall furnish to the Purchaser catalogues of spare parts.

(6) All As-built drawings/documents shall be certified by site indicating the changes before final submission.

6.0 MATERIAL/ WORKMANSHIP

6.1 General Requirement

6.1.1 Where the specification does not contain references to workmanship, equipment, materials and components of the covered equipment, it is essential that the same must be new, of highest grade of the best quality of their kind, conforming to best engineering practice and suitable for the purpose for which they are intended.

6.1.2 Incase where the equipment, materials or components are indicated in the specification as “similar” to any special standard, the Purchaser shall decide upon the question of similarity. When required by the specification or when required by the Purchaser the Contractor shall submit, for approval, all the information concerning the materials or components to be used in manufacture. Machinery, equipment, materials and components supplied, installed or used without such approval shall run the risk of subsequent rejection, it being understood that the cost as well as the time delay associated with the rejection shall be borne by the Contractor.

6.1.3 The design of the Works shall be such that installation, future expansions, replacements and general maintenance may be undertaken with a minimum of time and expenses. Each component shall be designed to be consistent with its duty and suitable factors of safety, subject to mutual agreements. All joints and fastenings shall be devised, constructed and documented so that the component parts shall be accurately positioned and restrained to fulfill their required function. In general, screw threads shall be standard metric threads. The use of other thread forms will only be permitted when prior approval has been obtained from the Purchaser.

6.1.4 Whenever possible, all similar part of the Works shall be made to gauge and shall also be made interchangeable with similar parts. All spare parts shall also be interchangeable and shall be made of the same materials and workmanship as the corresponding parts of the Equipment supplied under the Specification. Where feasible, common component units shall be employed in different pieces of equipment in order to minimize spare parts stocking requirements. All equipment of the same type and rating shall be physically and electrically interchangeable.

6.1.5 All materials and equipment shall be installed in strict accordance with the manufacturer’s recommendation(s). Only first-class work in accordance with the best modern practices will be accepted. Installation shall be considered as being the erection of equipment at its permanent location. This, unless otherwise specified, shall include unpacking, cleaning and lifting into position, grouting, levelling, aligning, coupling of or bolting down to previously installed equipment bases/foundations, performing the alignment check and final adjustment prior to initial operation, testing and commissioning in accordance with the manufacturer’s tolerances, instructions and the Specification. All factory assembled rotating machinery shall be checked for alignment and adjustments made as necessary to re-establish the manufacturer’s limits suitable guards shall be provided for the protection of personnel on all exposed rotating and / or moving machine parts and shall be designed for easy installation and removal for maintenance purposes. The spare equipment(s) shall be installed at designated locations and tested for healthiness.

6.1.6 The Contractor shall apply oil and grease of the proper specification to suit the machinery, as is necessary for the installation of the equipment. Lubricants used for installation purposes shall be drained out and the system flushed through where necessary for applying the lubricant required for operation. The Contractor shall apply all operational lubricants to the equipment installed by him.

6.2 Provisions for Exposure to Hot and Humid climate

Outdoor equipment supplied under the specification shall be suitable for service and storage under tropical conditions of high temperature, high humidity, heavy rainfall and environment favourable to the growth of fungi and mildew. The indoor equipments located in non-air conditioned areas shall also be of same type.

6.2.1 Space Heaters

6.2.1.1 The heaters shall be suitable for continuous operation at 230V as supply voltage. On-off switch and fuse shall be provided.

6.2.1.2 One or more adequately rated thermostatically connected heaters shall be supplied to prevent condensation in any compartment. The heaters shall be installed in the compartment and electrical connections shall be made sufficiently away from below the heaters to minimize deterioration of supply wire insulation. The heaters shall be suitable to maintain the compartment temperature to prevent condensation.

6.2.1.3 Suitable anti condensation heaters with the provision of thermostat shall be provided.

6.2.2 FUNGI STATIC VARNISH

Besides the space heaters, special moisture and fungus resistant varnish shall be applied on parts which may be subjected or predisposed to the formation of fungi due to the presence or deposit of nutrient substances. The varnish shall not be applied to any surface of part where the treatment will interfere with the operation or performance of the equipment. Such surfaces or parts shall be protected against the application of the varnish.

6.2.3 Ventilation opening

Wherever ventilation is provided, the compartments shall have ventilation openings with fine wire mesh of brass to prevent the entry of insects and to reduce to a minimum the entry of dirt and dust. Outdoor compartment openings shall be provided with shutter type blinds and suitable provision shall be made so as to avoid any communication of air / dust with any part in the enclosures of the Control Cabinets, Junction boxes and Marshalling Boxes, panels etc.

6.2.4 Degree of Protection

The enclosures of the Control Cabinets, Junction boxes and Marshalling Boxes, panels etc. to be installed shall provide degree of protection as detailed here under:

a) Installed out door: IP- 55

b) Installed indoor in air conditioned area: IP-31

c) Installed in covered area: IP-52

d) Installed indoor in non air conditioned area where possibility of entry of water is limited: IP-41.

e) For LT Switchgear (AC & DC distribution Boards): IP-52

The degree of protection shall be in accordance with IEC-60947 (Part-I) / IEC-60529. Type test report for degree of protection test, shall be submitted for approval.

6.3 RATING PLATES, NAME PLATES AND LABELS

6.3.1 Each main and auxiliary item of substation is to have permanently attached to it in a conspicuous position a rating plate of non-corrosive material upon which is to be engraved manufacturer's name, year of manufacture, equipment name, type or serial number together with details of the loading conditions under which the item of substation in question has been designed to operate, and such diagram plates as may be required by the Purchaser. The rating plate of each equipment shall be according to IEC requirement.

6.3.2 All such nameplates, instruction plates, rating plates of transformers, CB, CT, CVT, SA, Isolators, C & R panels and PLCC equipments shall be provided with English inscriptions.

6.4 FIRST FILL OF CONSUMABLES, OIL AND LUBRICANTS

All the first fill of consumables such as oils, lubricants, filling compounds, touch up paints, soldering/brazing material for all copper piping of circuit breakers and essential chemicals etc. which will be required to put the equipment covered under the scope of the specifications, into successful Operation, shall be furnished by the Contractor unless specifically excluded under the exclusions in these specifications and documents.

7.0 DESIGN IMPROVEMENTS / COORDINATION

7.1 The bidder shall note that the equipment offered by him in the bid only shall be accepted for supply. However, the Purchaser or the Contractor may propose changes in the specification of the equipment or quality thereof and if the Purchaser & contractor agree upon any such changes, the specification shall be modified accordingly.

7.2 If any such agreed upon change is such that it affects the price and schedule of completion, the parties shall agree in writing as to the extent of any change in the price and/or schedule of completion before the Contractor proceeds with the change. Following such agreement, the provision thereof, shall be deemed to have been amended accordingly.

7.3 The Contractor shall be responsible for the selection and design of appropriate equipments to provide the best co-ordinated 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.

7.4 The Contractor has to coordinate designs and terminations with the agencies (if any) who are Consultants/Contractor for the Purchaser. The names of agencies shall be intimated to the successful bidders.

7.5 The Contractor will be called upon to attend design co-ordination meetings with the Engineer, other Contractor's and the Consultants of the Purchaser (if any) during the period of Contract. The Contractor shall attend such meetings at his own cost at Owner's Corporate Centre, Nepal or at mutually agreed venue as and when required and fully cooperate with such persons and agencies involved during those discussions.

8.0 QUALITY ASSURANCE PROGRAMME

8.1 To ensure that the equipment 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 the Purchaser's 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 broadly outlined by the contractor and finalised after discussions before the award of contract. The detailed programme shall be submitted by the contractor after the award for reference. A quality assurance programme of the contractor shall generally cover the following:

(a) His organisation structure for the management and implementation of the proposed quality assurance programme:

(b) Documentation control system;

(c) Qualification data for bidder's key personnel;

(d) The procedure for purchases of materials, parts components and selection of sub-Contractor's services including vendor analysis, source inspection, incoming raw material inspection, verification of material purchases etc.

(e) System for shop manufacturing and site erection controls including process controls and fabrication and assembly control;

(f) Control of non-conforming items and system for corrective actions;

(g) Inspection and test procedure both for manufacture and field activities.

(h) Control of calibration and testing of measuring instruments and field activities;

(i) System for indication and appraisal of inspection status;

(j) System for quality audits;

(k) System for authorising release of manufactured product to the Purcahser.

(l) System for maintenance of records;

(m) System for handling storage and delivery; and

(n) A quality plan detailing out the specific quality control measures and procedures adopted for controlling the quality characteristics relevant to each item of equipment furnished and/or services rendered.

The Purchaser or his duly authorised representative reserves the right to carry out quality audit and quality surveillance of the system and procedure of the Contractor/his vendor's quality management and control activities.

8.2 Quality Assurance Documents

The contractor would be required to submit all the Quality Assurance Documents as stipulated in the Quality Plan at the time of purchaser's inspection of equipment/material

9.0 TYPE TESTING, INSPECTION, TESTING & INSPECTION CERTIFICATE

9.1 All equipment being supplied shall conform to type tests as per technical specification and shall be subject to routine tests in accordance with requirements stipulated under respective chapters.

9.2 The reports for all type tests as per technical specification shall be furnished by the Contractor alongwith equipment / material drawings. The type tests conducted earlier should have either been conducted in accredited laboratory (accredited based on IEC Guide 25 / 17025 or EN 45001 by the national accreditation body of the country where laboratory is located) or witnessed by Utility or representative of accredited test lab or reputed consultant.

The test reports submitted shall be of the tests conducted within last 10 (ten) years prior to the originally Scheduled date of bid opening. In case the test reports are of the test conducted earlier than 10 (ten) years prior to the originally Scheduled date of bid opening, the contractor shall repeat these test(s) at no extra cost to the purchaser.

However, in case of instrument transformers, the following type tests should have been conducted within 5 (five) years prior to the originally Scheduled date of bid opening.

i) Lightning Impulse Test

ii) Switching Impulse Test

iii) Multiple Chopped Impulse Test (For CT)

iv) Chopped Impulse Test (For CVT)

In case the test reports are of these tests (for instrument transformers) as mentioned above are conducted earlier than 5 (five) years prior to the originally Scheduled date of bid opening, the contractor shall repeat these test(s) at no extra cost to the purchaser.

Further, in the event of any discrepancy in the test reports i.e. any test report not acceptable due to any design/manufacturing changes (including substitution of components) or due to non-compliance with the requirement stipulated in the Technical Specification or any/all type tests not carried out, same shall be carried out without any additional cost implication to the Purchaser.

The Contractor shall intimate the Purchaser the detailed program about the tests atleast two (2) weeks in advance in case of domestic supplies & six (6) weeks in advance in case of foreign supplies.

Further, in case type tests are required to be conducted/repeated and the deputation of Inspector/Purchaser's representative is required, then all the expenses shall be borne by the contractor.

9.3 The Purchaser, his duly authorized representative and/or outside inspection agency acting on behalf of the Purchaser shall have at all reasonable times free access to the Contractor's/sub-vendors premises or Works and shall have the power at all reasonable times to inspect and examine the materials and workmanship of the Works during its manufacture or erection if part of the Works is being manufactured or assembled at other premises or works, the Contractor shall obtain for the Engineer and for his duly authorized representative permission to inspect as if the works were manufactured or assembled on the Contractor's own premises or works. Inspection may be made at any stage of manufacture, dispatch or at site at the option of the Purchaser and the equipment if found unsatisfactory due to bad workmanship or quality, material is liable to be rejected.

9.4 The Contractor shall give the Purchaser /Inspector fifteen (15) days written notice for on-shore and six (6) weeks notice for off-shore material being ready for joint testing including contractor and Purchaser. Such tests shall be to the Contractor's account except for the expenses of the Inspector. The Purchaser /inspector, unless witnessing of the tests is virtually waived, will attend such tests within fifteen (15) days of the date of which the equipment is notified as being ready for test/inspection, failing which the Contractor may proceed alone with the test which shall be deemed to have been made in the Inspector's presence and he shall forthwith forward to the Inspector duly certified copies of tests in triplicate.

9.5 The Purchaser or Inspector shall, within fifteen (15) days from the date of inspection as defined herein give notice in writing to the Contractor, of any objection to any drawings and all or any equipment and workmanship which in his opinion is not in accordance with the Contract. The Contractor shall give due consideration to such objections and shall either make the modifications that may be necessary to meet the said objections or shall confirm in writing to the Purchaser /Inspector giving reasons therein, that no modifications are necessary to comply with the Contract.

9.6 When the factory tests have been completed at the Contractor's or Sub-Contractor's works, the Purchaser/inspector shall issue a certificate to this effect within fifteen (15) days after completion of tests but if the tests are not witnessed by the Purchaser /Inspector, the certificate shall be issued within fifteen (15) days of receipt of the Contractor's Test certificate by the Engineer/Inspector. Failure of the Purchaser /Inspector to issue such a certificate shall not prevent the Contractor from proceeding with the Works. The completion of these tests or the issue of the certificate shall not bind the Purchaser to accept the equipment should, it, on further tests after erection, be found not to comply with the Contract. The equipment shall be dispatched to site only after approval of test reports and issuance of CIP by the Purchaser.

9.7 In all cases where the Contract provides for tests whether at the premises or at the works of the Contractor or of any Sub-Contractor, the Contractor except where otherwise specified shall provide free of charge such items 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 of the equipment in accordance with the Contract and shall give facilities to the Purchaser /Inspector or to his authorized representative to accomplish testing.

9.8 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.

9.9 The Purchaser will have the right of having at his own expenses any other test(s) of reasonable nature carried out at Contractor's premises or at site or in any other place in addition of aforesaid type and routine tests, to satisfy that the material comply with the specification.

9.10 The Purchaser reserves the right for getting any field tests not specified in respective chapters of the technical specification conducted on the completely assembled equipment at site. The testing equipments for these tests shall be provided by the Purchaser.

10.0 TESTS

10.1 Pre-commissioning Tests

On completion of erection of the equipment and before charging, each item of the equipment shall be thoroughly cleaned and then inspected jointly by the Purchaser and the Contractor for correctness and completeness of installation and acceptability for charging, leading to initial pre-commissioning tests at Site. The list of pre-commissioning tests to be performed are given in respective chapters and shall be included in the Contractor's quality assurance programme.

10.2 Commissioning Tests

10.2.1 The available instrumentation and control equipment will to be used during such tests and the Purchaser will calibrate, all such measuring equipment and devices as far as practicable.

10.2.2 Any special equipment, tools and tackles required for the successful completion of the Commissioning Tests shall be provided by the Contractor, free of cost.

10.2.3 The specific tests requirement on equipment have been brought out in the respective chapters of the technical specification.

10.3 The Contractor shall be responsible for obtaining statutory clearances from the concerned authorities for commissioning the equipment and the switchyard. However necessary fee shall be reimbursed on production of requisite documents.

11.0 PACKAGING & PROTECTION

11.1 All the equipments 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. On request of the Purchaser, the Contractor shall also submit packing details/associated drawing for any equipment/material under his scope of supply, to facilitate the Purchaser to repack any equipment/material at a later date, in case the need arises. While packing all the materials, the limitation from the point of view of availability of Railway wagon sizes should be taken into account. The Contractor shall be responsible for any loss or damage during transportation, handling and storage due to improper packing. Any demurrage, wharfage and other such charges claimed by the transporters, railways etc. shall be to the account of the Contractor. Purchaser takes no responsibility of the availability of the wagons.

11.2 All coated surfaces shall be protected against abrasion, impact, discoloration and any other damages. All exposed threaded portions shall be suitably protected with either a metallic or a non-metallic protecting device. All ends of all valves and pipings and conduit equipment connections shall be properly sealed with suitable devices to protect them from damage.

12.0 FINISHING OF METAL SURFACES

12.1 All metal surfaces shall be subjected to treatment for anti-corrosion protection. All ferrous surfaces for external use unless otherwise stated elsewhere in the specification or specifically agreed, shall be hot-dip galvanized after fabrication. High tensile steel nuts & bolts and spring washers shall be electro galvanized to service condition 4. All steel conductors including those used for earthing/grounding (above ground level) shall also be galvanized according to Equivalent International Standards.

12.2 HOT DIP GALVANISING

12.2.1 The minimum weight of the zinc coating shall be 610 gm/sq.m and minimum average thickness of coating shall be 86 microns for all items having thickness 6mm and above. For items lower than 6mm thickness requirement of coating thickness shall be as per relevant ASTM. For surface which shall be embedded in concrete, the zinc coating shall be 610 gm/sq. m minimum.

12.2.2 The galvanized surfaces shall consist of a continuous and uniform thick coating of zinc, firmly adhering to the surface of steel. The finished surface shall be clean and smooth and shall be free from defects like discoloured patches, bare spots, unevenness of coating, spelter which is loosely attached to the steel globules, spiky deposits, blistered surface, flaking or peeling off, etc. The presence of any of these defects noticed on visual or microscopic inspection shall render the material liable to rejection.

12.2.3 After galvanizing. no drilling or welding shall be performed on the galvanized parts of the equipment excepting that nuts may be threaded after galvanizing. Sodium dichromate treatment shall be provided to avoid formation of white rust after hot dip galvanization.

12.2.4 The galvanized steel shall be subjected to six one minute dips in copper sulphate solution as per IEC.

12.2.5 Sharp edges with radii less than 2.5 mm shall be able to withstand four immersions of the Standard Preece test. All other coatings shall withstand six immersions. The following galvanizing tests should essentially be performed as per relevant Standards.

- Coating thickness
- Uniformity of zinc
- Adhesion test
- Mass of zinc coating

12.2.6 Galvanised material must be transported properly to ensure that galvanised surfaces are not damaged during transit. Application of zinc rich paint at site shall not be allowed.

12.3 PAINTING

12.3.1 All sheet steel work shall be degreased, pickled, phosphated in accordance with the IS-6005/Equivalent International standard “Code of practice for phosphating iron and sheet”. All surfaces, which will not be easily accessible after shop assembly, shall beforehand be treated and protected for the life of the equipment. The surfaces, which are to be finished painted after installation or require corrosion protection until installation, shall be shop painted with at least two coats of primer. Oil, grease, dirt and swaf shall be thoroughly removed by emulsion cleaning. Rust and scale shall be removed by pickling with dilute acid followed by washing with running water, rinsing with slightly alkaline hot water and drying.

12.3.2 After phosphating, thorough rinsing shall be carried out with clean water followed by final rinsing with dilute dichromate solution and oven drying. The phosphate coating shall be sealed with application of two coats of ready mixed, stoving type zinc chromate primer. The first coat may be “flash dried” while the second coat shall be stoved.

12.3.3 After application of the primer, two coats of finishing synthetic enamel paint shall be applied, each coat followed by stoving. The second finishing coat shall be applied after inspection of first coat of painting.

12.3.4 The exterior and interior colour of the paint in case of new substations shall preferably be RAL 7032 for all equipment, marshalling boxes, junction boxes, control cabinets, panels etc. unless specifically mentioned under respective chapters of the equipments. Glossy white colour inside the equipments /boards /panels/junction boxes is also acceptable. The exterior colour for panels shall be matching with the existing panels in case of extension of a substation. Each coat of primer and finishing paint shall be of slightly different shade to enable inspection of the painting. A small quantity of finishing paint shall be supplied for minor touching up required at site after installation of the equipments.

12.3.5 In case the Bidder proposes to follow his own standard surface finish and protection procedures or any other established painting procedures, like electrostatic painting etc., the procedure shall be submitted alongwith the Bids for Purchaser’s review & approval.

12.3.6 The colour scheme as given below shall be followed for Fire Protection and Air Conditioning systems

S.No.	PIPE LINE	Base colour	Band colour
Fire Protection System			
1	Hydrant and Emulsifier system pipeline	FIRE RED	-
2	Emulsifier system detection line – water	FIRE RED	Sea Green
3	Emulsifier system detection line – Air	FIRE RED	Sky Blue
4	Pylon support pipes	FIRE RED	
Air Conditioning System			
5	Refrigerant gas pipeline – at compressor suction	Canary Yellow	-
6	Refrigerant gas pipeline – at compressor discharge	Canary Yellow	Red
7	Refrigerant liquid pipeline	Dark Admiralty Green	-
8	Chilled water pipeline	Sea Green	-
9	Condenser water pipeline	Sea Green	Dark Blue

The direction of flow shall be marked by → (arrow) in black colour.

Base Colour Direction of flow Band Colour

12.3.7 For aluminium casted surfaces, the surface shall be with smooth finish. Further, in case of aluminium enclosures the surface shall be coated with powder (coating thickness of 60 microns) after surface preparation for painting.

13.0 HANDLING, STORING AND INSTALLATION

13.1 In accordance with the specific installation instructions as shown on manufacturer's drawings or as directed by the Purchaser or his representative, the Contractor shall unload, store, erect, install, wire, test and place into commercial use all the equipment included in the contract. Equipment shall be installed in a neat, workmanlike manner so that it is level, plumb, square and properly aligned and oriented. Commercial use of switchyard equipment means completion of all site tests specified and energisation at rated voltage.

13.2 Contractor may engage manufacturer's Engineers to supervise the unloading, transportation to site, storing, testing and commissioning of the various equipment being procured by them separately. Contractor shall unload, transport, store, erect, test and commission the equipment as per instructions of the manufacturer's supervisory Engineer(s) and shall extend full cooperation to them.

13.3 The contractor shall have to ensure that the hard and flat indoor and outdoor storage areas are in place prior to commencement of delivery of material at site. Contractor shall also ensure availability of proper unloading and material handling equipment like cranes etc. and polyester/nylon ropes of suitable capacity to avoid damage during unloading and handling of material at site. All indoor equipments shall be stored indoors. Outdoor equipment may be stored outdoors but on a hard and flat raised area properly covered with waterproof and dustproof covers to protect them from water seepage and moisture ingress. However, all associated control panels, marshalling boxes operating boxes etc. of outdoor equipments are to be stored indoors only.

Storage of equipment on top of another one is not permitted if the wooden packing is used. Material opened for joint inspection shall be repacked properly as per manufacturer's recommendations.

During storage of material regular periodic monitoring of important parameters like oil level / leakage, SF6 / Nitrogen pressure etc. shall be ensured by the contractor.

13.4 In case of any doubt/misunderstanding as to the correct interpretation of manufacturer's drawings or instructions, necessary clarifications shall be obtained from the Purchaser. Contractor shall be held responsible for any damage to the equipment consequent to not following manufacturer's drawings/instructions correctly.

13.5 Where assemblies are supplied in more than one section, Contractor shall make all necessary mechanical and electrical connections between sections including the connection between buses. Contractor shall also do necessary adjustments/alignments necessary for proper operation of circuit breakers, isolators and their operating mechanisms. All components shall be protected against damage during unloading, transportation, storage, installation, testing and commissioning. Any equipment damaged due to negligence or carelessness or otherwise shall be replaced by the Contractor at his own expense.

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

13.7 The Contractor shall be fully responsible for the equipment/material until the same is handed over to the Purchaser in an operating condition after commissioning. Contractor shall be responsible for the maintenance of the equipment/material while in storage as well as after erection until taken over by Purchaser, as well as protection of the same against theft, element of nature, corrosion, damages etc.

13.8 Where material / equipment is unloaded by Purchaser before the Contractor arrives at site or even when he is at site, Purchaser by right can hand over the same to Contractor and there upon it will be the responsibility of Contractor to store the material in an orderly and proper manner.

13.9 The Contractor shall be responsible for making suitable indoor storage facilities, to store all equipment which requires indoor storage.

13.10 The words 'erection' and 'installation' used in the specification are synonymous.

13.11 Exposed live parts shall be placed high enough above ground to meet the requirements of electrical and other statutory safety codes.

13.12 The design and workmanship shall be in accordance with the best engineering practices to ensure satisfactory performance throughout the service life. If at any stage during the execution of the Contract, it is observed that the erected equipment(s) do not meet the above minimum clearances as given in clause 4.7.1 the Contractor shall immediately proceed to correct the discrepancy at his risks and cost.

13.13 Equipment Bases

A cast iron or welded steel base plate shall be provided for all rotating equipment which is to be installed on a concrete base unless otherwise agreed to by the Purchaser. Each base plate shall support the unit and its drive assembly, shall be of a neat design with pads for anchoring the units, shall have a raised lip all around, and shall have threaded drain connections.

14.0 TOOLS AND TACKLES

The Contractor shall supply with the equipment one complete set of all special tools and tackles for the erection, assembly, dis-assembly and maintenance of the equipment. However, these tools and tackles shall be separately, packed and brought on to Site.

15.0 AUXILIARY SUPPLY

15.1 The sub-station auxiliary supply is normally met through a system indicated under chapter "Electrical & Mechanical Auxiliaries" having the following parameters. The auxiliary power for station supply, including the equipment drive, cooling system of any equipment, air-conditioning, lighting etc shall be designed for the specified Parameters as under. The DC supply for the instrumentation and PLCC system shall also conform the parameters as indicated in the following.

Normal Voltage	Variation in Voltage	Frequency in HZ	Phase/Wire	Neutral connection
400V	± 10	50 ± 2.5%	3/4 Wire	Solidly Earthed.
230V	± 10	50 ± 2.5%	1/2 Wire	Solidly Earthed.
220V	190V to 240V	DC	-	Isolated 2 wire System
110V	95V to 120V	DC	-	Isolated 2 wire System
48V	_	DC	_	2 wire system (+) earthed

Combined variation of voltage and frequency shall be limited to ± 10%.

16.0 SUPPORT STRUCTURE

16.1 The equipment support structures shall be suitable for equipment connections at the first level i.e 5.9 meter from plinth level for 245 kV substations respectively. All equipment support structures shall be supplied alongwith brackets, angles, stools etc. for attaching the operating mechanism, control cabinets & marshalling box (wherever applicable) etc.

16.2 Support structure shall meet the following mandatory requirements:

16.2.1 The minimum vertical distance from the bottom of the lowest porcelain part of the bushing, porcelain enclosures or supporting insulators to the bottom of the equipment base, where it rests on the foundation pad shall be 2.55 metres.

17.0 CLAMPS AND CONNECTORS INCLUDING TERMINAL CONNECTORS

17.1 All power clamps and connectors shall conform to ANSI/NEMA CC1/ Equivalent International standard and shall be made of materials listed below :

For connecting ,ACSR conductors		Aluminum alloy casting conforming to BS:1490/ Equivalent International Standard
For connecting equipment terminals made of copper with ACSR conductors		Bimetallic connectors made from aluminum alloy casting conforming to BS:1490/ Equivalent International Standard with 2mm thick bimetallic liner.
For connecting GI		Galvanized mild shield wire
i)	Bolts nuts and plain washers	Electrogalvanised for sizes Plain, washers below M12, for thers hot dip galvanised.
ii)	Spring washers for item 'a' to 'c'	Electrogalvanised mild steel

17.2 Necessary clamps and connectors shall be supplied for all equipment and connections. The requirement regarding external corona and RIV as specified for any equipment shall include its terminal fittings. If corona rings are required to meet these requirements they shall be considered as part of that equipment and included in the scope of work.

17.3 Where copper to aluminum connections are required, bi-metallic clamps shall be used, which shall be properly designed to ensure that any deterioration of the connection is kept to a minimum and restricted to parts which are not current carrying or subjected to stress.

17.4 Low voltage connectors, grounding connectors and accessories for grounding all equipment as specified in each particular case, are also included in the scope of Work.

17.5 No current carrying part of any clamp shall be less than 10 mm thick. All ferrous parts shall be hot dip galvanised. Copper alloy liner of minimum 2 mm thickness shall be cast integral with aluminum body or 2 mm thick bi-metallic strips shall be provided for Bi-metallic clamps.

17.6 All casting shall be free from blow holes, surface blisters, cracks and cavities. All sharp edges and corners shall be blurred and rounded off.

17.7 Flexible connectors, braids or laminated straps made for the terminal clamps for bus posts shall be suitable for both expansion or through (fixed/sliding) type connection of 4" IPS AL. tube as required. In both the cases the clamp height (top of the mounting pad to centre line of the tube) should be same.

17.8 Clamp shall be designed to carry the same current as the conductor and the temperature rise shall be equal or less than that of the conductor at the specified ambient temperature. The rated current for which the clamp/connector is designed with respect to the specified reference ambient temperature, shall also be indelibly marked on each component of the clamp/connector, except on the hardware.

17.9 All current carrying parts shall be designed and manufactured to have minimum contact resistance.

17.10 Clamps and connectors shall be designed to be corona controlled.

17.11 Tests

17.11.1 Clamps and connectors should be type tested as per NEMA CC1/ Equivalent International Standard and shall also be subjected to routine tests as per NEMA CC1/ Equivalent International Standard. Following type test reports shall be submitted for approval as per clause 9.2 above except for sl. no.(ii) & (iii) for which type test once conducted shall be applicable (i.e. the requirement of test conducted within last ten years shall not be applicable).

i) Temperature rise test (maximum temperature rise allowed is 35°C over 50°C ambient)

ii) Short time current test

iii) Corona (dry) and RIV (dry) test (for 220 KV and above voltage level clamps)

iv) Resistance test and tensile test

18.0 CONTROL CABINETS, JUNCTION BOXES, TERMINAL BOXES & MARSHALLING BOXES FOR OUTDOOR EQUIPMENT

18.1 All types of boxes, cabinets etc. shall generally conform to & be tested in accordance with IEC-60439, as applicable, and the clauses given below:

18.2 Control cabinets, junction boxes, Marshalling boxes & terminal boxes shall be made of sheet steel or aluminum enclosure and shall be dust, water and vermin proof. Sheet steel used shall be atleast 2.0 mm thick cold rolled or 2.5 mm hot rolled or alternately 1.6 mm thick stainless steel can also be used. The box shall be properly braced to prevent wobbling. There shall be sufficient reinforcement to provide level surfaces, resistance to vibrations and rigidity during transportation and installation. In case of aluminum enclosed box the thickness of aluminum shall be such that it provides adequate rigidity and long life as comparable with sheet steel of specified thickness.

18.3 A canopy and sealing arrangements for operating rods shall be provided in marshalling boxes / Control cabinets to prevent ingress of rain water.

18.4 Cabinet/boxes shall be provided with double hinged doors with padlocking arrangements. The distance between two hinges shall be adequate to ensure uniform sealing pressure against atmosphere. The quality of the gasket shall be such that it does not get damaged/cracked during the operation of the equipment.

18.5 All doors, removable covers and plates shall be gasketed all around with suitably profiled EPDM/Neoprene gaskets. The gasket shall be tested in accordance with approved quality plan, BS:4255 / Equivalent International Standard . Ventilating Louvers, if provided, shall have screen and filters. The screen shall be fine wire mesh made of brass.

18.6 All boxes/cabinets shall be designed for the entry of cables from bottom by means of weather proof and dust-proof connections. Boxes and cabinets shall be designed with generous clearances to avoid interference between the wiring entering from below and any terminal blocks or accessories mounted within the box or cabinet. Suitable cable gland plate above the base of the marshalling kiosk/box shall be provided for this purpose along with the proper blanking plates. Necessary number of cable glands shall be supplied and fitted on this gland plate. Gland plate shall have provision for some future glands to be provided later, if required. The Nickel plated glands shall be dust proof, screw on & double compression type and made of brass. The gland shall have provision for securing armour of the cable separately and shall be provided with earthing tag. The glands shall conform to BS:6121.

18.7 A 230V, single phase, 50 Hz, 15 amp AC plug and socket shall be provided in the cabinet with ON-OFF switch for connection of hand lamps. Plug and socket shall be of industrial grade.

18.8 For illumination, a fluorescent tube or CFL of approximately 9 to 15 watts shall be provided. The switching of the fittings shall be controlled by the door switch. .

For junction boxes of smaller sizes such as lighting junction box, manual operated earth switch mechanism box etc., plug socket, heater and illumination is not required to be provided.

18.9 All control switches shall be of MCB/rotary switch type and Toggle/piano switches shall not be accepted.

18.10 Positive earthing of the cabinet shall be ensured by providing two separate earthing pads. The earth wire shall be terminated on to the earthing pad and secured by the use of self etching washer. Earthing of hinged door shall be done by using a separate earth wire.

18.11 The bay marshalling kiosks shall be provided with danger plate and a diagram showing the numbering/connection/feruling by pasting the same on the inside of the door.

18.12 a) The following routine tests alongwith the routine tests as per IEC 60529/ Equivalent International Standard shall also be conducted:

i) Check for wiring

ii) Visual and dimension check

b) The enclosure of bay marshalling kiosk, junction box, terminal box shall conform to IP-55 as per IEC 60529/ Equivalent International Standard including application of, 2.0 KV rms for 1 (one) minute, insulation resistance and functional test after IP-55 test.

20.0 TERMINAL BLOCKS AND WIRING

20.1 Control and instrument leads from the switchboards or from other equipment will be brought to terminal boxes or control cabinets in conduits. All interphase and external connections to equipment or to control cubicles will be made through terminal blocks.

20.2 Terminal blocks shall be 650V grade and have continuous rating to carry the maximum expected current on the terminals and non breakable type. These shall be of moulded piece, complete with insulated barriers, stud type terminals, washers, nuts and lock nuts. Screw clamp, overall insulated, insertion type, rail mounted terminals can be used in place of stud type terminals. But preferably the terminal blocks shall be non-disconnecting stud type of Elmex or Phoenix or Wago or equivalent make.

20.3 Terminal blocks for current transformer and voltage transformer secondary leads shall be provided with test links and isolating facilities. The current transformer secondary leads shall also be provided with short circuiting and earthing facilities.

20.4 The terminal shall be such that maximum contact area is achieved when a cable is terminated. The terminal shall have a locking characteristic to prevent cable from escaping from the terminal clamp unless it is done intentionally.

20.5 The conducting part in contact with cable shall preferably be tinned or silver plated however Nickel plated copper or zinc plated steel shall also be acceptable.

20.6 The terminal blocks shall be of extensible design.

20.7 The terminal blocks shall have locking arrangement to prevent its escape from the mounting rails.

20.8 The terminal blocks shall be fully enclosed with removable covers of transparent, non-deteriorating type plastic material. Insulating barriers shall be provided between the terminal blocks. These barriers shall not hinder the operator from carrying out the wiring without removing the barriers.

20.9 Unless otherwise specified terminal blocks shall be suitable for connecting the following conductors on each side.

a)	All circuits except CT/PT circuits	Minimum of two of 2.5 sq mm copper flexible.
b)	All CT/PT circuits	Minimum of 4 nos. of 2.5 sq mm copper flexible.

20.10 The arrangements shall be in such a manner so that it is possible to safely connect or disconnect terminals on live circuits and replace fuse links when the cabinet is live.

20.11 Atleast 20 % spare terminals shall be provided on each panel/cubicle/box and these spare terminals shall be uniformly distributed on all terminals rows.

20.12 There shall be a minimum clearance of 250 mm between the First/bottom row of terminal block and the associated cable gland plate for outdoor ground mounted marshalling box and the clearance between two rows of terminal blocks shall be a minimum of 150 mm.

20.13 The Contractor shall furnish all wire, conduits and terminals for the necessary interphase electrical connections (where applicable) as well as between phases and common terminal boxes or control cabinets.

20.14 All input and output terminals of each control cubicle shall be tested for surge withstand capability in accordance with the relevant IEC Publications, in both longitudinal and transverse modes. The Contractor shall also provide all necessary filtering, surge protection, interface relays and any other measures necessary to achieve an impulse withstand level at the cable interfaces of the equipment.

21.0 LAMPS & SOCKETS

21.1 Sockets

All sockets (convenience outlets) shall be suitable to accept both 5 Amp & 15 Amp pin round plug as per Nepalese Standard. They shall be switched sockets with shutters.

21.2 Hand Lamp:

A 230 Volts, single Phase, 50 Hz AC plug point shall be provided in the interior of each cubicle with ON-OFF Switch for connection of hand lamps.

21.3 Switches and Fuses:

21.3.1 Each panel shall be provided with necessary arrangements for receiving, distributing, isolating and fusing of DC and AC supplies for various control, signalling, lighting and space heater circuits. The incoming and sub-circuits shall be separately provided with miniature circuit breaker **/** switchfuse units. Selection of the main and Sub-circuit fuse ratings shall be such as to ensure selective clearance of sub-circuit faults. Potential circuits for relaying and metering shall be protected by HRC fuses.

21.3.2 All fuses shall be of HRC cartridge type conforming to IS:9228/ Equivalent International Standard mounted on plug-in type fuse bases. Miniature circuit breakers with thermal protection and alarm contacts will also be accepted. All accessible live connection to fuse bases shall be adequately shrouded. Fuses shall have operation indicators for indicating blown fuse condition. Fuse carrier base shall have imprints of the fuse rating and voltage.

22.0 Bushings, Hollow Column Insulators, Support Insulators:

22.1 Bushings shall be manufactured and tested in accordance with IEC-60137 while hollow column insulators shall be manufactured and tested in accordance with IEC-62155.The support insulators shall be manufactured and tested as per IEC-60168 and IEC-60273. The insulators shall also conform to IEC-60815 as applicable.

The bidder may also offer composite hollow insulators, conforming to IEC-61462.

22.2 Support insulators, bushings and hollow column insulators shall be manufactured from high quality porcelain. Porcelain used shall be homogeneous, free from laminations, cavities and other flaws or imperfections that might affect the mechanical or dielectric quality and shall be thoroughly vitrified tough and impervious to moisture.

22.3 Glazing of the porcelain shall be uniform brown in colour, free from blisters, burrs and similar other defects.

22.4 Support insulators/bushings/hollow column insulators shall be designed to have ample insulation, mechanical strength and rigidity for the conditions under which they will be used.

22.5 When operating at normal rated voltage there shall be no electric discharge between the conductors and bushing which would cause corrosion or injury to conductors, insulators or supports by the formation of substances produced by chemical action. No radio interference shall be caused by the insulators/bushings when operating at the normal rated voltage.

22.6 Bushing porcelain shall be robust and capable of withstanding the internal pressures likely to occur in service. The design and location of clamps and the shape and the strength of the porcelain flange securing the bushing to the tank shall be such that there is no risk of fracture. All portions of the assembled porcelain enclosures and supports other than gaskets, which may in any way be exposed to the atmosphere shall be composed of completely non hygroscopic material such as metal or glazed porcelain.

22.7 All iron parts shall be hot dip galvanised and all joints shall be air tight. Surface of joints shall be trued up porcelain parts by grinding and metal parts by machining. Insulator/bushing design shall be such as to ensure a uniform compressive pressure on the joints.

22.8 Tests

In bushing, hollow column insulators and support insulators shall conform to type tests and shall be subjected to routine tests in accordance with IS: 2099 & IS: 2544 & IS : 5621/ Equivalent International Standard .

23.0 MOTORS

Motors shall be "Squirrel Cage" three phase induction motors of sufficient size capable of satisfactory operation for the application and duty as required for the driven equipment and shall be subjected to routine tests as per applicable standards. The motors shall be of approved make.

23.1 Enclosures

a) Motors to be installed outdoor without enclosure shall have hose proof enclosure equivalent to IP-55 as per IEC 60529/ Equivalent International Standard . For motors to be installed indoor i.e. inside a box, the motor enclosure, shall be dust proof equivalent to IP-44 as per IS: 4691/ Equivalent International Standard .

b) Two independent earthing points shall be provided on opposite sides of the motor for bolted connection of earthing conductor.

c) Motors shall have drain plugs so located that they will drain water resulting from condensation or other causes from all pockets in the motor casing.

d) Motors weighing more than 25 Kg. shall be provided with eyebolts, lugs or other means to facilitate lifting.

23.2 Operational Features

a) Continuous motor rating (name plate rating) shall be at least ten (10) percent above the maximum load demand of the driven equipment at design duty point and the motor shall not be over loaded at any operating point of driven equipment that will rise in service.

b) Motor shall be capable at giving rated output without reduction in the expected life span when operated continuously in the system having the particulars as given in Clause 15.0 of this Chapter.

23.3 Starting Requirements:

a) All induction motors shall be suitable for full voltage direct-on-line starting. These shall be capable of starting and accelerating to the rated speed alongwith the driven equipment without exceeding the acceptable winding temperature even when the supply voltage drops down to 80% of the rated voltage.

b) Motors shall be capable of withstanding the electrodynamic stresses and heating imposed if it is started at a voltage of 110% of the rated value.

c) The locked rotor current shall not exceed six (6) times the rated full load current for all motors, subject to tolerance as given in IS:325/ Equivalent International Standard .

d) Motors when started with the driven equipment imposing full starting torque under the supply voltage conditions specified under Clause 15.0 shall be capable of withstanding atleast two successive starts from cold condition at room temperature and one start from hot condition without injurious heating of winding. The motors shall also be suitable for three equally spread starts per hour under the above referred supply condition.

e) The locked rotor withstand time under hot condition at 110% of rated voltage shall be more than starting time with the driven equipment of minimum permissible voltage by at least two seconds or 15% of the accelerating time whichever is greater. In case it is not possible to meet the above requirement, the Bidder shall offer centrifugal type speed switch mounted on the motor shaft which shall remain closed for speed lower than 20% and open for speeds above 20% of the rated speed. The speed switch shall be capable of withstanding 120% of the rated speed in either direction of rotation.

23.4 Running Requirements:

a) The maximum permissible temperature rise over the ambient temperature of 50 degree C shall be within the limits specified in IS:325/ Equivalent International Standard (for 3 - phase induction motors) after adjustment due to increased ambient temperature specified.

b) The double amplitude of motor vibration shall be within the limits specified in IS: 4729/ Equivalent International Standard. Vibration shall also be within the limits specified by the relevant standard for the driven equipment when measured at the motor bearings.

c) All the induction motors shall be capable of running at 80% of rated voltage for a period of 5 minutes with rated load commencing from hot condition.

23.5 TESTING AND COMMISSIONING

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 Contractor or Purchaser without any extra cost to the Purchaser. The Contractor shall arrange all instruments required for conducting these tests alongwith calibration certificates and shall furnish the list of instruments to the Purchaser for approval.

(a) Insulation resistance.

(b) Phase sequence and proper direction of rotation.

(c) Any motor operating incorrectly shall be checked to determine the cause and the conditions corrected.

24.0 TECHNICAL REQUIREMENT OF EQUIPMENTS

24.1 1.1 KV Grade Power & Control Cables

24.1.1 Applicable for PVC Control Cable

The manufacturers, whose PVC control cables are offered, should have designed, manufactured, tested and supplied in a single contract at least 100 Kms of 1.1 KV grade PVC insulated control cables as on the date of bid opening. Further the manufacturer should also have designed, manufactured, tested and supplied at least 1 km of 27C x 2.5 Sq.mm or higher size as on the originally Scheduled date of bid opening.

24.1.2 Applicable for PVC Power Cable

The manufacturer, whose PVC Power Cables are offered, should have designed, manufactured, tested and supplied in a single contract atleast 100 Kms of 1.1 KV or higher grade PVC insulated power cables as on the date of bid opening. Further the manufacturer should also have designed, manufactured, tested and supplied at least 1 km of 1C x 150 Sq. mm or higher size as on the originally Scheduled date of bid opening.

24.1.3 Applicable for XLPE Power Cables

The Manufacturer, whose XLPE Power cables are offered, should have designed, manufactured, tested and supplied in a single contract atleast 25 Kms of 1.1 KV or higher grade XLPE insulated power cables as on the date of bid opening. Further the manufacturer should also have designed, manufactured, tested and supplied at least 1 km of 1C x 630 Sq. mm or higher size as on the originally Scheduled date of bid opening.

24.2 LT Switchgear

24.2.1 The Manufacturer whose LT Switchgear are offered, should be a manufacturer of LT Switchboards of the type and rating being offered. He should have designed, manufactured, tested and supplied at least 50 nos. draw out circuit breaker panels, out of which at least 5 nos. should have been with relay and protection schemes with current transformer. He should have also manufactured at least 50 nos MCC panels comprising of MCCBs (ie Moulded Case Circuit Breakers) modules of the type offered which should be in successful operation as on originally Scheduled date of bid opening.

24.2.2 The Switchgear items (such as circuit breakers, fuse switch units, contactors etc.), may be of his own make or shall be procured from reputed manufacturers and of proven design. At least one hundred circuit breakers of the make and type being offered shall be operating satisfactory as on originally Scheduled date of bid opening.

ANNEXURE - A

LIST OF SPECIFICATIONS

GENERAL STANDARDS AND CODES

IEC-60060 (Part 1 to P4)	-	High Voltage Test Techniques
IEC 60068	-	Environmental Test
IEC-60117	-	Graphical Symbols
IEC-60156,	-	Method for the Determination of the Electrical Strength of Insulation Oils.
IEC-60270,	-	Partial Discharge Measurements.
IEC-60376	-	Specification and Acceptance of New Sulphur Hexafloride
IEC-60437	-	Radio Interference Test on High Voltage Insulators.
IEC-60507	-	Artificial Pollution Tests on High Voltage Insulators to be used on AC Systems.
IEC-62271-1	-	Common Specification for High Voltage Switchgear & Controlgear Standards.
IEC-60815	-	Guide for the Selection of Insulators in respect of Polluted Conditions.
IEC-60865 (P1 & P2)	-	Short Circuit Current - Calculation of effects.
ANSI-C.1/NFPA.70	-	National Electrical Code
ANSI-C37.90A	-	Guide for Surge Withstand Capability (SWC) Tests
ANSI-C63.21,	-	Specification for Electromagnetic Noise and
C63.3	-	Field Strength Instrumentation 10 KHz to 1 GHZ
C36.4ANSI-C68.1	-	Techniquest for Dielectric Tests
ANSI-C76.1/EEE21	-	Standard General Requirements and Test Procedure for Outdoor Apparatus Bushings.
ANSI-SI-4	-	Specification for Sound Level Metres
ANSI-Y32-2/C337.2	-	Drawing Symbols
ANSI-Z55.11	-	Gray Finishes for Industrial Apparatus and Equipment No. 61 Light Gray
NEMA-107T	-	Methods of Measurements of RIV of High Voltage Apparatus
NEMA-ICS-II	-	General Standards for Industrial Control and Systems Part ICSI-109
CISPR-1	-	Specification for CISPR Radio Interference Measuring Apparatus for the frequency range 0.15 MHz to 30 MHz
CSA-Z299.1-1978h	-	Quality Assurance Program Requirements
CSA-Z299.2-1979h	-	Quality Control Program Requirements
CSA-Z299.3-1979h	-	Quality Verification Program Requirements
CSA-Z299.4-1979h	-	Inspection Program Requirements

TRANSFORMERS AND REACTORS

IEC-60076 (Part 1 to 5)	-	Power Transformers
IEC-60214	-	On-Load Tap-Changers.
IEC-60289	-	Reactors.
IEC- 60354	-	Loading Guide for Oil - Immersed power trans formers
IEC-60076-10	-	Determination of Transformer and Reactor Sound Levels
ANSI-C571280	-	General requirements for Distribution, Power and Regulating Transformers
ANSI-C571290	-	Test Code for Distribution, Power and Regulation Transformers
ANSI-C5716	-	Terminology & Test Code for Current Limiting Reactors
ANSI-C5721	-	Requirements, Terminology and Test Code for Shunt Reactors Rated Over 500 KVA
ANSI-C5792	-	Guide for Loading Oil-Immersed Power Transformers upto and including 100 MVA with 55 deg C or 65 deg C Winding Rise
ANSI-CG,1EEE-4	-	Standard Techniques for High Voltage Testing

CIRCUIT BREAKERS

IEC-62271-100	-	High-voltage switchgear and controlgear - Part 100: Alternating current circuit-breakers
IEC-62271-101	-	High-voltage switchgear and controlgear - Part 101: Synthetic testing
IEC-62155	-	Hollow pressurized and unpressurized ceramic and glass insulators for use in electrical equipment with rated voltages greater than 1 000 V
IEC-62271-110	-	High-voltage switchgear and controlgear - Part 110: Inductive load switching
IEC-62271-109	-	High-voltage switchgear and controlgear - Part 110: Inductive load switching

CURRENT TRANSFORMERS, VOLTAGE TRANSFORMERS AND COUPLING CAPACITOR VOLTAGE TRANSFORMERS

IEC-60044-1	-	Current transformers.
IEC-60044-2	-	Inductive Voltage Transformers.
IEC-60044-5	-	Instrument transformers - Part 5: Capacitor voltage transformers
IEC-60358	-	Coupling capacitors and capacitor dividers.
IEC-60044-4	-	Instrument Transformes : Measurement of Partial Discharges
IEC-60481	-	Coupling Devices for power Line Carrier Systems.

ANSI-C5713	-	Requirements for Instrument transformers
ANSIC92.2	-	Power Line Coupling voltage Transformers
ANSI-C93.1	-	Requirements for Power Line Carrier Coupling Capacitors

BUSHING

IEC-60137	-	Insulated Bushings for Alternating Voltages above 1000V

SURGE ARRESTERS

IEC-60099-4	-	Metal oxide surge arrestors without gaps
IEC-60099-5	-	Selection and application recommendation
ANSI-C62.1	-	IEE Standards for S A for AC Power Circuits
NEMA-LA 1	-	Surge Arresters

CUBICLES AND PANELS & OTHER RELATED EQUIPMENTS

IEC-60068.2.2	-	Basic environmental testing procedures Part 2: Test B: Dry heat
IEC-60529	-	Degree of Protection provided by enclosures.
IEC-60947-4-1	-	Low voltage switchgear and control gear.
IEC-61095	-	Electromechanical Contactors for household and similar purposes.
IEC-60439 (P1 & 2)	-	Low Voltage Switchgear and control gear assemblies
ANSI-C37.20	-	Switchgear Assemblies, including metal enclosed bus.
ANSI-C37.50	-	Test Procedures for Low Voltage Alternating Current Power Circuit Breakers
ANSI-C39	-	Electric Measuring instrument
ANSI-C83	-	Components for Electric Equipment
NEMA-AB	-	Moulded Case Circuit and Systems
NEMA-CS	-	Industrial Controls and Systems
NEMA-PB-1	-	Panel Boards
NEMA-SG-5	-	Low voltage Power Circuit breakers
NEMA-SG-3	-	Power Switchgear Assemblies
NEMA-SG-6	-	Power switching Equipment
NEMA-5E-3	-	Motor Control Centers
1248 (P1 to P9)	-	Direct acting indicating analogue electrical measuring instruments & their accessories.

Disconnecting switches

IEC-62271-102	-	High-voltage switchgear and controlgear - Part 102: Alternating current disconnectors and earthing switches
IEC-60265 (Part 1 & 2)	-	High Voltage switches

ANSI-C37.32	-	Schedule of preferred Ratings, Manufacturing Specifications and Application Guide for high voltage Air Switches, Bus supports and switch accessories
ANSI-C37.34	-	Test Code for high voltage air switches
NEMA-SG6	-	Power switching equipment

PLCC and line traps

IEC-60353	-	Line traps for A.C. power systems.
IEC-60481	-	Coupling Devices for power line carrier systems.
IEC-60495	-	Single sideboard power line carrier terminals
IEC-60683	-	Planning of (single Side-Band) power line carrier systems.
CIGRE	-	Teleprotection report by Committee 34 & 35.
CIGRE	-	Guide on power line carrier 1979.
CCIR	-	International Radio Consultative Committee
CCITT	-	International Telegraph & Telephone Consultative Committee
EIA	-	Electric Industries Association

Protection and control equipment

IEC-60051: (P1 to P9)	-	Recommendations for Direct Acting indicating analogue electrical measuring instruments and their accessories.
IEC-60255 (Part 1 to 23)	-	Electrical relays.
IEC-60297		
(P1 to P4)	-	Dimensions of mechanical structures of the 482.6mm (19 inches) series.
IEC-60359	-	Expression of the performance of electrical & electronic measuring equipment.
IEC-60387	-	Symbols for Alternating-Current Electricity meters.
IEC-60447	-	Man machine interface (MMI) - Actuating principles.
IEC-60521	-	Class 0.5, 1 and 2 alternating current watt hour metres
IEC-60547	-	Modular plug-in Unit and standard 19-inch rack mounting unit based on NIM Standard (for electronic nuclear instruments)
ANSI-81	-	Screw threads
ANSI-B18	-	Bolts and Nuts
ANSI-C37.1	-	Relays, Station Controls etc.
ANSI-C37.2	-	Manual and automatic station control, supervisory and associated telemetering equipment
ANSI-C37.2	-	Relays and relay systems associated with electric power apparatus
ANSI-C39.1	-	Requirements for electrical analog indicating instruments

MOTORS

IEC-60034 (P1 to P19:)	-	Rotating electrical machines
IEC-Document 2	-	Three phase induction motors
(Central Office) NEMA-MGI		Motors and Generators

Electronic equipment and components

MIL-21B, MIL-833 & MIL-2750		
IEC-60068 (P1 to P5)	-	Environmental testing
IEC-60326 (P1 to P2)	-	Printed boards
		Material and workmanship standards
ASTM	-	Specification and tests for materials

Clamps & connectors

NEMA-CC1	-	Electric Power connectors for sub station
NEMA-CC 3	-	Connectors for Use between aluminium or aluminum-Copper Overhead Conductors

Bus hardware and insulators

IEC-60120	-	Dimensions of Ball and Socket Couplings of string insulator units.
IEC-60137	-	Insulated bushings for alternating voltages above 1000 V.
IEC-60168	-	Tests on indoor and outdoor post insulators of ceramic material or glass for Systems with Nominal Voltages Greater than 1000 V.
IEC-62155	-	Hollow pressurized and unpressurized ceramic and glass insulators for use in electrical equipment with rated voltages greater than 1 000 V
IEC-60273	-	Characteristices of indoor and outdoor post insulators for systems with nominal voltages greater than 1000V.
IEC-61462	-	Pressurized and un-pressurized insulator for use in electrical equipment with rated voltage greater than 1000V – Definitions, Test methods, acceptance criteria and design recommendations
IEC-60305	-	Insulators for overhead lines with nominal voltage above 1000V-ceramic or glass insulator units for a.c. systems Characteristics of String Insulator Units of the cap and pintype.
IEC-60372 (1984)	-	Locking devices for ball and socket couplings of string insulator units : dimensions and tests.
IEC-60383 (P1 and P2)	-	Insulators for overhead lines with a nominal voltage above 1000 V.
IEC-60433	-	Characteristics of string insulator units of the long rod type.
IEC-60471	-	Dimensions of Clevis and tongue couplings of string insulator units.

ANSI-C29	-	Wet process proelain insulators
ANSI-C29.1	-	Test methods for electrical power insulators
ANSI-C92.2	-	For insulators, wet-process porcelain and toughened glass suspension type
ANSI-C29.8	-	For wet-process porcelain insulators apparatus, post-type
ANSI-G.8	-	Iron and steel hardware
CISPR-7B	-	Recommendations of the CISPR, tolerances of form and of Position, Part 1
ASTM A-153	-	Zinc Coating (Hot-Dip) on iron and steel hardware

Strain and rigid bus-conductor

ASTM-B 230-82	-	Aluminum 1350 H19 Wire for electrical purposes
ASTM-B 231-81	-	Concentric - lay - stranded, aluminum 1350 conductors
ASTM-B 221	-	Aluminum - Alloy extruded bar, road, wire, shape
ASTM-B 236-83	-	Aluminum bars for electrical purpose (Bus-bars)
ASTM-B 317-83	-	Aluminum-Alloy extruded bar, rod, pipe and structural shapes for electrical purposes (Bus Conductors)

Batteries and batteries charger

Battery

IEC:60896-21&22	-	Lead Acid Batteries Valve Regulated types – Methods of Tests & Requirements
IEC: 60623	-	Vented type nickel Cadmium Batteries
IEC:60622	-	Secondary Cells & Batteries – Sealed Ni-Cd rechargeable single cell
IEC:60623	-	Secondary Cells & Batteries – Vented Ni-Cd rechargeable single cell
IEC:60896-11	-	Stationary Lead Acid Batteries – Vented Type – General requirements & method of tests
IEEE-485	-	Recommended practices for sizing of Lead Acid Batteries
IEEE-1115	-	Sizing of Ni-Cd Batteries
IEEE-1187	-	Recommended practices for design & installation of VRLA Batteries
IEEE-1188	-	Recommended practices for design & installation of VRLA Batteries
IEEE-1189	-	Guide for selection of VRLA Batteries

Battery Charger

IEEE-484	-	Recommended Design for installation design and installation of large lead storage batteries for generating stations and substations.
IEEE-485	-	Sizing large lead storage batteries for generating stations and substations

Wires and cables

ASTMD-2863	-	Measuring the minimum oxygen concentration to support candle like combustion of plastics (oxygen index)
IEC-60096 (part 0 to p4)	-	Radio Frequency cables.
IEC-60183	-	Guide to the Selection of High Voltage Cables.
IEC-60189 (P1 to P7)	-	Low frequency cables and wires with PVC insulation and PVC sheath.
IEC-60227 (P1 to P7)	-	Polyvinyl Chloride insulated cables of rated voltages up to and including 450/750V.
IEC-60228	-	Conductors of insulated cables
IEC-60230	-	Impulse tests on cables and their accessories.
IEC-60287 (P1 to P3)	-	Calculation of the continuous current rating of cables (100% load factor).
IEC-60304	-	Standard colours for insulation for low-frequency cables and wires.
IEC-60331	-	Fire resisting characteristics of Electric cables.
IEC-60332 (P1 to P3)	-	Tests on electric cables under fire conditions.
IEC-60502	-	Extruded solid dielectric insulated power cables for rated voltages from 1 kV upto to 30 kV
IEC-754 (P1 and P2)	-	Tests on gases evolved during combustion of electric cables.

Painting

ANSI-Z551	-	Gray finishes for industrial apparatus and equipment
SSPEC	-	Steel structure painting council

HORIZONTAL CENTRIFUGAL PUMPS

API-610	-	Centrifugal pumps for general services
	-	Hydraulic Institutes Standards
BS:599	-	Methods of testing pumps
PTC-8.2	-	Power Test Codes - Centrifugal pumps

DIESEL ENGINES

ASME Power Test Code	-	Internal combustion engine PTC-17
	-	Codes of Diesel Engine Manufacturer's Association, USA

PIPING VALVES & SPECIALITIES

BS:5150	-	Specification for cast iron gate valves

PG Test Procedures

NFPA-13	-	Standard for the installation of sprinkler system
NFPA-15	-	Standard for water spray fixed system for the fire protection
NFPA-12A	-	Standard for Halong 1301 Fire Extinguishing System

NFPA-72E	-	Standard on Antomatic Fire Detectors
NFPA-12	-	Standard on Carbon dioxide extinguisher systems

Electrical generating and distributing stations code of practice

Steel structures

ANSI-B18.2.1	-	Inch series square and Hexagonal bolts and screws
ANSI-B18.2.2	-	Square and hexagonal nuts
ANSI-G8.14	-	Round head bolts
ASTM-A6	-	Specification for General Requirements for rolled steel plates, shapes, sheet piling and bars of structural use
ASTM-A36	-	Specifications of structural steel
ASTM-A47	-	Specification for malleable iron castings
ASTM-A143	-	Practice for safeguarding against embilement of Hot Galvanized structural steel products and procedure for detaching embrilement
ASTM-A242	-	Specification for high strength low alloy structural steel
ASTM-A283	-	Specification for low and intermediate tensile strength carbon steel plates of structural quality
ASTM-A394	-	Specification for Galvanized steel transmission tower bolts and nuts
ASTM-441	-	Specification for High strength low alloy structural manganese vanadium steel.
ASTM-A572	-	Specification for High strength low alloy colombium-Vanadium steel of structural quality
AWS D1-0	-	Code for welding in building construction welding inspection
AWS D1-1	-	Structural welding code
AISC	-	American institute of steel construction
NEMA-CG1	-	Manufactured graphite electrodes

Piping and pressure vessels

ASME	-	Boiler and pressure vessel code
ASTM-A120	-	Specification for pipe steel, black and hot dipped, zinc-coated (Galvanized) welded and seamless steel pipe for ordinary use
ASTM-A53	-	Specification for pipe, steel, black, and hot-dipped, zinc coated welded and seamless
ASTM-A106	-	Seamless carbon steel pipe for high temperature service
ASTM-A284	-	Low and intermediate tensile strength carbon-silicon steel plates for machine parts and general construction.
ASTM-A234	-	Pipe fittings of wrought carbon steel and alloy steel for moderate and elevated temperatures

ASTM-S181	-	Specification for forgings, carbon steel for general purpose piping
ASTM-A105	-	Forgings, carbon steel for piping components
ASTM-A307	-	Carbon steel externally threated standard fasteners
ASTM-A193	-	Alloy steel and stainless steel bolting materials for high temperature service
ASTM-A345	-	Flat rolled electrical steel for magnetic applications
ASTM-A197	-	Cupola malleable iron
ANSI-B2.1	-	Pipe threads (Except dry seal)
ANSI-B16.1	-	Cast iron pipe flangesand glanged fitting. Class 25, 125, 250 and 800
ANSI-B16.1	-	Malleable iron threaded fittings, class 150 and 300
ANSI-B16.5	-	Pipe flanges and flanged fittings, steel nickel alloy and other special alloys
ANSI-B16.9	-	Factory-made wrought steel butt welding fittings
ANSI-B16.11	-	Forged steel fittings, socket-welding and threaded
ANSI-B16.14	-	Ferrous pipe plug, bushings and locknuts with piplethreads
ANSI-B16.25	-	Butt welding ends
ANSI-B18.1.1	-	Fire hose couplings screw thread.
ANSI-B18.2.1	-	Inch series square and hexagonal bolts and screws
ANSI-B18.2.2	-	Square and hexagonal nuts
NSI-B18.21.1	-	Lock washers
ANSI-B18.21.2	-	Plain washers
ANSI-B31.1	-	Power piping
ANSI-B36.10	-	Welded and seamless wrought steel pipe
ANSI-B36.9	-	Stainless steel pipe

ACSR MOOSE CONDUCTOR

IEC:437-1973	Test on High Voltage Insulators NEMA:107-1964 CISPR
Part - V	Overhead Transmission Purposes
BS:215(Part-II)	Aluminium Conductors galvanized IEC:209-1966 steel reinforced extra high
BS:215(Part-II)	voltage (400 kV and above)

GALVANISED STEEL EARTHWIRE

P5:1992)	overhead transmission purposes.

ANNEXURE - B

Sl No.	LIST OF DRAWINGS/DOCUMENTS
1	Single Line Diagram
2	Electrical Layout – Plan and Sections
3	Tower, Equipment & cable trench layout drawing
4	Earthing system design calculation & layout drawing
5	Lighting protection system design & drawings
6	Structure Layout (Plan & Section) drawing
7	Cantilever Strength calculations (if applicable)
8	Design calculation for Sag – Tension stringing chart
9	GTP and drawings for Bus-Post Insulator
10	Tension/suspension string insulator and Hardware Assembly GTP and drawing
11	Soil Investigation Report (if applicable)
12	**Circuit Breakers (220kV,132kV, 33 kV- As applicable)** - GA drawing, GTP, Type test Reports
13	**CTs & CVTs (220kV,132 kV, 33kV- As applicable)** - GA drawing, GTP, Type test Reports
14	**Surge Arrestors (216kV,120kV, 30kV- As applicable)** - GA drawing, GTP, Type test Reports
15	**Isolators (220kV,132kV, 33 kV- As applicable)** - GA drawing, GTP, Type test Reports
16	**Control, Relay Panels and Substation Automation system** - GTP, technical literature, type test reports
17	**PLCC, LINE TRAP & Digital Protection Coupler** - GTP and technical literature
18	**Civil Works (as applicable)** **a)** Control Room Building Structure Design, Foundation Design & Drg., Plinth Beam Design & Drg. and column Design & Drg. upto G.F. Level **b)** Auto transformer foundation design/drawings **c)** Reactor foundation design/drawings **d)** 220/132/11kV Tower, structure & foundation design/drawings. **e)** 220/132/11kV Equipment support structure & foundation design/drawing

NOTE:

1. The above list of drawing/document is only illustrative and not exhaustive. The contractor shall submit drawings/documents as per requirement of Technical specification.

CHAPTER 3 – SWITCHGEAR

ISOLATORS

CONTENTS

CHAPTER 3- SWITCHGEAR

ISOLATORS

1.0 GENERAL:

1.1 The Isolators and accessories shall conform in general to IEC: 62271-102 except to the extent explicitly modified in specification and shall be in accordance with requirement of Chapter 2-GTR.

1.2 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. 220 kV & below rated isolators shall be double break type, unless specified otherwise.

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

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

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

1.3.3 The isolator shall be designed for use in the geographic and meteorological conditions as given in Chapter 2-GTR.

2.0 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 fail safe type. Suitable individual interlocking coil arrangements shall be provided. The interlocking coil shall be suitable for continuous operation from DC supply and within a variation range as stipulated in Chapter 2-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.

f) Isolator rated for above 72.5 kV shall be of extended mechanical endurance class - M2 as per IEC-62271-102. Isolator rated for 72.5 kV and below shall be of extended mechanical endurance class - M1 as per IEC-62271-102. All earth switches shall be of M0 duty**.**

3.0 CONSTRUCTIONAL FEATURES:

The features and constructional details of Double Break Isolators, earth switches and accessories shall be in accordance with requirements stated hereunder:

3.1 **Contacts:**

a) The contacts shall be self aligning and self cleaning and so designed that binding cannot occur after remaining closed for prolonged periods of time 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 to heating effects.

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

3.2 **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 supporting structure.

3.3 **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 they cannot 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 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.

3.4 **Insulator :**

a) The insulator shall conform to or IEC-60168. The porcelain of the insulator shall conform to the requirements stipulated under Chapter 2-GTR and shall have a minimum cantilever strength of **1000**/600 Kgs. for 245/145 kV insulators respectively.

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

c) The parameters of the insulators shall meet the requirements specified under Chapter 2-GTR.

d) Insulator shall be type and routine tested as per IEC-60168**.**

e) For 245 kV Insulator: (For Isolator)

Top PCD	=	127 mm
No. of holes	=	4 x M16
Bottom PCD	=	**275 mm**
No. of holes	=	8 x 18 dia

f) For 145 kV Insulator: (For Isolator)

Top PCD	=	127 mm
No. of holes	=	4 x M16
Bottom PCD	=	254 mm
No. of holes	=	8 x 18 dia

3.5 **Name Plate :**

The name plate shall conform to the requirements of IEC incorporating year of manufacture.

4.0 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) The earthing switches shall be constructionally interlocked with the isolator so that the earthing 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 be provided for de-linking electrical drive for manual operation.

e) 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.

f) 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.

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

h) Isolator design shall be such as to permit addition of earth switches at a future date. It should be possible to interchange position of earth switch to either side.

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

j) 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.

5.0 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 Chapter 2-GTR and shall be made of cast aluminium/aluminum sheet of adequate thickness (minimum 3 mm) .

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 Chapter 2-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 electromechanical 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) The test report for blocked rotor test of motor shall be submitted as per the requirement of clause 23.0 of Chapter 2: GTR of Technical Specification.

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.

6.0 OPERATION :

a) The main Isolator and earth switches shall be gang operated in case of 245 kV, 145 kV & 36kV. However, 245 kV Tandem Isolators shall be individual-pole operated. The operating mechanism of 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. 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 center" device in the operating mechanism to prevent accidental opening by wind, vibration, short circuit forces or movement of the support structures.

c) Each isolator/pole of isolator and earthswitch shall be provided with a manual operating handle enabling one man to open or close the isolator with ease in one movement 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 shall be provided with positive 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. 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 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 rustproof.

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 indicator 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.

7.0 TERMINAL CONNECTOR STUD/PAD:

The isolator terminal pads/studs shall be made of high quality copper or aluminium 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.

8.0 SUPPORT STRUCTURE:

245 kV/145/36 kV Isolators shall be suitable for mounting on support structures to be supplied in accordance with stipulations of Chapter 2-GTR.

9.0 TESTS:

9.1 In continuation to the requirements stipulated under Chapter 2-GTR the isolator alongwith its earthing switch and operating mechanism should have been type tested as per IEC 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, 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**.**

9.2 The test reports of the type tests 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 Purchaser's review.

(i) Radio interference voltage test.

(ii) Seismic withstand test on isolator mounted on Support structure. The test shall be performed in the following position :

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

10.0 SPARE PARTS AND MAINTENANCE EQUIPMENT:

Bidder shall include in his proposal mandatory spare parts in accordance with the requirements stipulated in Chapter 1 - PSR.

11.0 TECHNICAL PARAMETERS:

(In addition to those specified under Chapter 2-GTR)

I. 245 kV ISOLATORS:

A11.1	Type	Outdoor
A11.2	Rated current at 50^{o}C ambient temperature	1600A / 2500 A (As applicable).
A11.3	Rated short time withstand current of isolator and earth switch (for 1 Sec.)	40 kA/ 50 kA (as applicable)
A11.4	Rated dynamic short circuit withstand current of isolator and earth switch	100 kAp / 125 kAp (as applicable)
A11.5	Temperature rise over design ambient temperature	As per table V of IEC-694.
A11.6	Rated mechanical terminal load	As per table III of IEC-62271-102 or as per value calculated in Chapter 2-GTR whichever is higher.
A11.7	Operating mechanism of isolator/earth switch	A.C. Motor operated
A11.8	No. of auxiliary contacts on each isolator	Besides requirement of this spec., the bidder shall wire up 5 NO + 5 NC to TBs (Reversible) for Purchaser's future use.
A11.9	No. of auxiliary contacts on each earthing switch	Besides requirement of this spec., the bidder shall wire up 3 NO + 3 NC to TBs (Reversible) for Purchaser's future use.
A11.10	Operating time	15 sec. or less
A11.11	Number of terminal in control cabinet (Interpole cabling shall be supplied by Contractor)	All contacts & control circuits are to be wired upto control cabinet plus 24 spare terminals evenly distributed.

II. 145 kV ISOLATORS:

B11.1	Type	Outdoor
B11.2	Rated current at 50^{O}C ambient temperature	1250 A
B11.3	Rated short time withstand current of isolator and earth switch	31.5 kA for 1 Sec.
B11.4	Rated dynamic short circuit withstand current of isolator and earth switch	80 kAp
B11.5	Temperature rise over design ambient temperature	As per table V of IEC-694.
B11.6	Rated mechanical terminal load.	As per table III of IEC-62271-102 or as per value calculated in Chapter 2-GTR whichever is higher.
B11.7	Operating mechanism of isolator/earth switch	A.C. Motor operated
C11.8	No. of auxiliary contacts on each isolator	Besides requirement of this spec., 5 NO + 5 NC to contacts, wired to terminal block exclusively for Purchaser's use in future.
B11.9	No. of auxiliary contacts on each earthing switch	Besides requirement of this spec., the bidder shall wire up 3 NO + 3 NC to TBs (Reversible) for Purchaser's future use.
B11.10	Operating time	15 sec. or less
B11.11	Number of terminal in control cabinet (Interpole cabling shall be supplied by Contractor)	All contacts & control circuits are to be wired upto control cabinet plus 24 spare terminals evenly distributed.

III. 33kV ISOLATOR

C11.1	Type	Outdoor (Double Break)
C11.2	Temperature rise over design ambient temperature	As per table V of IEC 62271-1
C11.3	Rated mechanical terminal load	As per table-III of IEC 62271-102 IEC 129(1984) or as per value calculated in Chapter 2-GTR whichever is higher
C11.4	Number of terminals in control cabinet (Interpole cabling shall be Supplied by contractor)	All contacts and control circuits are to be wired upto control cabinet plus 24 terminals exclusively for Owner's use.
C11.5	Rated current at design ambient temperature	1250/800 Amps(as applicable).
C11.6	Rated short time withstand current of isolator and earthswitch	25 kA for 3 Sec
C11.7	Rated dynamic short circuit withstand current of isolator and earth switch	As per IEC
C11.8	Operating mechanism for Isolator and Earth switch	Manual
C11.9	No. of auxiliary contacts on each isolator	5 NO + 5 NC contacts, wired to terminal block exclusively for Owner's use in future.
C11.10	No. of auxiliary contacts on each earthing switch	3 NO + 3 NC contacts wired to terminal block exclusively for Owner's use in future.

C.I The porcelain of the 36 kV insulators shall have minimum cantilever strength of 450 KGS

C.II 33 kV Isolator shall be gang operated for main blades and earth switches.

12.0 PRE-COMMISSIONING TESTS

12.1 An indicative list of tests on isolator and earthswitch 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 Purchaser without any extra cost to the Purchaser. The Contractor shall arrange all instruments required for conducting these tests alongwith calibration certificates and shall furnish the list of instruments to the Purchaser for approval.

(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.

12. 2 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. The commissioning report shall be signed by the manufacturer's representative.

TECHNICAL SPECIFICATION FOR

AIR CONDITIONING SYSTEM

TABLE OF CONTENTS

TECHNICAL SPECIFICATION FOR

AIR CONDITIONING SYSTEM

1 GENERAL

1.1 This specification covers supply, installation, testing and commissioning and handing over to POWERGRID of Air conditioning system for the control room building and switch-yard panel rooms.

1.2 Air conditioning units for control room building shall be set to maintain the inside DBT at 24 ^{o} C ± 2^{o}C and the air conditioning system for switch-yard panel rooms shall be set to maintain DBT inside switch-yard panel rooms below 24^{o}C.

1.3 Controllers shall be provided in Control room and Battery room for controlling and monitoring the AC units in these rooms as detailed in clause no.2.3.4.

1.4 Each switch-yard panel room shall be provided with temperature transducer to monitor the temperature of the panel room. The Temperature transducer shall have the following specification:

Sensor	:	Air temperature sensor (indoor use)
Output	:	4 to 20mA
Temperature range	:	-5^{o}C to 60^{o}C
Resolution	:	0.1^{o}C
Accuracy	:	0.5^{o}C or better.

2 AIR CONDITIONING SYSTEM FOR CONTROL ROOM BUILDING & relay room.

Air conditioning requirement of control room building shall be met using High wall type split AC units of 2TR.

2.1 Scope

The scope of the equipment to be furnished and services to be provided under the contract are outlined hereinafter and the same is to be read in conjunction with the provision contained in other sections/ clauses. The scope of the work under the contract shall be deemed to include all such items, which although are not specifically mentioned in the bid documents and/or in Bidder's proposal, but are required to make the equipment/system complete for its safe, efficient, reliable and trouble free operation.

2.1.1 Required number of High wall type split AC units of 2TR capacity each complete with air cooled outdoor condensing unit having hermetically sealed compressor and high wall type indoor evaporator unit with cordless remote controller.

2.1.2 Copper refrigerant piping complete with insulation between the indoor and outdoor units as required.

2.1.3 First charge of refrigerant and oil shall be supplied with the unit.

2.1.4 GSS/Aluminium sheet air distribution ducting for distributing conditioned dehumidified air along with supply air diffusers and return air grilles with volume control dampers and necessary splitters etc., suitable fixtures for grilles/diffusers and supports for ducting complete with insulation.

2.1.5 Local start/stop facility for local starting/ stopping of all electrical equipment/ drives.

2.1.6 All instruments and local control panels alongwith controls and interlock arrangements and accessories as required for safe and trouble free operation of the units.

2.1.7 PVC drain piping from the indoor units upto the nearest drain point.

2.1.8 Supply and erection of Power and control cable and earthing.

2.1.9 MS Brackets for outdoor condensing units, condensers as required.

2.2 **Technical specifications.**

2.2.1 **High wall type split AC units**

2.2.1.1 The split AC units shall be complete with indoor evaporator unit, outdoor condensing units and cordless remote control units.

2.2.1.2 Outdoor unit shall comprise of hermetically/semi hermetically sealed compressors mounted on vibration isolators, propeller type axial flow fans and copper tube aluminium finned coils all assembled in a sheet metal casing. The casing and the total unit shall be properly treated and shall be weatherproof type. They shall be compact in size and shall have horizontal discharge of air.

2.2.1.3 The indoor units shall be high wall type. The indoor unit shall be compact and shall have elegant appearance. They shall have low noise centrifugal blowers driven by suitable motors and copper tube aluminium finned cooling coils. Removable and washable polypropylene filters shall be provided. They shall be complete with multi function cordless remote control unit with special features like programmable timer, sleep mode and soft dry mode etc.

2.2.1.4 Cooling capacity of 2TR AC units shall not be less than 22000btu/hr. and shall have energy efficiency rating of 3star or above.

2.2.2 Controllers shall be provided in Control room and Battery room, one controller for each room, to control and monitoring of AC units and shall have the following facilities;

- Standby units shall come in to operation automatically whenthe running main unit fails
- Main and standby units shall be changed over periodically which shall be finalised during detailed engineering.
- Following alarms shall be provided:

  a. Compressor On/OFF condition of each unit
  b. Compressor failure of each unit
  c. Power OFF to AC unit
  d. High temperature in room.

2.3 The Split AC units shall be of Carrier, Voltas, Blue Star, Hitachi, Daikin, LG, National, O'General or Samsung make.

2.4 **Warranty**

All compressors shall have minimum 5 years Warranty from the date of commissioning.

3 AIR CONDITIONING SYSTEM FOR SWITCHYARD PANEL ROOMS.

3.1 Air conditioning system shall be provided in the switchyard panel rooms used for housing control and protection panels. These panel rooms will be located in the switchyard area and generally unmanned. Therefore, the air-conditioning system shall be rugged, reliable, maintenance free and designed for long life.

3.2 Air conditioning system is required for maintaining the temperature below 24^{o}C for sub-station control and protection panels. This shall be achieved using Packaged AC units with free cooling arrangement as per clause 3.4. The system shall be designed for 24 Hours, 365 Days of the year operation to maintain the inside Switchyard panel rooms temperature for proper operation of the critical equipment.

3.3 Number and rating of the units for each panel room shall be as follows:

i. For panel room of length not more than 6 metres.: 2 nos. (1 working + 1 standby) AC units of 2TR capacity each.
ii. For panel room of length more than 6 metres.: 2 nos. (1 working + 1 standby) AC units of 3TR capacity each.

3.4 **Technical specification for Packaged AC units with Free Cooling.**

3.4.1 Each AC unit shall be complete with air cooled condensing unit with scroll compressor, direct expansion type evapourating unit and microprocessor controller. AC units shall be provided with free cooling arrangement. In free cooling mode, the refrigerant cycle of AC unit shall be switched off and outside air (after filtration) shall be circulated inside the conditioned space through the operation of dampers provided with suitable sensors. This mode shall come into operation in the following conditions;

i. When the ambient temperature is below a preset value, which is to be decided during detailed engineering.
ii. In case of failure of refrigeration system of both the units.

3.4.2 One of the air-conditioners shall be running at a time and shall maintain the required temperature. On failure of the running air-conditioner, the other air-conditioner shall start automatically. To ensure longer life of the system and to keep the AC units healthy, change over of the standby unit shall be done periodically through the controller. Further, if inside temperature of the room reaches 35^{o}C due to any emergency condition, the standby air-conditioner shall also start running to maintain the temperature less than 24^{o}C and system shall generate an alarm for such a situation. After achieving this temperature, the standby unit shall again shut off. However any hunting situation shall be reported. No heating or humidification is envisaged for the air conditioning system inside the Switchyard panel rooms.

3.4.3 Packaged AC units with free cooling shall be designed for high sensitive cooling with sensible heat factor of 90% or above.

3.4.4 Each air conditioner shall be completely self-contained. All components of the units shall be enclosed in a powder coated cabinet. The unit shall be assembled, wired, piped, charged with refrigerant and fully factory tested as a system to ensure trouble free installation and start up. Suitable isolation or other by-passing arrangement shall be provided such that any unit/component could be maintained/ repaired without affecting the running standby unit.

3.4.5 The AC units shall be mounted on the wall and the maintenance of unit shall be possible from outside the Switchyard panel room.

3.4.6 Required Features of Various Components

The compressor shall be very reliable, trouble free and long life i.e. hermetically sealed Scroll type of reputed make suitable for continuous operation. Compressor should be installed on vibration isolated mountings or manufacturer's recommended approved mounting. Valve shall be provided for charging/topping up of refrigerant. The bidder shall furnish details of their compressor indicating the MTBF, life of compressor and continuous run time of compressor without failure. The contractor shall also furnish details of all accessories i.e. refrigeration system, evaporator coil, condenser coil, evaporator blower, filter, cabinet, indoor supply and return grill etc. during detailed engineering.

3.5 **Warranty**

All compressors shall have minimum 5 years Warranty from the date of commissioning

3.6 For owner's remote monitoring purposes, necessary digital inputs shall be provided for 'ON' and 'OFF' condition of each compressor.

CHAPTER: SWITCHYARD ERECTION

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1.0 GENERAL

The detailed scope of work includes design, engineering, manufacture, testing at works, supply on FOR destination site basis, insurance, handling, storage, erection testing and commissioning of various items and works as detailed herein.

This Chapter covers the description of the following items.

A. Supply of

- Earthing & Earthing materials
- Lightning protection materials
- Cabling material
- Other items

B. Erection Of all items

2.0 AAC / ACSR CONDUCTOR

2.2 Details of ACSR Conductor

2.2.1 The details of the ACSR Moose conductors shall be as per the standard guaranteed technical particulars enclosed in Annexure-A are tabulated below:

ACSR MOOSE CONDUCTOR:

Sl. No.	Description	Unit	ACSR MOOSE
a)	Stranding and wire diameter	mm	54/3.53 (Al)+ 7/3.53 (Steel)
b)	Number of Strands		
	Steel centre	Nos.	1
	1st Steel Layer	Nos.	6
	1st Aluminium Layer	Nos.	12
	2nd Aluminium Layer	Nos.	18
	3rd Aluminium Layer	Nos.	24
c)	Sectional area of Aluminium	Sq. mm	528.5
d)	Total sectional area	Sq. mm	597.00
e)	Overall diameter	mm	31.77
f)	Approximate weight	kg/ km	2004
g)	Calculated d.c. resistance at 20oC	ohm/ km	0.05552
h)	Minimum UTS	kN	161.2

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2.2.2 The details of Aluminium strand are as follows:

ACSR MOOSE CONDUCTOR:

Sl. No.	Description	Unit	ACSR MOOSE
a)	Minimum breaking load of strand before stranding	KN	1.57
b)	Minimum breaking load of strand after stranding	KN	1.49
c)	Maximum D.C. resistance of strand at 20 deg. Centigrade	Ohm /KM	2.921

2.2.3 The details of steel strand are as follows:

ACSR MOOSE CONDUCTOR:

Sl. No.	**Description**	**Unit**	**ACSR MOOSE**
a)	Minimum breaking load of strand before stranding	KN	12.86
b)	Minimum breaking load of strand after stranding	KN	12.22
c)	Minimum number of twists to be withstood in torsion test when tested on a gauge length of 100 times diameter of wire	Nos.	18 (Before stranding) 16 (Before stranding

2.3 Workmanship

2.3.1 The finished conductor shall be smooth, compact, uniform and free from all imperfections including kinks (protusion of wires), wire cross over, over riding, looseness (wire being dislocated by finger/hand pressure and/or unusual bangle noise on tapping), material inclusions, white rust, powder formation or black spot (on account of reaction with trapped rain water etc.), dirt, grit etc.

2.3.2 All the Aluminium and steel strands shall be smooth, uniform and free from all imperfections, such as spills and splits, diemarks, scratches, abrasions, etc., after drawing.

2.3.3 The steel strands shall be hot dip galvanised and shall have a minimum zinc coating of 260 gms/sq.m. after stranding of the uncoated wire surface. The zinc coating shall be smooth, continuous and of uniform thickness, free from imperfections and shall withstand minimum three dips in standard Preece test. The finished strands and the individual wires shall be of uniform quality and have the same properties and characteristics as prescribed in ASTM designation : B 498-74.

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2.3.4 The steel strands shall be preformed and post formed in order to prevent spreading of strands in the event of cutting of composite core wire. Care shall be taken to avoid, damages to galvanisation during pre-forming and post-forming operation.

2.4 Joints in Wires

2.4.1 Aluminium Wires

Joints in aluminium wires shall be as per relevant International standard.

2.4.2 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.

2.5 Tolerances

The manufacturing tolerances shall be as per relevant International standard.

A. AAC Bull and AAC Tarantala conductor:

a)	Diameter of Aluminium and Steel Strands						
		AAC BULL			AAC TARANTALA		
		Standard	Maximum	Minimum	Standard	Maximum	Minimum
	Aluminium	4.25 mm	4.29 mm	4.21 mm	5.23	5.28	5.18

b)	Lay ratio of Conductor					
			AAC BULL		AAC TARANTALA	
			Maximum	Minimum	Maximum	Minimum
	Aluminium	6 wire layer	16	10	16	10
		12 wire layer	16	10	16	10
		18 wire layer	16	10	16	10
		24 wire layer	14	10	-	-

B. ACSR Bersimis and ACSR Moose conductor:

a)	Diameter of Aluminium and Steel Strands						
		ACSR BERSIMIS			ACSR MOOSE		
		Standard	Maximum	Minimum	Standard	Maximum	Minimum
	Aluminium	4.57 mm	4.61 mm	4.53 mm	3.53 mm	3.55 mm	3.51 mm
	Steel	2.54 mm	2.57 mm	2.51 mm	3.53 mm	3.60 mm	3.46 mm

b)	Lay ratio of Conductor					
			ACSR BERSIMIS		ACSR MOOSE	
			Maximum	Minimum		
	Steel	6 wire layer	18	13	18	16
	Aluminium	8/12 wire layer	17	10	14	12
		14/18 wire layer	16	10	13	11
		20/24 wire layer	14	10	12	10

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2.6 Materials

2.6.1 Aluminium

The aluminium strands shall be hard drawn from electrolytic aluminium rods having purity not less than 99.5% and a copper content not exceeding 0.04%.

2.6.2 Steel

The steel wire strands shall be drawn from high carbon steel wire rods and shall conform to the following chemical composition:

Element	% Composition
Carbon	0.50 to 0.85
Manganese	0.50 to 1.10
Phosphorous	Not more than 0.035
Sulphur	Not more than 0.045
Silicon	0.10 to 0.35

2.6.3 **Zinc**

The zinc used for galvanising shall be electrolytic High Grade Zinc of 99.95% purity.

2.7 **Standard Length**

2.7.1 The conductor shall be supplied as required. No joint shall be allowed within a single span of stringing, jumpers and equipment interconnection.

2.8 Tests :

2.8.1 The following type, acceptance & routine tests and tests during manufacturing shall be carried out on the conductor.

2.8.2 **Type Tests**

In accordance with the stipulation of specification, the following type tests reports of the conductor shall be submitted for approval as per clause 9.2 of Chapter 2 - GTR.

a) UTS test on stranded conductor. .

b) Corona extinction voltage test (dry)

(c) Radio Interference voltage test (dry)

(d) DC resistance test on stranded conductor

2.8.3 **Acceptance Tests**

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a) Visual check for joints, scratches etc. and lengths of conductor

b) Dimensional check on steel and aluminium strands

c) Check for lay ratios of various layers

d) Galvanising test on steel strands

e) Torsion and Elongation test on steel strands

f) Breaking load test on steel and aluminium strands

g) Wrap test on steel and aluminium strands

h) DC resistance test on aluminium strands

i) UTS test on welded joint of aluminium strands

NOTE:

All the above tests except test mentioned at (a) shall be carried out on aluminium and steel strands after stranding only.

2.8.4 **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) All acceptance test as mentioned in Clause 2.7.3 above to be carried out on each coil.

2.8.5 **Tests During Manufacture**

a) Chemical analysis of zinc used for galvanising

b) Chemical analysis of aluminium used for making aluminium strands

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c) Chemical analysis of steel used for making steel strands

2.8.6 **Sample Batch for Type Testing**

The Contractor shall offer material for selection of samples for type testing, only after getting quality assurance plans approved from Owner's Quality Assurance Department. The sample shall be manufactured strictly in accordance with the Quality Assurance Plan approved by Owner.

3.0 Galvanised Steel Earth wire

3.1 Details of Earth wire

3.1.1 The contractor shall supply the earthwire as per the standard guaranteed technical particulars enclosed in Annexure-E of the technical specification, Chapter 12 – Switchyard Erection and separate approval is not required during detailed engineering.

Owner has also standardised the guaranteed technical particulars for the earthwire which are enclosed in Annexure-E of the technical specification, Chapter 12 – Switchyard Erection. The contractor shall supply the earthwire as per the standard guaranteed technical particulars.

3.1.2 The basic details of the earth wire are tabulated below:

Sl.No.	Description	Unit	Value
1.	Stranding & Wire diameter	mm	7/3.66 (steel)
2.	Strands a) Steel Core b) Outer layer	 No. No.	 1 (one) 6 (six)
3.	Total sectional area	Sq. mm.	73.65

Other technical details are furnished in of Annexure -E of this Specification.

3.2 Workmanship

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

3.2.2 The finished material shall have minimum brittleness as it will be subjected to appreciable vibration while in use.

3.2.3 The steel strands shall be hot dip qalvanised (and shall have minimum Zinc coating of 275 gms/sq.m) after stranding of the uncoated wire surface. The zinc

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coating shall be smooth, continuous, of uniform thickness, free from imperfections and shall withstand three and a half dips after stranding in standard Preece test. The steel wire rod shall be of such quality and purity that, when drawn to the size of the strands specified and coated with zinc, the finished strands shall be of uniform quality and have the same properties and characteristics as prescribed in ASTM designation B498-74.

3.2.4 The steel strands shall be preformed and post formed in order to prevent spreading of strands while cutting of composite earth wire. Care shall be taken to avoid damage to galvanisation during preforming and postforming operation.

3.2.5 To avoid susceptibility towards wet storage stains (white rust), the finished material shall be provided with a protective coating of boiled linseed oil.

3.3 Joints in Wires

There shall be no joint of any kind in the finished steel wire strand entering into the manufacture of the earth wire. There shall be no strand joints or strand splices in any length of the completed stranded earth wire.

3.4 Tolerances

The manufacturing tolerance to the extent of the following limits only shall be permitted in the diameter of the individual steel strands and lay length of the earth wire:

	Standard	Maximum	Minimum
Diameter	3.66 mm	3.75 mm	3.57 mm
Lay length	181 mm	198 mm	165 mm

3.5 **Materials**

3.5.1 Steel

The steel wire strands shall be drawn from high carbon steel rods and shall conform to the following requirements as to the chemical composition.

Element	% Composition
Carbon	Not more than 0.55
Manganese	0.4 to 0.9
Phosphorous	Not more than 0.04
Sulphur	Not more than 0.04
Silicon	0.15 to 0.35

3.5.2 Zinc

The zinc used for galvanising shall be electrolytic High Grade Zinc of 99.95% purity. It shall conform to and satisfy all the requirements of IS: 209 -1979/ Equivqlent BS standard.

3.6 Standard Length

3.6.1 The earth wire shall be supplied in standard drum length of manufacturer.

3.8 **TESTS**

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3.8.1 The following type, routine & acceptance tests and tests during manufacturing shall be carried out on the earthwire.

3.8.2 **TYPE TESTS**

In accordance with the stipulation of specification, the following type tests reports of the earthwire shall be submitted for approval as per clause 9.2 of Chapter 2 - GTR.

a) UTS test

b) DC resistance test

3.8.3 **ACCEPTANCE TESTS**

a) Visual check for joints, scratches etc. and length of Earthwire

b) Dimensional check

c) Galvanising test

d) Lay length check

e) Torsion test

f) Elongation test

g) Wrap test

h) DC resistance test

i) Breaking load test

j) Chemical Analysis of steel

3.8.4 **ROUTINE TESTS**

a) Check that there are no cuts, fins etc. on the strands.

b) Check for correctness of stranding.

3.8.5 **TESTS DURING MANUFACTURE**

a) Chemical analysis of zinc used for galvanising

b) Chemical analysis of steel

3.8.6 **SAMPLE BATCH FOR TYPE TESTING**

The Contractor shall offer material for sample selection for type testing, only after getting quality assurance programme approved by the Owner. The samples for type testing shall be manufactured strictly in accordance with the Quality Assurance Programme approved by the Owner.

5.0 Earthing Conductors

5.1 General

All conductors buried in earth and concrete shall be of mild steel. All conductors above ground level and earthing leads shall be of galvanised steel, except for cable trench earthing.

5.2 Constructional Features

5.2.1 Galvanised Steel

a) The minimum weight of the zinc coating shall be 618 gm/sq. m. and minimum thickness shall be 85 microns.

b) The galvanised surfaces shall consist of a continuous and uniformly thick coating of zinc, firmly adhering to the surfaces of steel. The finished surface shall be clean and smooth and shall be free from defects like discoloured patches, bare spots, unevenness of coating, spelter which is loosely attached to the steel globules, spiky deposits, blistered surfaces, flaking or peeling off etc. The presence of any of these defects noticed on visual or microscopic inspection shall render the material liable to rejection.

5.3 Tests

In accordance with stipulations of the specifications galvanised steel shall be subjected to four one minute dips in copper sulphate solution as per IS : 2633// Equivqlent BS standard.

6.0 Spacers

6.1 General

The spacers are to be located at a suitable spacing to limit the short circuit forces as per IEC -60865. Wherever Employer's 220kV & 132kV standard gantry structures are being used, the spacer span(s) for different conductor / span configurations and corresponding short circuit forces shall be as per Annexure-D. For strung buses, flexible type spacers shall be used whereas for jumpers and other connections rigid type spacers shall be used.

Wherever Employer's 220kV & 132kV standard gantry structures are not being used, necessary spacer span calculation shall be provided by the contractor during detailed engineering for the approval of Employer.

6.2 Constructional Features

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6.2.1 No magnetic material shall be used in the fabrication of spacers except for GI bolts and nuts.

6.2.2 Spacer design shall be made to take care of fixing and removing during installation and maintenance.

6.2.3 The design of the spacers shall be such that the conductor does not come in contact with any sharp edge.

6.3 **Tests**

Each type of spacers shall be subjected to the following type tests, acceptance tests and routine tests:

6.3.1 Type Tests: Following type test reports shall be submitted for approval as per clause 9.2 of Chapter 2 - GTR.

a) **Clamp slip tests**

The sample shall be installed on test span of twin conductor bundle string or quadruple conductor bundle string (as applicable) at a tension of 44.2 kN. One of the clamps of the sample when subjected to a longitudinal pull of 2.5 kN parallel to the axis of the conductor shall not slip on the conductor. The permanent displacement between the conductor and the clamp of sample measured after removal of the load shall not exceed 1.0 mm. Similar tests shall be performed on the other clamps of the same sample.

b) Fault current test.

c) Corona Extinction Voltage Test (Dry).

This test shall be performed on 220 kV equipment as per procedure mentioned at Annexure - C, Minimum Corona Extinction voltage shall be 156 kV (rms) line to ground for 220 kV spacers.

d) RIV Test (Dry)

This test shall be performed as per procedure mentioned at Annexure - C, Maximum RIV level at 156 kV (rms) line to ground for 220 kV spacers shall be 1000 micro volts, across 300 ohm resistor at 1 MHz

e) Resilience test (if applicable)

f) Tension Test

g) Log decremant test (if applicable)

h) Compression test

i) Galvanising test

6.3.2 **Acceptance Test**

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a) Visual examination

b) Dimensional verification

c) Movement test

d) Clamp slip test

e) Clamp bolt torque test (if applicable)

f) Assembly torque test

g) Compression test

h) Tension test

i) Galvanising test

j) Hardness test for neoprene (if applicable)

The shore hardness of different points on the elastometer surface of cushion grip clamp shall be measured by shore hardness meter. It shall be between 65 to 80.

k) Ultimate Tensile Strength Test

The UTS of the retaining rods shall be measured. It shall not be less than 35 kg/Sq. mm.

6.3.3 **Routine test**

a) Visual examination

b) Dimensional verification

8.0 GROUNDING SYSTEM

8.1 GENERAL

This specification covers the design, supply, delivery, installation and testing of the complete grounding system as described below.
The complete station grounding work shall be in accordance with the recommendation in the "Guide for Safety in Substation Grounding" IEEE No. 80 and the requirements of this section.

8.2 GROUNDING INSTALLATION FEATURES

8.2.1 The installation shall be complete in all respects for efficient and trouble free service. All work shall be carried out in a first class neat workman like manner. Grounding conductors shall be handled carefully to avoid kinking and cutting of the conductors during laying and installation.All exposed ground conductors runs shall be taken in a neat manner, horizontal, vertical and parallel to building walls or columns and shall not be laid haphazardly.

8.2.2 For all connections made to equipment or to the structures, the grounding conductor, connectors and equipment enclosures shall have good clean contact surfaces. Grounding conductor connection to all electrical equipment, switchgear, transformers, motors, panels, conduit system, equipment enclosures, cable trays, distribution boards, equipment frames, bases, steel structure, etc. shall be by pressure type or bolting type connectors.

8.2.3 All lap, cross and tee connections between two grounding conductors shall be made by thermowelding process or compression type connector. The various joints shall have adequate mechanical strength as well as necessary electrical conductivity not less than that of the parent conductors of the joints. All accessories for grounding installation shall be of quality and design approved by the Employer. The earthing connection between earthing pad of equipment/structures shall be made by two earthing leads.

8.2.4 Ground conductors, when crossing underground trenches, directly laid underground pipe and equipment foundation, if any, shall be at least 300mm below the bottom elevation of such trenches/pipes.

8.2.5 The maximum size of each grid of grounding mat shall not exceed 4X4 meters. The terminals for connecting ground mat and equipment shall be terminated whenever necessary. (The new grounding shall be bonded with existing grounding network.) at Dhalkebar and Hitauda Substations.

8.3 GROUNDING CONDUCTOR

8.3.1 Main Ground Grid
The main ground system shall consist of a grounding grid buried minimum 0.6 meter below grade level. The grounding grid shall consist of copper flat conductor cable or stranded copper wire of minimum size (cross sectional area) 160sq. mm.

8.3.2 Ground Electrodes
The ground electrodes shall be 16mm diameter and 3.0 meter long (min.) copper clad steel. Theseshall be driven into ground and connected to the main ground grid.

8.3.3 Risers
The risers shall consist of copper conductor of adequate size (but not less than 160 sq. mm.) connected at one end to the main ground mat and at the other end to the equipment.

8.4 DESIGN REQUIREMENTS

8.4.1 The Contractor shall measure the soil resistivity in presence of the Employer. Based on the resistivity the contractor shall calculate the total length of buried ground conductor, number of grounding electrode and their depth and spacing to achieve a grounding system resistance of less than 1.0 (One) Ohm.

8.4.2 The Contractor shall calculate the cross-section considering the maximum fault level of 40 kA.

8.4.3 The Contractor shall submit the details of calculations of the grounding

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system for the Employer's approval. The earthing system shall be of single earthing system for the whole substation i.e. all earthings shall be connected to main earthing grid.

8.5 **TESTS**

On completion of the installation, either wholly or in sections, it shall be tested in compliance with relevant Code by the Contractor in presence of the Employer. The cost of any test including labor, material and equipment charges shall be borne by the Contractor. If the ground grid resistance can not be obtained as per his design, then additional grounding conductors shall be buried in the earth, or if necessary, buried in treated soil to obtain the required low ground resistance without any additional cost.

8.7 **DRAWINGS**

After award of the Contract, the Contractor shall furnish the grounding layout drawing with dimensions showing the location of grounding grids, electrodes, test link chambers and risers, backed up by necessary calculations for Employer's approval. The work shall have to be started at site only after getting approval from the Employer. If alteration is required for any work done before getting Employer's approval, the same shall have to be done by the Contractor at no extra cost to the Employer.

STATION GROUNDING SYSTEM

DESCRIPTION	UNIT	REQD
1. Main ground grid conductor material		Copper
2. Main ground grid conductor size	Sq.mm	≥ 160
3. Cross section of riser conductors	Sq mm	≥ 160
4. Ground electrodes		
-Material		Copper clad steel
-Diameter	mm	≥ 16
-Length	meter	3
5. Material of risers		Copper
6. Earthing system designed for	ohm	≤ 1

10.0 Bay Equipment

10.1 The disposition of various bay equipments shall be as per single line diagrams and layout drawings.

10.2 Bay Marshalling Kiosk:-

One no. of bay marshalling kiosk shall be provided for each 220 kV and 132 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) To receive two incoming 400V, 3 phase, 63Amps, AC supply with auto changeover and MCB unit and distribute minimum six outgoing 400V,

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3 phase, 16 Amps AC supplies controlled by MCB.

(ii) To distribute minimum ten outgoing 230V, 10 Amps single phase supplies to be controlled by MCB to be drawn from above 3 phase incomers.

(iii) 200 nos. terminal blocks in vertical formation for interlocking facilities for substations without automation system.

(iv) Necessary Terminal Blocks for terminating cables from ACDB and switchyard panel rooms.

11.0 Equipment Erection DETAILS

11.1 For equipment interconnection, the surfaces of equipment terminal pads, Aluminium tube, conductor & terminal clamps and connectors shall be properly cleaned. After cleaning, contact grease shall be applied on the contact surfaces of equipment terminal pad, Aluminium tube/conductor and terminal clamps to avoid any air gap in between. Subsequently bolts of the terminal pad/terminal connectors shall be tightened and the surfaces shall be cleaned properly after equipment interconnection.

11.2 Muslin or leather cloth shall be used for cleaning the inside and outside of hollow insulators.

11.3 All support insulators, circuit breaker interrupters and other fragile equipment shall preferably be handled with cranes having suitable booms and handling capacity.

11.4 Bending of Aluminium tube and compressed air piping if any should be done by a bending machine and through cold bending only. Bending shall be such that inner diameter of pipe is not reduced.

11.5 Cutting of the pipes wherever required shall be such as to avoid flaring of the ends. Hence only a proper pipe cutting tool shall be used. Hack saw shall not be used.

11.6 Handling of equipment shall be done strictly as per manufacturer's/supplier's instructions/instruction manual.

11.7 Handling equipment, sling ropes etc. should be tested periodically before erection for strength.

11.8 The slings shall be of sufficient length to avoid any damage to insulator due to excessive swing, scratching by sling ropes etc.

12.0 STORAGE

12.1 The Contractor shall provide and construct adequate storage shed for proper

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storage of equipments, where sensitive equipments shall be stored indoors. All equipments during storage shall be protected against damage due to acts of nature or accidents. The storage instructions of the equipment manufacturer/Owner shall be strictly adhered to.

13.0 CABLING MATERIAL

13.1 CABLE TAGS AND MARKERS

13.1.1 Each cable and conduit run shall be tagged with numbers that appear in the cable and conduit schedule.

13.1.2 The tag shall be of aluminium with the number punched on it and securely attached to the cable conduit by not less than two turns of 20 SWG GI wire. Cable tags shall be of rectangular shape for power cables and of circular shape for control cables.

13.1.3 Location of cables laid directly underground shall be clearly indicated with cable marker made of galvanised iron plate.

13.1.4 Location of underground cable joints shall be indicated with cable marker with an additional inscription “Cable joints”.

13.1.5 The marker shall project 150 mm above ground and shall be spaced at an interval of 30 meters and at every change in direction. They shall be located on both sides of road and drain crossings.

13.1.6 Cable tags shall be provided on all cables at each end (just before entering the equipment enclosure), on both sides of a wall or floor crossing, on each duct/conduit entry and at each end & turning point in cable tray/trench runs. Cable tags shall be provided inside the switchgear, motor control centres, control and relay panels etc., wherever required for cable identification, where a number of cables enter together through a gland plate.

13.2 Cable Supports and Cable Tray Mounting Arrangements

13.2.1 The Contractor shall provide embedded steel inserts on concrete floors/walls to secure supports by welding to these inserts or available building steel structures.

13.2.2 The supports shall be fabricated from standard structural steel members.

13.2.3 Insert plates will be provided at an interval of 750 mm wherever cables are to be supported without the use of cable trays, such as in trenches, while at all other places these will be at an interval of 2000 mm.

13.2.4 Vertical run of cables on equipment support structure shall be supported on perforated cable trays of suitable width which shall be suitably bolted/clamped with the equipment support structure.

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13.3 Cable Termination and Connections

13.3.1 The termination and connection of cables shall be done strictly in accordance

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with cable and termination kit manufacturer's instructions, drawing and/or as directed by the Owner.

13.3.2 The work shall include all clamping, fittings, fixing, plumbing, soldering, drilling, cutting, taping, heat shrinking (where applicable), connecting to cable terminal, shorting and grounding as required to complete the job.

13.3.3 Supply of all consumable material shall be in the scope of Contractor.

13.3.4 The equipment will be generally provided with undrilled gland plates for cables/conduit entry. The Contractor shall be responsible for drilling of gland plates, painting and touching up. Holes shall not be made by gas cutting.

13.3.5 Control cable cores entering control panel/switchgear/MCCB/MCC/ miscellaneous panels shall be neatly bunched, clamped and tied with nylon strap or PVC perforated strap to keep them in position.

13.3.6 The Contractor shall tag/ferrule control cable cores at all terminations, as instructed by the Owner. In panels where a large number of cables are to be terminated and cable identification may be difficult, each core ferrule may include the complete cable number as well.

13.3.7 Spare cores shall be similarly tagged with cable numbers and coiled up.

13.3.8 All cable entry points shall be sealed and made vermin and dust proof. Unused openings shall be effectively closed.

13.3.9 Double compression type nickel plated (coating thickness not less than 10 microns) brass cable glands shall be provided by the Contractor for all power and control cables to provide dust and weather proof terminations.

13.3.10 They shall comprise of heavy duty brass casting, machine finished and nickel plated, to avoid corrosion and oxidation. Rubber components used in cable glands shall be neoprene and of tested quality. Cable glands shall be of approved make.

13.3.11 The cable glands shall also be suitable for dust proof and weather proof termination. The test procedure, if required, has to be discussed and agreed to between Owner and cable gland manufacturer.

13.3.12 If the cable-end box or terminal enclosure provided on the equipment is found unsuitable and requires modification, the same shall be carried out by the Contractor, as directed by the Owner.

13.3.13 Crimping tool used shall be of approved design and make.

13.3.14 Cable lugs shall be tinned copper solderless crimping type conforming to IS-8309 & 8394/ Equivqlent International standard. Bimetallic lugs shall be used depending upon type of cables used.

13.3.15 Solderless crimping of terminals shall be done by using corrosion inhibitory compound. The cable lugs shall suit the type of terminals provided.

13.4 STORAGE AND HANDLING OF CABLE DRUMS

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13.4.1 Cable drums shall be unloaded, handled and stored in an approved manner and rolling of drums shall be avoided as far as possible. For short distances, the drums may be rolled provided they are rolled slowly and in proper direction as marked on the drum.

14.0 Directly Buried Cables

14.1 The Contractor shall construct the cable trenches required for directly buried cables. The scope of work shall include excavation, preparation of sand bedding, soil cover, supply and installation of brick or concrete protective covers, back filling and ramming, supply and installation of route markers and joint markers. The Bidder shall ascertain the soil conditions prevailing at site, before submitting the bid.

14.2 The cable (power and control) between LT station, control room, DG set location and fire lighting pump house shall be laid in the buried cable trenches. In addition to the above, for lighting purpose also, buried cable trench can be used in outdoor area.

14.3 Cable route and joint markers and RCC warning covers shall be provided wherever required. The voltage grade of cables shall be engraved on the marker.

15.0 Installation of Cables

15.1 Cabling in the control room shall be done on ladder type cable trays for vertical runs while cabling in switchyard area shall be done on angles in the trench.

15.2 All cables from bay cable trench to equipment's including and all interpole cables (both power and control) for all equipment, shall be laid in PVC pipes of minimum 50 mm nominal outside diameter which shall be buried in the ground at a depth of 250mm below finish formation level. Separate PVC pipes shall be laid for control and power cables. Cable pull boxes of adequate size shall be provided if required.

15.3 Cables shall be generally located adjoining the electrical equipment through the pipe insert embedded in the floor. In the case of equipments located away from cable trench either pipe inserts shall be embedded in the floor connecting the cable trench and the equipment or in case the distance is small, notch/opening on the wall shall be provided. In all these cases necessary bending radius as recommended by the cable manufacturer shall be maintained.

15.4 Cable racks and supports shall be painted after installation with two coats of metal primer (comprising of red oxide and zinc chromate in a synthetic medium) followed by two finishing coats of aluminium paint.

15.5 Suitable arrangement should be used between fixed pipe / cable trays and equipment terminal boxes, where vibration is anticipated.

15.6 Power and control cables in the cable trench shall be laid in separate tiers.

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The order of laying of various cables shall be as follows, for cables other than directly buried.

a) Power cables on top tiers.

b) Control instrumentation and other service cables in bottom tiers.

15.7 Single core cables in trefoil formation shall be laid with a distance of three times the diameter of cable between trefoil centre lines. All power cables shall be laid with a minimum centre to centre distance equal to twice the diameter of the cable of higher size of cables.

15.8 Trefoil clamps for single core cables shall be of pressure die cast aluminium (LM-6), Nylon -6 or fibre glass and shall include necessary fixing GI nuts, bolts, washer etc. These are required at every 2 metre of cable runs.

15.9 Power and control cables shall be securely fixed to the trays/supports with self locking type nylon ties with deinterlocking facility at every 5 metre interval for horizontal run. Vertical and inclined cable runs shall be secured with 25 mm wide and 2 mm thick aluminium strip clamps at every 2m.

15.10 Cables shall not be bent below the minimum permissible limit. The permissible limits are as follows:

Table of Cable and	Minimum bending radius
Power cable	12 D
Control cable	10 D

D is overall diameter of cable

15.11 Where cables cross roads, drains and rail tracks, these shall be laid in reinforced spun concrete or steel pipes buried at not less than one metre depth.

15.12 In each cable run some extra length shall be kept at a suitable point to enable one (for LT cables)/two (for H.T. cables) straight through joints to be made in case the cable develop fault at a later date.

15.13 Selection of cable drums for each run shall be so planned as to avoid using straight through joints. Cable splices will not be permitted except where called for by the drawings, unavoidable or where permitted by the Owner. If straight through joints are unavoidable, the Contractor shall use the straight through joints kit of reputed make.

15.14 Control cable terminations inside equipment enclosures shall have sufficient lengths so that changing of termination in terminal blocks can be done without requiring any splicing.

15.15 Metal screen and armour of the cable shall be bonded to the earthing system of the station, wherever required by the Owner.

15.16 Rollers shall be used at intervals of about two metres while pulling cables.

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15.17 All due care shall be taken during unreeling, laying and termination of cable to avoid damage due to twist, kinks, sharp bends, etc.

15.18 Cable ends shall be kept sealed to prevent damage. In cable vault, fire resistant seal shall be provided underneath the panels.

15.19 Inspection on receipt, unloading and handling of cables shall generally be in accordance with relevant international standard.

15.20 Wherever cable pass through floor or through wall openings or other partitions, GI/PVC wall sleeves with bushes having a smooth curved internal surface so as not to damage the cable, shall be supplied, installed and properly sealed by the Contractor at no extra charges.

15.21 Contractor shall remove the RCC/Steel trench covers before taking up the work and shall replace all the trench covers after the erection-work in that particular area is completed or when further work is not likely to be taken up for some time.

15.22 Contractor shall furnish three copies of the report on work carried out in a particular week, indicating cable numbers, date on which laid, actual length and route, testing carried out, terminations carried out, along with the marked up copy of the cable schedule and interconnection drawing wherever any modifications are made.

15.23 Contractor shall paint the tray identification number on each run of trays at an interval of 10 m.

15.24 In case the outer sheath of a cable is damaged during handling/installation, the Contractor shall repair it at his own cost to the satisfaction of the Owner. In case any other part of a cable is damaged, the same shall be replaced by a healthy cable at no extra cost to the Owner, i.e. the Contractor shall not be paid for installation and removal of the damaged cable.

15.25 All cable terminations shall be appropriately tightened to ensure secure and reliable connections. The Contractor shall cover the exposed part of all cable lugs whether supplied by him or not with insulating tape, sleeve or paint.

15.26 **Cable trays**

i) The cable trays shall be of G.S.sheet and minimum thickness of sheet shall be 2mm.

ii) The Contractor shall perform all tests and inspection to ensure that material and workmanship are according to the relevant standards.

A 2.5 metre straight section of 300mm, 600mm 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.

15.27 **Conduits, Pipes and Duct Installation**

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15.27.1 Contractor shall supply and install all rigid conduits, mild steel pipes,flexible conduits, hume pipes etc. including all necessary sundry materials such as tees, elbows, check nuts, bushing, reducers, enlargers, coupling cap, nipples, gland sealing fittings, pull boxes etc as specified and to be shown in detailed drawing. The size of the conduit/pipe shall be selected on the basis of 40% fill criterion.

15.27.2 Contractor shall have his own facility for bending, cutting and threading the conduits at site. Cold bending should be used. All cuts & threaded ends shall be made smooth without leaving any sharp edges. Anticorrosive paint shall be applied at all field threaded portions.

15.27.3 All conduit/pipes shall be extended on both sides of wall/floor openings. The fabrication and installation of supports and the clamping shall be included in the scope of work by Contractor.

15.27.4 When two lengths of conduits are joined together through a coupling, running threads equal to twice the length of coupling shall be provided on each conduit to facilitate easy dismantling of two conduits.

15.27.5 Conduit installation shall be permanently connected to earth by means of special approved type of earthing clamps. GI pull wire of adequate size shall be laid in all conduits before installation.

15.27.6 Each conduit run shall be painted with its designation as indicated on the drawings such that it can be identified at each end.

15.27.7 Embedded conduits shall have a minimum concrete cover of 50 mm.

15.27.8 Conduit run sleeves shall be provided with the bushings at each end.

15.27.9 Metallic conduit runs at termination shall have two locknuts and a bushing for connection. Flexible conduits shall also be suitably clamped at each end with the help of bushings. Bushings shall have rounded edges so as not to damage the cables.

15.27.10 Where embedded conduits turn upwards from a slab or fill, the termination dimensions shown on the drawings, if any, shall be taken to represent the position of the straight extension of the conduit external to and immediately following the bend. At least one half of the arc length of the bend shall be embedded.

15.27.11 All conduits/pipes shall have their ends closed by caps until cables are pulled. After cables are pulled, the ends of conduits/pipes shall be sealed in an approved manner to prevent damage to threaded portions and entrance of moisture and foreign material.

15.27.12 For underground runs, Contractor shall excavate and back fill as necessary.

15.27.13 Contractor shall supply, unload, store and install conduits required for the lighting installation as specified. All accessories/fittings required for making the installation complete, including but not limited to pull out boxes, ordinary and inspection tees and elbow, checknuts, male and female bushings (brass or galvanised steel), caps, square headed male plugs, nipples, gland sealing

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fittings ,pull boxes, conduits terminal boxes, gaskets and box covers, saddle terminal boxes, and all steel supporting work shall be supplied by the Contractor. The conduit fittings shall be of the same material as conduits.

15.27.14 All unarmoured cables shall run within the conduits from lighting panels to lighting fixtures, receptacles etc.

15.27.15 Size of conduit for lighting shall be selected by the Contractor during detailed engineering.

15.27.16 Exposed conduits shall be run in straight lines parallel to building columns, beams and walls. Unnecessary bends and crossings shall be avoided to present a neat appearance.

15.27.17 Conduit supports shall be provided at an interval of 750mm for horizontal runs and 1000mm for vertical runs.

15.27.18 Conduit supports shall be clamped on the approved type spacer plates or brackets by saddles or U- bolts. The spacer plates or brackets in turn, shall be securely fixed to the building steel by welding and to concrete or brick work by grouting or by nylon rawl plugs. Wooden plug inserted in the masonary or concrete for conduit support is not acceptable.

15.27.19 Embedded conduits shall be securely fixed in position to preclude any movement. In fixing embedded conduit, if welding or brazing is used, extreme care should be taken to avoid any injury to the inner surface of the conduit.

15.27.20 Spacing of embedded conduits shall be such as to permit flow of concrete between them.

15.27.21 Where conduits are placed alongwith cable trays, they shall be clamped to supporting steel at an interval of 600mm.

15.27.22 For directly embedding in soil, the conduits shall be coated with an asphalt-base compound. Concrete pier or anchor shall be provided wherever necessary to support the conduit rigidly and to hold it in place.

15.27.23 Conduit shall be installed in such a way as to ensure against trouble from trapped condensation.

15.27.24 Conduits shall be kept, wherever possible, at least 300mm away from hot pipes, heating devices etc. when it is evident that such proximity may reduce the service life of cables.

15.27.25 Slip joints shall be provided when conduits cross structural expansion joints or where long run of exposed conduits are installed, so that temperature change will cause no distortion due to expansion or contraction of conduit run.

15.27.26 For long conduit run, pull boxes shall be provided at suitable intervals to facilitate wiring.

15.27.27 Conduit shall be securely fastened to junction boxes or cabinets, each with a lock nut inside and outside the box.

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15.27.28 Conduits joints and connections shall be made thoroughly water-tight and rust proof by application of a thread compound which insulates the joints. White lead is suitable for application on embedded conduit and red lead for exposed conduit.

15.27.29 Field bends shall have a minimum radius of four (4) times the conduit diameter. All bends shall be free of kinks, indentations of flattened surfaces. Heat shall not be applied in making any conduit bend. Separate bends may be used for this purpose.

15.27.30 The entire metallic conduit system, whether embedded or exposed, shall be electrically continuous and thoroughly grounded. Where slip joints are used, suitable bounding shall be provided around the joint to ensure a continuous ground circuit.

15.27.31 After installation, the conduits shall be thoroughly cleaned by compressed air before pulling in the wire.

15.27.32 Lighting fixtures shall not be suspended directly from the junction box in the main conduit run.

16.0 Junction Box

a) The Contractor shall supply and install junction boxes complete with terminals as required. The brackets, bolts, nuts, screws etc required for erection are also included in the scope of the Contractor.

b) Junction boxes having volume less than 1600 cubic centimeters may be installed without any support other than that resulting from connecting conduits where two or more rigid metallic conduits enter and accurately position the box. Boxes shall be installed so that they are level, plumb and properly aligned to present a pleasing appearance.

c) Boxes with volumes equal to or greater than 1600 cubic cm, and smaller boxes terminating on less than two rigid metallic conduits or for other reasons not rigidly held, shall be adequately supported by auxiliary steel of standard steel shapes or plates to be fabricated and installed. The Contractor shall perform all drilling, cutting, welding, shimming and bolting required for attachment of supports.

17.0 TESTING AND COMMISSIONING

17.1 An indicative list of tests for testing and commissioning is given below. Contractor shall perform any additional test based on specialities of the items as per the field Q.P./instructions of the equipment Contractor or Owner without any extra cost to the Owner. The Contractor shall arrange all equipments instruments and auxiliaries required for testing and commissioning of equipments alongwith calibration certificates and shall furnish the list of instruments to the Owner for approval.

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17.2 **GENERAL CHECKS**

(a) Check for physical damage.

(b) Visual examination of zinc coating/plating.

(c) Check from name plate that all items are as per order/specification.

(d) Check tightness of all bolts, clamps and connecting terminals using torque wrenches.

(e) For oil filled equipment, check for oil leakage, if any. Also check oil level and top up wherever necessary.

(f) Check ground connections for quality of weld and application of zinc rich paint over weld joint of galvanised surfaces.

(g) Check cleanliness of insulator and bushings.

(h) All checks and tests specified by the manufacturers in their drawings and manuals as well as all tests specified in the relevant code of erection.

(i) Check for surface finish of grading rings (Corona control ring).

(j) Pressure test on all pneumatic lines at 18.5 times the rated pressure shall be conducted.

17.3 STATION EARTHING

a) Check soil resistivity

b) Check continuity of grid wires

c) Check earth resistance of the entire grid as well as various sections of the same.

d) Check for weld joint and application of zinc rich paint on galvanised surfaces.

e) Dip test on earth conductor prior to use.

17.4 **AAC/ ACSR STRINGING WORK, TUBULAR BUS WORK AND POWER CONNECTORS**

a) Physical check for finish

b) Electrical clearance check

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c) Testing of torque by torque wrenches on all bus bar power connectors and other accessories.

d) Millivolt drop test on all power connectors.

e) Sag and tension check on conductors.

17.5 **ALUMINIUM TUBE WELDING**

a) Physical check

b) Millivolt drop test on all joints.

c) Dye penetration test & Radiography test on 10% sample basis on weld joints.

b) Test check on 5% sample joints after cutting the weld piece to observe any voids etc.

17.6 INSULATOR

Visual examination for finish, damage, creepage distance etc.

17.7 All pre/commissioning activities and works work for substation equipment shall be carried out in accordance with owner's "Pre- Commissioning procedures and formats for substation bay equipments" by the contractor. This document shall be provided to the successful contractor during detailed engineering stage.

CHAPTER-6: CONTROL AND RELAY PANELS

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CHAPTER 6: CONTROL, RELAY & PROTECTION PANELS

1. TYPE OF PANELS

1.1 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 panels. In case of panel having width more than 800mm, double leaf-doors shall be provided. Doors shall have handles with either built-in locking facility or will be provided with pad-lock.

1.2 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 either with built-in locking facility or shall be provided with pad-locks. 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.

2. CONSTRUCTIONAL FEATURES

2.1. Control and Relay Board shall be of panels of simplex or duplex type design as indicated in bill of quantity. 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 add more number of panels or** provide panels with larger dimensions. 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.

2.2. 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 IEC 60529 (Part-1).

2.3. 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.

2.4. All doors, removable covers of panels shall be gasketed all around with synthetic gaskets Neoprene/EPDM. 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

2.5. 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.

2.6. 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.

2.7. 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.

2.8. Relay/protection panels of modern modular construction would also be acceptable.

3. MOUNTING

3.1. 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.

3.2. 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.

3.3. 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.

3.4. The centre lines of switches, push buttons and indicating lamps shall not be less than 750mm from the bottom of the panel. The centre lines of relays, meters and recorders shall not be less than 450mm from the bottom of the panel.

3.5. 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.

3.6. No equipment shall be mounted on the doors.

3.7. 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.

4. PANEL INTERNAL WIRING

4.1. 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

4.2. 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 transfer 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.

4.3. All internal wiring shall be securely supported, neatly arranged, readily accessible and connected to equipment terminals and terminal blocks. Wiring gutters & troughs shall be used for this purpose.

4.4. Auxiliary bus wiring for AC and DC supplies, voltage transformer circuits, annunciation circuits and other common services shall be provided near the top of the panels running throughout the entire length of the panels.

4.5. 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. Engraved 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.

4.6. 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.

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

5. TERMINAL BLOCKS

5.1. 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 wiring diagrams. All terminal blocks shall have shrouding with transparent unbreakable material.

5.2. 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.

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

5.4. 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 of 2.5mm Sq. copper.
- AC/DC Power Supply Circuits: One of 6mm Sq. Aluminium.
- All other circuits: minimum of one of 2.5mm Sq. Copper.

5.5. There shall be a minimum clearance of 250mm between the first row of terminal blocks and the associated cable gland plate or panel side wall. Also the clearance between two rows of terminal blocks edges shall be minimum of 150mm.

5.6. 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.

5.7. The number and sizes of the Owner's multi core incoming external cables will be furnished to the Contractor 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.

6. PAINTING

The painting shall be carried out as detailed in Chapter 2–GTR.

7. MIMIC DIAGRAM

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

7.2. 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 be 10mm for bus bars and 7mm for other connections. Painted overlaid mimic is also acceptable.

7.3. Mimic bus colour will be decided **during detailed Engineering.**

7.4. 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.

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

8. NAME PLATES AND MARKINGS

8.1. 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.

8.2. 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.

8.3. 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, serial number and electrical rating data.

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

8.5. 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

8.6. 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.

9. MISCELLANEOUS ACCESSORIES

9.1. **Plug Point**: 230V, 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.

9.2. **Interior Lighting**: Each panel shall be provided with a fluorescent lighting fixture rated for 230 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.

9.3. **Switches and Fuses**: Each panel shall be provided with necessary arrangements for receiving, distributing and isolating of DC and AC supplies for various control, signaling, 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'.

9.4. **Space Heater**: Each panel shall be provided with a thermostatically connected space heater rated for 230V, 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. EARTHING

10.1. 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.

10.2. 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.

10.3. 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.

10.4. 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.

10.5. 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.

10.6. An electrostatic discharge **arrangement** shall be provided in each panel **so as to discharge human body before he handles the equipments inside the panels**.

11. 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, Bus 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.

11.1. Indicating Instruments

11.1.1. Unless otherwise specified, all electrical indicating instruments shall be of digital type suitable for flush mounting.

11.1.2. Instruments shall have 4-digit display; display height being not less than 25 mm

11.1.3. Instrument shall confirm to relevant IEC 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.

11.1.4. Digital voltage and frequency meters shall be of class: 0.5 and shall have digital display of 5 and 4 digits respectively, with display size, not less than 25mm (height).

11.2. Transducers

11.2.1. Transducers (for use with Indicating Instruments and Telemetry/Data Communication application) shall in general conform to IEC:688-1

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

11.2.3. 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.

11.2.4. The transducer characteristic shall be linear throughout the measuring range.

11.2.5. The transducer output shall be load independent.

11.2.6. The input & output of the transducer shall be galvanically isolated.

11.2.7. Each transducer shall be housed in a separate compact case and have suitable terminals for inputs & outputs.

11.2.8. The transducers shall be suitably protected against transient high peaks of voltage & current.

11.2.9. 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.

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

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

11.2.12. 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.

11.2.13. The transducers shall have a low AC ripple on output less than 1%.

11.2.14. The transducer shall have dual output.

12. ANNUNCIATION SYSTEM for Control Panel

12.1. 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.

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

12.3. 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 5 mm.

12.4. 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.

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

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

Hooter	Alarm Annunciation
Bell	Annunciation DC failure
Buzzer	AC supply failure

12.7. 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
4.	Reset Push Button Pressed	Close	On	OFF
		Open	Off	OFF
5.	Lamp Test Push Button Pressed	Open	Steady On	OFF

12.8. Audible annunciation for the failure of DC supply to the annunciation system shall be provided and this annunciation shall operate on 230 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 is restored.

12.9. A separate voltage check relay shall be provided to monitor the failure of supply (230V 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.

12.10. 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 a time.

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 (not applicable for extension of substation) :

- Flasher relay for annunciation system
- Push button for Flasher test
- 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 not prevent the registering of any new annunciation that may land during the test.

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 milli seconds.

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 withstand test , high frequency disturbance test–

class III and fast transient disturbance test –level III as per IEC 60255.

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

13. SWITCHES

13.1. 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.

13.2. 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	:	Pistol grip, lockable and black.

13.3. 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.

13.4. 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 for non- effectively earthed systems and for reading all line to line voltages for effectively earthed systems.

13.5. 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 into 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.

13.6. 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.

13.7. The contacts of all switches shall preferably open and close with snap action to minimise arcing. Contacts of switches shall be spring assisted and contact faces shall be with rivets of pure silver or silver alloy. Springs shall not be used as current carrying parts

13.8. The contact combination and their operation shall be such as to give completeness to the interlock and function of the scheme.

13.9. The contact rating of the switches shall be as follows :

Description	Contact Rating in Amps		
	220V DC	**50V DC**	**230V 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	-	-

14. INDICATING LAMPS

14.1. 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.

14.2. The lamps shall be provided with suitable resistors.

14.3. 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.

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

15. POSITION INDICATORS (if Applicable)

15.1. 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. Their strips shall be of the same colour as the associated mimic.

15.2. 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.

15.3. The rating of the indicator shall not exceed 2.5 W.

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

16. SYNCHRONISING EQUIPMENT

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

16.1. The synchronising instruments shall be mounted either on a synchronising 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

16.1. 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 exceeding 10%. 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. The relay shall have an adjustable time setting range of 0.5-20 seconds. 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

16.1. 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.

16.1. 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.

16.1. 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.

17. RELAYS

17.1. 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 the rear.

17.2. All protective relays shall be of numerical type and communication protocol shall be as per IEC 61850. Further, the test levels of EMI as indicated in IEC 61850 shall be applicable to these relays.

17.3. 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.

17.4. 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. Voltage operated relays shall have adequate thermal capacity for continuous operation.

17.5. 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.

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

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

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

17.9. 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 of the 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).

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

17.11. 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 OWNER.

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

17.13. 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.

18. TRANSMISSION LINE PROTECTION

18.1. All relays shall be suitable for series compensated line.

18.2. 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 220KV transmission lines and Main and back up protection for 132 KV transmission lines.

18.3. The Transmission system for which the line protection equipment are required is **indicated in Chapter 1 – Project Specification Requirement.**

18.4. 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.

18.5. The protective relays shall be suitable for use with capacitor voltage transformers having non-electronic damping and transient response as per IEC.

18.6. 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.

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

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

For 220KV

Main-I: Numerical distance protection scheme

Main-II: Numerical distance protection scheme of a make different from that of Main –I

For 132KV

Main: Numerical distance protection scheme

Back up: Directional Over Current and Earth fault Protection

The detailed description of line protections is given here under.

18.9. **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 to ground faults

(c) shall have stepped time-distance characteristics and three independent zones (zone 1, zone-2 and zone-3)

(d) shall have mho or quadrilateral or other suitably shaped characteristics for zone-1 , zone-2 and zone- 3

(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)

(i) for 220 KV lines:

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

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

(i) shall have facilities for offset features with adjustable 10-20% of Zone-3 setting

(j) shall have variable residual compensation

(k) shall have memory circuits 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

(l) shall have weak end in-feed feature

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

(n) 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 1 sec.

(o) 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 mill seconds. If separate high speed trip relays are used , the operating time of the same shall not be more than 10 milliseconds

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

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

(r) include power swing blocking protection which shall

- have suitable setting range to encircle the distance protection described above
- block tripping during power swing conditions
- release blocking in the event of actual fault

(s) include fuse failure protection which shall monitor all the three 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 7 milliseconds
- remain inoperative for system earth faults

(t) 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 220KV transmission lines

(u) Must have a current reversal guard feature.

18.10. **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 with a definite minimum time of 3.0 seconds at 10 times setting
- 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 with a definite minimum time of 3.0 seconds at 10 times setting
- 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 in the relay for open delta voltage to the relay

18.11. **LINE OVER VOLTAGE PROTECTION RELAY** shall

(a) monitor all three phases

(b) have two independent stages

(c) stage- I & II as built-in with line distance relays Main I & II respectively are acceptable

(d) have an adjustable setting range of 100-170% of rated voltage with 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 100-200 mill seconds for the second stage

(f) be tuned to power frequency

(g) provided with separate operation indicators (flag target) for each stage relays

(h) have a drop-off to pick-up ratio greater than 95%

(i) provide separate out-put contacts for each 'Phase' and stage for breaker trip relays, event logger and other scheme requirements

18.12. All trip relays used in transmission line protection scheme shall be of self/electrical reset type depending on application requirement.

19. **CIRCUIT BREAKER PROTECTION:**

This shall include following functions:

19.1. **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 5-300 seconds

(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 programming.

(e) be of single shot type

(f) have priority circuit to closing of both circuit breakers in case 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) provided for sub-station automation system is also acceptable.

19.2. **LOCAL BREAKER BACK-UP PROTECTION SCHEME** shall

(a) be triple pole type

(b) have an operating time of less than 15 milli seconds

(c) have a resetting time of less than 15 milli seconds

(d) have three over current elements

(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 equipment protections

(f) have a setting range of 20-80% of rated current

(g) have a continuous thermal withstand two times rated current irrespective of the setting

(h) have a timer with continuously adjustable setting range of 0.1-1 seconds

(i) have necessary auxiliary relays to make a comprehensive scheme

(j) be similar relays for complete scope of work as per specification

20. REACTOR PROTECTION

20.1. **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

20.2. **Restricted Earth Fault Protection Relay** shall

(a) be single pole type

(b) be of current/voltage operated high impedance type

(c) have a current setting of 10-40% 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 1000 Volts

20.3. **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 30-80 degree

(e) have a definite time delay relay with a continuously adjustable setting range of 0.2-2.0 seconds

(f) include VT failure relay which shall block the tripping during VT fuse failure condition

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.

21. TRANSFORMER PROTECTION

All transformer protection functions may be grouped into Group-I and Group-II protections in the following manner:

Group-I Protection: Following protection functions may be provided in Group-I Transformer protection relay:

a) Differential Protection as per clause no. 21.1

b) Over fluxing Protection for HV side as per clause no. 21.2

c) Direction Over current and earth fault protection for HV side as per clause no. 21.4

d) Over Load Protection as per clause no. 21.5

Group-II Protection: Following protection functions may be provided in Group-II Transformer protection relay:

e) REF Protection as per clause no. 21.3

f) Over fluxing Protection for IV/LV side as per clause no. 21.2

g) Direction Over current and earth fault protection for IV/LV side as per clause no. 21.4

h) Neutral Current Relay for Single Phase Transformer Bank

The various protections as built-in function of Group I/II protections shall be accepted only if the functional requirements of corresponding protections as specified in clause no. 21.1 to 21.6 are met otherwise separate protection relay(s) shall be offered.

21.1. 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) have an adjustable bias setting range of 20-50%

(e) be suitable for rated current of 1 Amp.

(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 analogue channels in case of 400kV class and above transformers or 6 analogue channels for lower voltage transformers and Voltage in one channel

The disturbance recorder shall have the facility to record the following external digital channel signals apart from the digital signals pertaining to differential relay:

1. REF protection operated
2. HV Breaker status (Main and tie)
3. IV Breaker status
4. Bucholz /OLTC Bucholz alarm / trip etc.
5. WTI/OTI/PRD alarm/trip of transformer etc.

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.

21.2. **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' Vs. 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 95 % or better

21.3. **Restricted Earth Fault Protection** shall

(a) be single pole type

(b) be of current/voltage operated type

(c) have a current setting range of 10-40% of 1 Amp./ have a suitable voltage setting range

(d) be tuned to the system frequency

21.4. **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

21.5. **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 than 95%.

21.6. **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

21.7. **Further, Transformer auxiliary protections contacts (Buchholz, PRV, 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.**

22. TEE DIFFERENTIAL PROTECTION RELAYS

22.1. **TEE-1 Differential 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 of 20-50%

(e) have an operating current setting of 15% of 1 Amp or less

22.2. **TEE-2 Differential 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 1 Amp

(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 1000 volts

23. 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 logger.

(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

24. TRIPPING RELAY

High Speed Tripping Relay shall

(a) be instantaneous (operating time not to exceed 10 milli-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, Disturbance recorder, fault Locator, etc.

(e) be provided with operation indicators for each element/coil.

25. 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.

26. BUS BAR PROTECTION

26.1. Single bus bar protection scheme shall be provided for each main bus and transfer bus (as applicable) for 220KV and 132 KV voltage levels

26.2. Each Bus Bar protection scheme shall

(a) have maximum operating time up to trip impulse to trip relay for all types of faults of 25 milli seconds at 5 times setting value.

(b) operate selectively for each bus bar

(c) give hundred percent security up to 63 KA fault level for 220KV and 31.5 KA for 132 KV

(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) incorporate clear zone indication

(g) be of phase segregated and triple pole type

(h) 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

(i) 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.

(j) be transient free in operation

(k) include continuous D.C. supplies supervision

(l) not cause tripping for the differential current below the load current of heaviest loaded feeder. Contractor shall submit application check for the same.

(m) shall include necessary C.T. switching relays wherever C.T. switching is involved and have 'CT' selection incomplete alarm

(n) include protection 'IN/OUT' switch for each zone

(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 under this specification. 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.

26.3. Built-in Local Breaker Backup protection feature as a part of bus bar protection scheme shall also be acceptable.

26.4. 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.

26.5. 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.

27. WEATHER PROOF RELAY PANELS (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 IEC-60529).

(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 padlocking arrangement.

(f) All doors, removable covers and panels shall be gasketed all around with synthetic gaskets Neoprene/EPDM. 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.

(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 30^{o}C. On-off switch and fuse shall be provided. Heater shall be suitable for 230V 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.

28. FAULT RECORDER

28.1. The fault recorder shall be provided for transmission line and the fault recorder as in-built feature of line distance relay is also acceptable provided the requirements of following clauses are met.

28.2. 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.

28.3. 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.

28.4. The acquisition unit is connected with evaluation unit being supplied as described in chapter 17 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.

28.5. 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 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 printer. The desktop PC shall have Pentium - IV processor or better and having a clock speed 3.0GHz or better. The hard disk capacity of PC shall not be less than 300 GB and RAM capacity shall not be less than 3 GB

28.6. The evaluation unit hardware, for substations having SAS, shall be as described in clause no. 4.0 of chapter sub-station automation system.

28.7. Fault recorder shall have atleast 8 analogue and 16 digital channels for each feeder.

28.8. 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.

28.9. 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.

28.10. 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.

28.11. Necessary software for transferring the data automatically from local evaluation unit to a remote station and receiving the same at the remote station through owner's PLCC/VSAT/LEASED LINE shall be provided.

28.12. 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)

28.13. The Evaluation unit shall be connected to the printer to obtain the graphic form of disturbances whenever desired by the operator.

28.14. 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 chapter sub-station automation clause no. 8.0 and DR evaluation unit.

28.15. 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.

(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 100 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 shall be typically used to record the following digital channels :

1 Main CB R phase open

2 Main CB Y phase open

3 Main CB B phase open

4 Main-1 carrier received

5 Main-1 protection operated

6 Main/Tie /TBC Auto reclosed operated

7 Over Voltage -Stage-1 /2 operated

8 Reactor / Stub/TEE-1/2/UF protection operated

9 Direct Trip received

10 Main-2 carrier received

11 Main- 2/ Back Up protection operated

12 Bus bar protection operated

13 LBB operated of main /tie/TBC circuit breaker

14 Tie/TBC CB R phase open

15 Tie/TBC CB Y phase open

16 Tie/TBC CB B phase open

(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) 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.

28.16. The **colour laser** printer shall be provided which 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 trigger source and Graphic form of analogue and digital signals of all the channels. Two packets of **A4 size** paper (500 sheets in each packet) suitable for printer shall be supplied.

28.17. Each Fault recorder shall have its own time generator and the clock of the time generator shall be such that the drift is limited to $\pm$0.5 seconds/day, if allowed to run without synchronisation. Further, Fault recorder shall have facility to synchronise its time generator from Time Synchronisation Equipment having output of following types

- Voltage signal : (0-5V continuously settable, with 50m Sec. minimum pulse duration)

- Potential free contact (Minimum pulse duration of 50 m Sec.)
- IRIG-B
- RS232C

The recorder shall give annunciation in case of absence of synchronising within a specified time.

28.18. Substations where Time Synchronisation Equipment is not available, time generator of any one of the Fault recorders can be taken as master and time generators of other Fault recorders and Event loggers in that station shall be synchronised to follow the master.

29. **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 2 cycles

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 infeed
- 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

30. TIME SYNCHRONISATION EQUPMENT

30.1. The Time synchronisation equipment shall receive the co-ordinated Universal Time (UTC) **transmitted** through Geo Positioning Satellite System (GPS) and synchronise equipments to the Nepal Standard Time in a substation.

30.2. Time synchronisation equipment shall include antenna, all special cables and processing equipment etc.

30.3. 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.

30.4. Equipment shall operate up to the ambient temperature of 50 degree centigrade and 80% humidity.

30.5. 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).

30.6. Equipment shall meet the requirement of IEC 60255 for storage & operation.

30.7. The system shall be able to track the satellites to ensure no interruption of synchronisation signal.

30.8. The output signal from each port shall be programmable at site for either one hour, half hour, minute or second pulse, as per requirement.

30.9. 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

30.10. The equipment shall have a periodic time correction facility of one second periodicity.

30.11. Time synchronisation equipment shall be suitable to operate from 220V DC or 110V DC as available at Substation.

30.12. 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 having display size of approx. 100 mm height.

31. RELAY TEST KIT

31.1. One relay test kit shall comprise of the following equipment as detailed here under

3 sets	Relay tools kits
2 nos.	Test plugs **for TTB**
2 nos.	Test plugs for using with modular type relays (if applicable)

32. TYPE TESTS

32.1. 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 IEC 60255-5

b) DC Voltage dips and interruptions/Variation as per IEC 6100-4-29.

c) High frequency disturbance test as per IEC 61000-4 16, Class IV (Not applicable for electromechanical relays)

d) Electrostatic discharges as per IEC 61000-4-2, level; 4 (not applicable for Electromechanical relays)

e) Fast transient test as per IEC 61000, 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 distance protection relays and current differential protection relays
- Conformance test as per IEC 61850-10.

For Fault recorder, Disturbance recorder; only performance tests are intended under this item.

g) Tests for thermal and mechanical requirements as per IEC 60255-6

h) Tests for rated burden as per IEC 60255-6

i) Contact performance test as per IEC 60255-0-20 (not applicable for Distance to fault locator and Disturbance recorder)

In case there is a change either in version or in model (Except firmware) of the relay, the contractor has to submit the type test reports for the offered revision/model.

32.2. 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 committee 34 report on Evaluation of characteristics and performance of Power system protection relays and protective systems.

33. 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 cannot be provided in single panel. Similarly, Group-I & Group-II protections for transformer cannot be provided in single panel.

CONTROL PANEL

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 (DC healthy 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/lamp test	3 nos	for each control panel
p	Synchronising Socket	1 no.	for each Circuit Breaker if required
q	Synchronising selector Switch required	1 no.	for each Circuit Breaker switch if
r	Protection Transfer Switch	1 no.	for each breaker in case of DMT /DM*/SMT scheme(Except TBC And BC Breaker)-*with Bypass ISO
s	Mimic to represent SLD	Lot	in all control panels
t	Voltmeter with selector reactor Switch	1 no	for each line, transformer , bus
u	Cut out, mounting and wiring for RWTI and selector switch	Lot	for transformers/reactors

<u>Notes:</u>

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. Common synchronising switch is also acceptable in Synchronising trolley for new Substations. In this case. individual synchronising selector switch is not required for each Circuit Breaker in control panel

5. 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.

LINE PROTECTION PANEL (220 & 132kV)

The Line Protection panel for transmission lines shall consist of following protection features/schemes

Sl. No.	Description	220kV	132kV
1.	Main-1 Numerical Distance protection scheme	1 Set	1 Set
2.	Main-2 Numerical Distance protection scheme	1 Set	NIL
3.	Over Voltage Protection Scheme	NIL	NIL
4.	Fault Recorder	1 Set	NIL
5.	Distance to fault Locator	1 Set	1 Set
6.	3 Phase Trip Relays	2 Nos.	2 Nos.
7.	Flag relays, carrier receive relays, aux. Relays, timers etc as per scheme requirements	As required	As required
8.	Under Voltage protection relay for isolator/earth switch	2 Nos	2 Nos
9. .	Cut-out and wiring with TTB for POWERGRID supplied energy meter	1 Set	1 Set
10.	Directional Back up Over current and E/F protection scheme	NIL	1 Set

In a substation where 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.

a) BUSCOUPLER PANEL

Sl No.	DESCRIPTION	QTY
1	Bay Control Unit/Bay Control & Protection Unit	1NO.
2	Numerical Non Directional Over Current and Earth Fault Relay 1No.with High Set Feature and in built LBB protection(LBB function as part of BCU is acceptable)	1NO.
3	Master Trip Relay with adequate no of contacts 1 No.and Electrical Resettable type	1NO.
5	CB Troubles and Alarm (Part of BCU)	1 SET
6	Metering (part of BCU)	1 SET

b) 220/132kV TRANSFORMER CONTROl & PROTECTION RELAY PANEL

I. The protection panel for 220/33kV Transformer shall consist of the following equipments.

		220kV Side	33kV
1	Transformer Differential protection scheme	1 no	NIL
2	Restricted Earth fault protection scheme	1 no	1 no
3	Directional back up over current and E/F Relay With non-directional high set feature	1set	Nil
4	Non-Directional back up over current and E/F Relay with non-directional high set feature (Part of 33kV BCU is acceptable)	NIL	1 Set
5	Over fluxing protection scheme	Nil	1No.
6	Over load protection scheme	1No.	Nil
7	Three phase trip relays	2No.	2No.
8	Trip supervision relay	2No.	2No.
9	Scheme requirements including transformer Alarms and trip function	Lot	Lot
10	Disturbance Recorder	1No.	-------
11	Revenue Energymeter (As per T.S. Chapter-1)	1No.	1No.

$ BCU for 220kV Bay has been included in the BOQ details of SAS.

c) 33kV BREAKER RELAY PANEL
(Acceptable as Part of Line /transformer Relay panel)

The breaker relay panel for 33kV shall comprise of the following :

	Without A/R
1. DC supply supervision relay	2 no.
2.Trip circuit supervision relays	2 nos.
3. Emergency CB TNC Switches	1 No.
4. Flag relays, aux. relays, timers, trip relays etc. As per scheme requirements. (Acceptable as part of BCU)	Lot

d) TRANSFORMER PROTECTION PANEL (220/132kV)

The protection panel for Auto transformer/Transformer shall consists of the following features/schemes:

S. 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 directional high set feature	1 set	1 set
4.	Over Fluxing Protection scheme	1 no.	--
5.	Overload protection scheme	1 nos.	NIL
6.	Three phase trip relays	2 nos.	2 nos.
7.	CVT selection relays as per scheme requirement	Lot	Lot
8.	Cut-out and wiring with TTB for energy meter	1 set	1 set
9.	Transformer Neutral Current relay for 1-Phase transformer bank	1 Set	
10.	Flag Relays/Aux. Relays for wiring Transformer auxiliary protection contacts such as Buchholz, Oil Temperature, Winding Temperature, PRV, OLTC Buchholz etc. as per scheme requirements	As required	

The above protection schemes may be clubbed in Group-I/II as per clause no. 21 of technical specification.

e) **REACTOR PROTECTION PANEL (220kV & 132kV)**

The protection panel for Reactor shall consist of the following protection 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 etc. as per scheme requirements	As required

f) **BREAKER RELAY PANEL (220kV & 132kV)**

The breaker relay panel shall comprise 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

Trip supervision relays shall be 2 or 6 numbers as per no. of trip coils for each 132KV Circuit breaker

Note: Equipment/relays to be provided under CB Relay Panel may be accommodated in the Protection Panels to be provided for Transmission Line/Transformer/Reactor as applicable.

34. ERECTION AND MAINTENANCE TOOL EQUIPMENTS

All special testing equipment required for the installation and maintenance of the apparatus, instruments devices shall be furnished in relevant schedule

35. TROPICALISATION

Control 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.

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 the figure-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 500 MW

System parameters

System voltage =400KV

CTR= 1000/1

PTR = 400000/110 (with CVT, the parameters of CVT model are shown in figure –2)

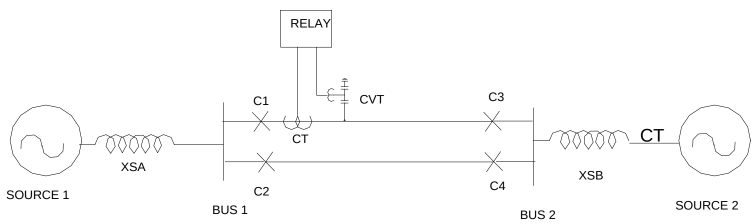

FIGURE 1

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 in Kms	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)

* Alternatively , the tests can be done with 10 Ω secondary impedance and source impedance may accordingly be modified

CVT Model

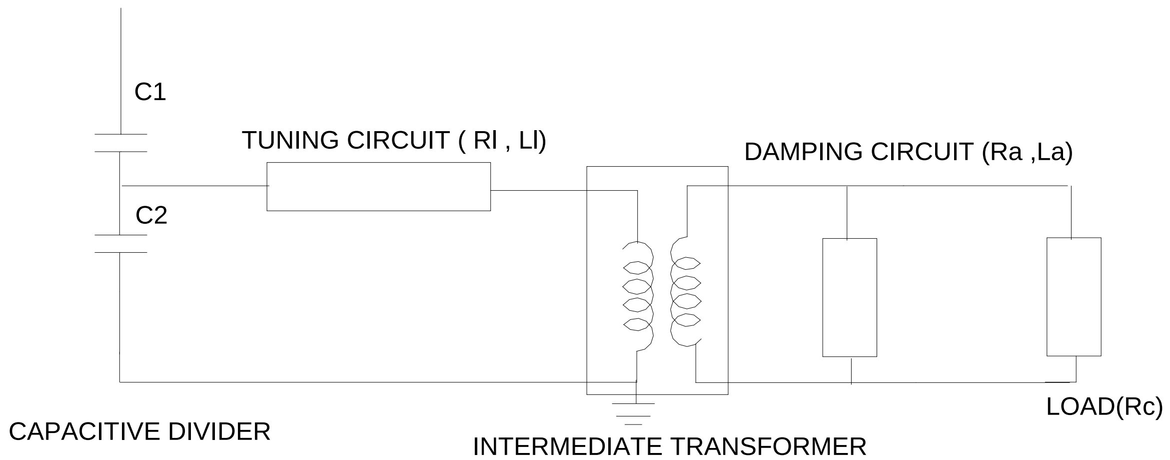

Figure-2

XC1	1.455 µ mho
XC2	27.646 µ mho
Rl	320 Ω
XLl	34243 Ω
Ra	4.200 Ω
Xla	197.92 Ω

Rc	14.00 Ω
Transformation ratio of Intermediate transformer	181.8

Details of fault cases to be done

Sl no	Description	Single source with short line (2 Ω)		Single source long line (20 Ω)	Double source with short double line (2 Ω)	Double source with long single line (20 Ω)
		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
1	Dynamic accuracy for zone 1	Tests to be done at 2 locations (84 % and 76 % of line length) X 4 faults (RN , YB, YBN, RYB) X 2 fault inception 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) X 2 fault inception 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) X 2 fault inception 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) X 2 fault inception angle (0°, 90°)= 16 cases
2	Operating time for zone 1 at SIR =4	Tests to be done at 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°) =	Tests to be done at 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	Tests to be done at 3 locations (0 % , 40 % and 64 % of line length) X 4 faults (RN , YB, YBN, RYB) X 4 fault inception angle (0°, 30°,60°	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 °)= 16 cases	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

Sl no	Description	Single source with short line (2 Ω)		Single source long line (20 Ω)	Double source with short double line (2 Ω)	Double source with long single line (20 Ω)
		48 cases	cases	and 90°)= 48 cases		
3	Operating time for zone II and Zone III	Tests to be done at 1 location (100 % of line length) X 1 faults (RN, YB, YBN, RYB) X 2 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 2 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 2 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 % and 80 % of line length) X 1 faults (RN) X 1 fault inception angle (0 degrees) = 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) X 2 faults (RN in circuit 1 to BN in circuit 2	

Sl no	Description	Single source with short line (2 Ω)		Single source long line (20 Ω)	Double source with short double line (2 Ω)	Double source with long single line (20 Ω)
					and RN in circuit 1 to RYN in circuit 2 in 10 ms) X 1 fault inception angle (0 °) = 4 cases (*1)	
7	Directional sensitivity					Tests to be done at 1 location (0% reverse) X 6 faults (RN ,YB, YBN , RYB,RN with Rf=13.75 ohm(sec) and RYN with Rf= 13.75 Ohm (sec) X 2 fault inception angle (0° ,90°) = 12cases
8	Limit for fault resistance					Tests to be done at 2 location (0% and 68 % of line length) X 1 fault (RN with Rf=13.75 ohm(sec) X 2 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 30 ms) X 2 load direction (from A to B and from B to A) =

Sl no	Description	Single source with short line (2 Ω)		Single source long line (20 Ω)	Double source with short double line (2 Ω)	Double source with long single line (20 Ω)
						16 cases
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 all cases under 1 and 2	Measure fault location for all cases under 1 and 2	Measure fault location for all cases under 2 and 6	Measure fault location for all cases under 2, 7 and 9

CHAPTER 7: SUBSTATION AUTOMATION SYSTEM

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CHAPTER 17: SUBSTATION AUTOMATION SYSTEM

1.0 GENERAL

1.1. The substation automation system shall be offered from a manufacturer who must have designed, manufactured, tested, installed and commissioned substation automation system as per following **Qualification.**

i) Must have manufacturing experience of at least 5 (Five) years.
ii) Must have successfully completed the supply of SAS, over last five (5) years period ending on the last date of bid submission.
iii) Must hold a valid ISO 9001:2000 (including design in scope of registration) certification.
iv) Must submit the type test report carried out by reputed independent testing laboratory.

1.2. The Substation Automation System (SAS) shall be installed to control and monitor all the sub-station equipment from remote control centre (RCC) as well as from local control centre.

The SAS shall contain the following main functional parts:

- Bay control Intelligence Electronic Devices (IEDs) for control and monitoring.
- IEC 61850 compatible Bay control and protective relays (IEDs)
- Redundant Human Machine Interface (HMI) and DR work Station
- Redundant managed switched Ethernet Local Area Network communication infrastructure with hot standby.
- Gateway for remote control via industrial grade hardware through (MCC) on IEC60870-5-104 protocol
- Gateway for remote supervisory control (to RLDC), the gateway should be able to communicate with LDC on IEC 60870-5-101 protocol. Protocol converter should be used wherever required to match to existing communication system installed at MCC to be located at Baneshwor Substation.
  The specific protocol to be implemented is enclosed as Appendix-I.. It shall be the bidder's responsibility to integrate his offered system with existing system for exchange of desired data. The requirement of IO point shall be worked out by the bidder as per criterion enclosed as Appendix-II for data exchange with LDCs.
- Remote HMI.
- Industrial grade peripheral equipment like printers, display units, key boards, Mouse, terminal equipment for communication link etc. with necessary furniture.

1.3. 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.

1.4. The communication gateway shall facilitate the information flow with Master control center. 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.

1.5. The point to point testing of all signals from switchyard equipment terminal to substation controller shall be in the scope of bidder.

2. SYSTEM DESIGN

The SAS shall be designed as a common integrated system enabling local substation control and monitoring, protection relay management and remote control from the Main/Backup Control Centre.

The SAS shall provide complete control and monitoring system of the electrical substation by means of modern HMI facilities, replacing fully conventional station level and voltage level control boards/panels.

The SAS from the Control / Monitoring Structure point of view shall be designed as multilevel control system including:

1. Bay Control Level from local Bay Computer or Protection HMI
2. Station Control Level from Operator HMI (Level 2)
3. SCADA/Supervisory Control Level from SCC or ECC (Level 3)

2.1 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 Chapter 1 - GTS.

The systems shall be of the state-of-the art suitable for operation under electrical environment present in 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 (MCC) via gateways.

The system shall be designed such that personnel without any background knowledge in Microprocessor-based technology are able to operate the system. The operator 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.

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.

Bidder shall offer 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) housed in air-conditioned *Panel Room* suitably located and Station HMI in Control Room building for overall optimisation in respect of cabling and control room building..

2.2 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 two levels, i.e. in a station and a bay level.

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 IEDs should be directly connected to the switchgear without any need for additional interposition or transducers.

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 GI conduit pipes. Data exchange is to be realised using IEC 61850 protocol with a redundant managed switched Ethernet communication infrastructure

The communication shall be made in fault tolerant ring in redundant mode, 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

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.

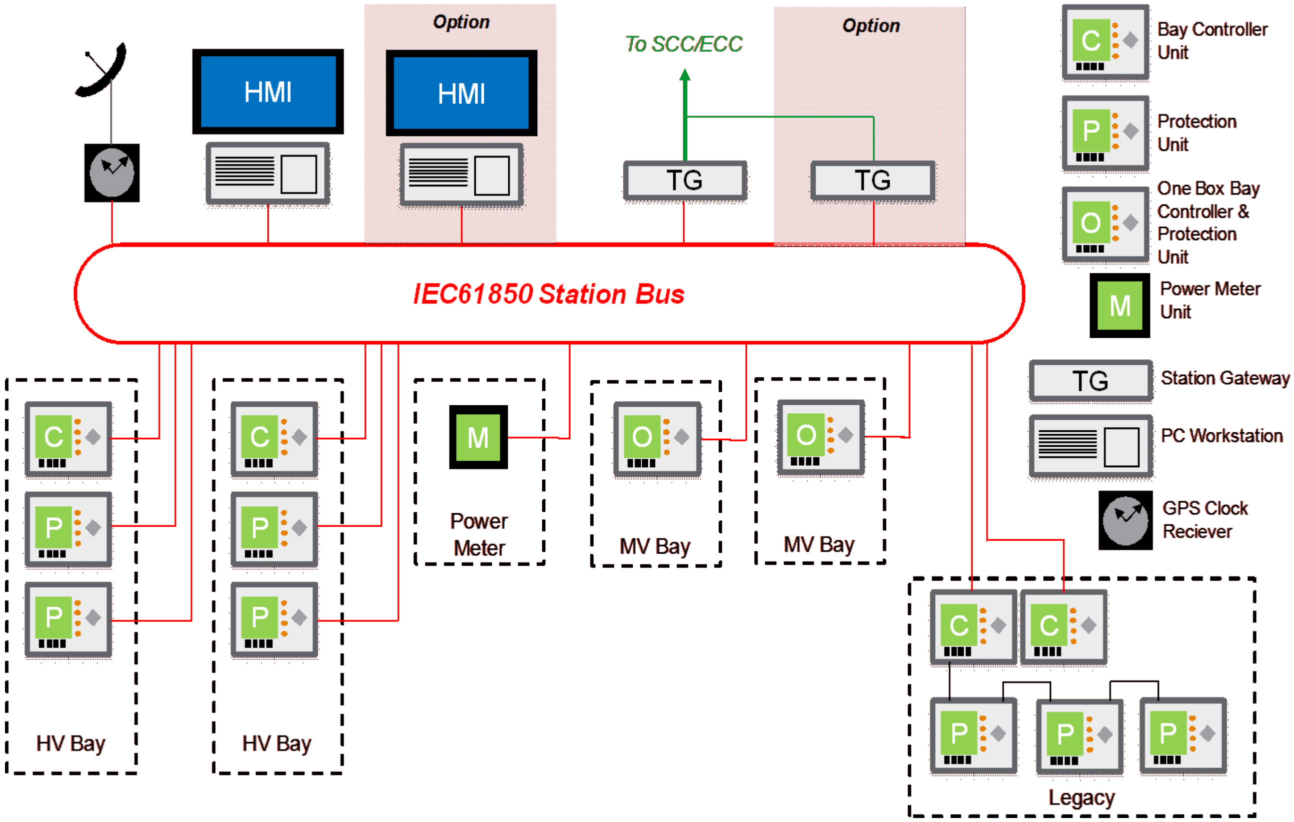
The station level contains the station-oriented functions, which cannot be realised at bay level, e.g. alarm list or event list related to the entire substation, gateway for the communication with remote control centres.

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.

In addition of above the SAS shall also include but not limited to following:

- A series of standard bays panels interconnected by an open protocol. A standard bay panel contains all the IEDs needed for the local control and protection of the bay. A bay is a feeder, a transformer, a coupler, a capacitor bank, a diameter or a Common Services Bay. Each bay has a local/remote switch enabling or disabling the local control.
- A Telecontrol Gateway even redundant, providing the interface between the substation and the remote control centre. It is active when the substation is in remote mode. The protocol is IEC 60870-5-101 or IEC 608670-5-104.
- An Operator interfaces (HMI), providing the local supervision and control of the substation, sequence of events, archiving, printing, engineering, SAS maintenance and data analysis. It is active when the substation is in local. This operator interface can be duplicated locally or remotely. Remotely it may be accessed from an Internet browser.
- Optional data concentrators, even redundant, providing the interface between legacy field bus communicating IED's and the IEC61850 substation bus. The protocols are serial or TCP/IP versions for IEC 60870-5, DNP3.0 and Modbus.
- A Local Area Network infrastructure so-called, interconnecting all station equipment, enabling their communication using the IEC61850-8-1 protocol.



The SAS shall be bay oriented, i.e.:

- o Addition of a new feeder or transformer shall be an easy operation from a configuration and manufacturing point of view (copy of an existing model). The system interlocking shall be done by the mean of a topological interlocking, using the topology and expert rules to authorise or inhibit the switchgear operation. All these data will be exchanged between involved IED using the standard IEC61850 GOOSE or equivalent procedures.
- o Each bay has an autonomous behaviour, i.e. local control and interlocking, sequence of events, etc. It is connected to other bays by logical means for system wide functions, such as interlocking or Busbar protection, but can have a downgraded mode with complete protection and control of the local bay.
- o Each IED shall have its own integrated Ethernet switch.

2.3 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.

The operation shall depend on the conditions of other functions, such as interlocking, synchro-check, etc. (see description in"Bay level control functions").

2.3.1 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.

2.3.2 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.

2.3.3 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.

2.3.4 Self-supervision

Continuous self-supervision function with self-diagnostic feature shall be included.

2.3.5 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).

The Functional requirement shall be divided into following levels:

a. Bay (a bay comprises of one circuit breaker and associated disconnector, earth switches and instrument transformer) Level Functions

b. System Level Functions

3.1. 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.

3.1.1. Bay control functions

3.1.1.1. Overview

Functions

- Control mode selection
- Select-before-execute principle
- Command supervision:
  - o Interlocking and blocking
  - o Double command
- Synchrocheck, voltage selection
- Run Time Command cancellation
- Transformer tap changer control (Raise and lower of tap) (for power transformer bays)
- Operation counters for circuit breakers and pumps
- Hydraulic pump/ Air compressor runtime 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
- Extension possibilities with additional I/O's inside the unit or via fibre-optic communication and process bus

3.1.1.2. 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 bay control 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**.**

REMOTE mode

Control authority in this mode is given to a higher level (Remote Control Centre) and the installation can be controlled only remotely. Control operation from lower levels shall not be possible in this operating mode.

3.1.1.3. 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

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.

3.1.1.4. Transformer tap changer control

Raise and lower operation of OLTC taps of transformer shall be facilitated through Bay controller IED.

3.1.2. Bay protection functions

3.1.2.1. 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 function shall be as per detailed in Chapter 15 – Control, Relay & Protection Panels.

3.1.2.2. **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. 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.

3.2. System level functions

3.2.1. Status supervision

The position of each switchgear, e.g. circuit breaker, isolator, earthing switch, transformer tap changer 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 position changes.

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.

3.2.2. 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 be updated every 2 seconds.

Threshold limit values shall be selectable for alarm indications.

3.2.3. 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

3.2.4. Station HMI

3.2.4.1. 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 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. REMOTE) shall not be possible in this operating mode.

3.2.4.2. Presentation and dialogues

General

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 any screen selected by the operator.

The following standard pictures shall be available from the HMI:

- 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**.**
- Measurement dialogues
- Alarm list, station / bay-oriented
- Event list, station / bay-oriented
- System status

3.2.4.3. 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

3.2.4.4. 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.

3.2.4.5. 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.

3.2.4.6. 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.

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 class

3.2.4.7. Alarm list

Faults and errors occurring in the substation shall be listed in an alarm list and shall be immediately transmitted to the control centre. The alarm list shall substitute a conventional alarm tableau, and shall constitute an evaluation of all station alarms. It shall contain unacknowledged alarms and persisting faults. The date and time of occurrence shall be indicated.

The alarm list shall consist of a summary display of the present alarm situation. Each alarm shall be reported on one line that contains:

- The date and time of the alarm
- The name of the alarming object
- A descriptive text
- The acknowledgement state.

Whenever an alarm condition occurs, the alarm condition must be shown on the 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.

3.2.4.8. 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 object picture, all attributes like

- Type of blocking
- Authority
- Local / remote control
- RSCC / SAS control
- Errors
- etc.,

shall be displayed.

3.2.4.9. Control dialogues

The operator shall give commands to the system by means of mouse click located on 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

3.2.5. 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.

3.2.6. Reports

The reports shall provide time-related follow-ups of measured and calculated values. The data displayed shall comprise:

- Trend reports:
  - 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 displayed 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 kept 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 24 hours.

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 value it interrupts (in both condition i.e. manual opening and fault tripping)

v. Equipment operation details shift wise and during 24 hours.

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 frequency and 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 to the formats for which data is available in the SAS database.

3.2.7. 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 as column 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.

3.2.8. 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 or once per day) to a dedicated computer and be stored on the hard disc.

3.2.9. Disturbance analysis

The PC-based work station shall have necessary software to evaluate all the required information for proper fault analysis.

3.2.10. 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.

3.2.11. Automatic sequences

The available automatic sequences in the system should be listed and described, (e.g. sequences related to the bus transfer). It must be possible to initiate pre-defined automatic sequences by the operator and also define new automatic sequences.

3.3. Gateway

Gateway offered shall be of reputed make with modular structure & high availability. The Gateway provided for the above system shall be rack mounted. LED indications should be provided on the front of the cards to know the status of communication by looking at the front of the communication card. The Gateway shall also support PLC programming for future controls at complied are stipulated hereunder.

Technical Parameters of Gateway

1.	Power supply	: 230V+/-10V,50 HzAC
2.	Processor Type	: Intel Pentium D 820 Processor, 2.8 GHz or Higher Standard L2 2MB, 800 MHz front side bus
3.	Chipset	: INTEL 945 GC chipset :. :
4.	Memory Type	: DDR2-Synch DRAM PC2-5300 @ 667 MHz
5.	Standard memory	4GB
6.	Memory slots	2 DIMM
7.	Hardware monitoring	: System Monitor (fan, temp., Voltage)
8.	Memory upgrade	: Expandable
9.	Internal hard disk drive	: 160 GB
10.	Hard disk drive speed	: 7200 rpm
11.	Protocols capabilities	: IEC 61850, IEC 69870-5-101/104, Modbus
13.	Chassis type	: Industrial Rack mount BP chassis
14.	Video adapter, bus	: PCI Express ™X16
16.	Audio	: Integrated Audio with External speakers & Microphone
17.	Network Interface	: Integrated 10/100/1000 Gigabit Fast Ethernet-WOL, Dual RJ-45 with Two LED indicators
25.	Antivirus s/w	: Registered standard latest Anti-virus software

3.3.1 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 as follows:
(a) Two ports for Remote Control Centre
(b) Two ports for Regional System Coordination Centre (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 (MCC & RLDC). The substation automation system shall support the use of a different communication data exchange rate (bits per second), scanning 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 SAS shall also allow all necessary S/S data (which are very important to monitor by RLDC for whole system study) transfer to LDC main communication system. There may require typical protocol converter depending upon LDC RTU system.

3.3.2 Remote Control Centre (MCC) 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, microwave, optical fibre, VSAT or leased line, the details of which shall be provided during detailed Engineering.

3.3.3 Interface equipment:

The Contractor shall provide interface equipment for communicating between Substation Automation system and Remote control centre and between Substation Automation system and Regional System Coordination Centre (RSCC). However, the communication channels available for this purpose are specified in Chapter 1 - GTS.

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.

3.3.4 Communication Protocol

The communication protocol for gateway to control centre must be open protocol and shall support IEC 60870-5-101 and IEC 61850 for all levels of communication for sub-station automation such as Bay to station HMI, gateway to remote station etc.

The telecontrol gateway shall interface up to 5 telecontrol centres, each with a possible link redundancy. It maintains a database per control centre.

The gateway shall be able to send to the remote control centre, but not limited to:

- Single point indication with time.
- Double point indication with time.

- Transformer tap position with time.
- Measurement value with time.
- Integrated total (counters).
- Disturbance record files.

The gateway shall be able to receive from the control centre:

- Single control, either direct or as a select/execute sequence.
- Double control, either direct or as a select/execute sequence.
- Interrogation command on a group of data.
- Clock synchronisation.
- Counter freeze.
- Taking control. This facility allows a remote control point to force the mode of the substation from LOCAL to REMOTE and to define on which port the SCADA controls must be accepted.

TG shall comply with Cyber Security function as described in specification.

4.0 System hardware:

4.1 Redundant Station HMI, Remote HMI and Disturbance Recorder Work station:

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 and trend data for thirty(30) days,
2. Storage of all necessary software,
3. 40GB space for OWNER'S use.

Supplier shall demonstrate that the capacity of hard disk is sufficient to meet the above requirement.

4.1.1 **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.

4.1.2 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.

4.1.3 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.

4.1.4 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 Filesystems. 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**.**

4.1.5 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 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.

4.2 Bay level unit

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. 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. 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 control centre. The bay unit shall have the capability to store all the data for at least 24 hours.

One number Bay level unit shall be provided for supervision and control of each 220 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 of service.

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.

The bay control unit for future bay (if required as per Chapter 1 – Project Specification Requirement) 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.

4.2.1 Input/Output (I/O) modules

The I/O modules shall form a part of the bay level unit and shall provide coupling to the substation equipment. The I/O modules shall acquire all switchgear information (i.e. data coming directly from the switchgear or from switchgear interlocking devices) and transmit commands for operation of the switchgear. The measured values of voltage and current shall be from the secondaries of instrument transformers. The digital inputs shall be acquired by exception with 1 ms resolution. Contact bouncing in digital inputs shall not be assumed as change of state

Technical Parameters of BCU: It is a minimum requirement, the contractor shall demonstrate the adequacy of the capacity provided.

1. Power supply:	110 VDC, + 15%, Power consumption: < 15W Ripple (peak to peak): < 12%
2. Protocol Capabilities:	Ethernet based communication: Dual on ¬Board with dual I.P. addresses on IEC-61850 & upgradeable in future.
3. Binary Input processing	: Hardwired Digital Input should be acquired via digital boards or IED connected by a serial link. Software Digital Input coming from configurable relays & other devices with 1 ms time tagging. Support GOOSE mode digital boards or IED connected by a serial link. Software Digital Input coming from configurable relays & other devices with 1 ms time tagging. Support GOOSE mode.
4. Analogue Input processing	: 110V for Voltage inputs, 1A & 5A for Current inputs and transducer (4-20 mA) inputs for station auxiliaries should process measurements received through the communication network with 16-bit resolution.
5. Measured value acquisition	: Monitoring of calculated four CT & four PT/CVT direct primary measures.
6. Derived values	: From the direct primary measures: RMS currents & voltages, network frequency active power, reactive power, apparent power, Power factor, Phase angles,
7. Digital Outputs	: DO used for switching device in field or inside C/R via digital boards, should also configurable & contain security, interlocks etc.
8. Sub-station/bay	: Should use logical equation and pre defined Inter-locking rules & sub-station topology for operation.
9. Trip Circuit Supervision	: Supervise trip circuits for both the conditions of Breaker.
10. Event Logging	: Storage of events up to 2000 in ROM.
11. Disturbance files & record of wave forms	: Five records of waveforms and disturbance files stored and accessible by HMI/DR work Station.
12. Gateway support	: Should interface with Gateway for Remote Control facility.
13. Local control, Operation	: Local control & Operation should be possible and Display using backlit LCD Display and keypad of BCU.
14. Self-monitoring	: Power ON and continuous cyclic self-monitoring tests. Abnormality result should be displayed.
15. I/O processing	: As per our required I/O list with 20% extra for Capacities each bay.
16. Internal Ethernet	: 4 X 10/100 Base T (RJ-45) ports+2X10/100 Base Switches Fx (optical) ports for redundant Ethernet network.
17. Additional ports	: 1 X RS232 and 3 X RS485 can support IEC 103 Modbus, should be s/w configurable.
19. Mounting & design	: Rack fitting with modular design.

4.3 Switchyard Panel Room:

The switchyard panel room shall be constructed to house Bay level units, bay mimic, relay and protection panels, PLCC panels etc.. The layout of equipment/panel shall be subject to Owner's approval. The switchyard panel room shall be provided with necessray illuminations, fire alarm system with at least two detectors with necessary power supply if required and it shall be wired to SAS. The detailed constructional requirement of switchyard panel room is detailed in chapter 14 civil of technical specification and air conditioning requirement of switchyard panel room shall be as detailed in chapter 10 Air conditioning system of technical specification. The air conditioner provided in switchyard panel room shall be monitored from substation automation system.

4.4 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 shutdown. The contractor shall provide all necessary software tools along with source codes to 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.

- The SAS must be able to have a 30% expansion in term of bays and 20% configurable I/O s within the bays. This reserved capacity shall be used without any additional hardware such as CPU, I/O Cards and Terminal Blocks etc.
- The SAS components (HMI, TG, Bays) must have the capability to manage at least two configuration databases, in order to enable fast and secure system extension. At a given instant only one database shall be active on each component. The dual database shall be activate from the HMI when changing the system configuration.
- The SAS must be able to integrate in the future new IEDs on IEC 61850.The SAS must be able to support future SCL standard (IEC61850-6) for its configuration.

5.0 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 of any feeder may not force a shut-down of the parts of the system which are not affected by the system adaptation.

5.1.1 Station level software

5.1.1.1 Human-machine interface (HMI)

The base HMI software package for the operator station shall include the main SAS functions 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.

5.1.2 Bay level software

5.1.1.1 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.

5.1.1.2 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.

5.1.1.3 Network Management System (NMS):

The contractor shall provide a 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 <u>DR</u> 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 fault 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 demand reports.
(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

5.1.1.4 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.

Cyber-security

The cyber security features shall improve the overall quality of the system and improve the reliability and the availability of operations by securing the access of each device and providing an audit capability. The solution should be based on IEC62351, IEC62443-3-3, and NERC-CIP Vendors shall be certified for Bronze Level Practice Certification (IEC62443-2-4).

6.0 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:

6.1 Type Tests:

6.1.1 Control IEDs and Communication Equipment:

a. Power Input:
- i. Auxiliary Voltage
- ii. Current Circuits
- iii. Voltage Circuits
- iv. Indications

b. Accuracy Tests:
- i. Operational Measurd 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 value Acquisition
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

6.2 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. 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.

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 with the site acceptance test (SAT).

6.2.1 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.

6.2.2 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.

6.3 Site Acceptance Tests:

The site acceptance tests (SAT) shall completely verify all the features of SAS hardware and software. The bidder shall submit the detailed SAT procedure and SAT procedure shall be read in conjunction with the specification.

7.0 SYSTEM OPERATION

7.1 Substation Operation

7.1.1 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 and date
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.

8.0 POWER SUPPLY

Power for the substation automation system shall be derived from substation 220V DC system.
2No.s of Inverter of minimum 2KVA capacity shall be provided for servers, gateways 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. Inverter shall be connected to 220V DC independent source and should be used to drive 1No. each server/HMI/Gateway so that in case any failure of DC power supply system is not affected.

9.0 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

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.

- List of Drawings
- Substation automation system architecture
- Block Diagram
- Guaranteed technical parameters, Functional Design Specification and Guaranteed 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)
- Product Manuals
- Assembly Drawing
- Operator’s Manual
- Complete documentation of implemented protocols between various elements
- Listing of software and loadable in CD ROM
- Other documents as may be required during detailed engineering

Two sets of hard copy and Four sets of CD ROM containing all the as built documents/drawings shall be provided.

10.0 TRAINING, SUPPORT SERVICES, MAINTENANCE AND SPARES

10.1 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 Nepal. 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.

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.

10.2 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 techniques and diagnostic procedures for each element of the computer system, e.g., processors, auxiliary memories, LANs, routers and printers. Configuration of all the hardware equipments.

(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.

10.3 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 the system.

(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.

10.4 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 major algorithms. Associated maintenance and expansion techniques.
(c) Software Development: Techniques and conventions to be used for the preparation and integration of new software functions.
(d) Software Generation: Generation of application software from source code and associated software configuration control procedures.
(e) Software Documentation: Orientation in the organization and use of functional and detailed design documentation and of programmer and user manuals.
(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.

10.5 Requirement of training:

The contractor shall provide training for OWNER'S personnel comprehensively covering following courses.

S. No.	Name of Course
1	Computer System Hardware
2	Computer System Software
3	Application Software

11.0 Maintenance

11.1 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 bi-monthly visit of their representative to site 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.

12.0 RELIABILITY AND AVAILABILITY

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 electromagnetic interference (EMI)
- High quality components and boards
- Modular, well-tested hardware
- Thoroughly developed and tested modular software
- Easy-to-understand programming language for application programming
- Detailed graphical documentation and application software
- Built-in supervision and diagnostic functions
- Security
  - Experience of security requirements
  - 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 potential rise

Outage terms

1) Outage

The state in which substation automation system or a unit of SAS is unavailable for Normal Operation as defined in the clause 7.1 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 time shall be counted to the nearest 1/4th of an hour. Time less than 1/4th of an hour shall be counted as having duration of 1/4th 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 leap year).

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.

12.1 Guarantees Required

The availability for the complete SAS shall be guaranteed by the Contractor. Bidder shall include in their offer the detailed calculation for the availability. 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.

13.0 Spares

13.1 Consumables:

All consumables such as paper, cartridges shall be supplied by the contractor till the SAS is taken over by the owner.

13.2 Availability Spares:

In addition to mandatory spares as listed in section project for SAS, the bidder is required to list the spares, which may be required for ensuring the guaranteed availability during the guaranteed availability period. The final list of spares shall form part of scope of supply and accordingly the price thereof shall be quoted by the bidder and shall be considered in the evaluation of the bids. 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 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.

14.0 LIST OF EQUIPMENTS

Quantity of equipments shall be decided by bidder in order to achieve guaranteed reliability and availability as declared by bidder.

i) Station HMI
ii) Redundant Station HMI (in Hot-stand by mode)
iii) Bay level units along with bay mimic as detailed in Chapter 1 – Project Specification Requirement.
iv) Bay Level Unit for Auxiliary system (as per requirement)
v) Disturbance Recorder Work Station(Maintenance HMI)
vi) Colour Laser Printer – 1 No. (For Reports & Disturbance records)
vii) Dot matrix printers - (one each for Alarms and log sheets)
viii) All interface equipment for gateway to RCC and RSCC
ix) Communication infrastructure between Bay level units, Station HMI, Printers, gateways, redundant LAN etc. as required
x) Remote workstation including HMI and along with one printer
xi) Modems as per requirement.
xii) Any other equipment as necessary.

List of Analogue and Digital Inputs

Basic Monitoring requirements are:

- Switchgear status indication
- Measurements (U, I, P, Q, f)
- Event
- Alarm
- Winding temperature of transformers & reactors
- ambient temperature
- Status and display of 400V LT system, 220V & 48V DC 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 Transformer

List of Inputs

The list of input for typical bays is as below:-

Analogue inputs

i) For line
Current R phase
Y phase
B phase
Voltage R-Y phase
Y-B phase
B-R phase

ii) For transformer/reactor
Current R phase
Y phase
B phase
WTI (for transformer and reactor)
Tap position (for transformer only)

iii) For TBC and bus coupler

Current R phase
Y phase
B phase

iv) Common

a) Voltage for Bus-I, Bus-II and Transfer bus wherever applicable

Voltage	R-Y phase
	Y-B phase
	B-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 220V DCDB-I
viii) Voltage of 220V DCDB-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 48V DCDB-I
xiv) Voltage of 48V DCDB-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 recloser 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 LOCATOR FAULTY
xxi) MAIN-I/II CVT FUSE FAIL
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-I START
xxx) MAIN-I/II Carrier aided trip
xxxi) MAIN-I/II fault in reverse direction
xxxii) MAIN-I/II ZONE-2 TRIP
xxxiii) MAIN-I/II ZONE-3 TRIP
xxxiv) MAIN-I/II weak end infeed optd
xxxv) MAIN-II PSB alarm
xxxvi) MAIN-II SOTF TRIP
xxxvii) MAIN-II R-PH TRIP
xxxviii) MAIN-II Y-PH TRIP
xxxix) MAIN-II B-PH TRIP
xl) MAIN-II 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 CHANNEL FAIL
xlvii) PLCC Protection Channel-I FAIL
xlviii) PLCC Protection Channel-II FAIL

2. **Transformer bays**

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) REF OPTD
ix) DIF OPTD
x) OVERFLUX ALARM (MV)
xi) OVERFLUX TRIP (MV)
xii) OVERFLUX ALARM (HV)
xiii) OVERFLUX TRIP (HV)
xiv) HV BUS CVT ½ FUSE FAIL
xv) MV BUS CVT ½ FUSE FAIL
xvi) OTI ALARM/TRIP
xvii) PRD OPTD
xviii) OVERLOAD ALARM
xix) BUCHOLZ TRIP
xx) BUCHOLZ ALARM
xxi) OLTC BUCHOLZ ALARM
xxii) OLTC BUCHOLZ TRIP

xxiii) OIL LOW ALARM
xxiv) back-up o/c (HV) optd
xxv) back-up e/f (HV)optd
xxvi) 220v DC-I/II source fail
xxvii) TAP MISMATCH
xxviii) GR-A PROTN OPTD
xxix) GR-B PROTN OPTD
xxx) back-up o/c (MV) optd
xxxi) back-up e/f (MV)optd

3. **Transformer bays**

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) REF OPTD
ix) DIF OPTD
x) HV BUS CVT ½ FUSE FAIL
xi) OTI ALARM/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

4. Line/Bus Reactor bays (as applicable):

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) REF OPTD
ix) DIF OPTD
x) Line/ BUS CVT ½ FUSE FAIL
xi) OTI ALARM/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 bar Protection**

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

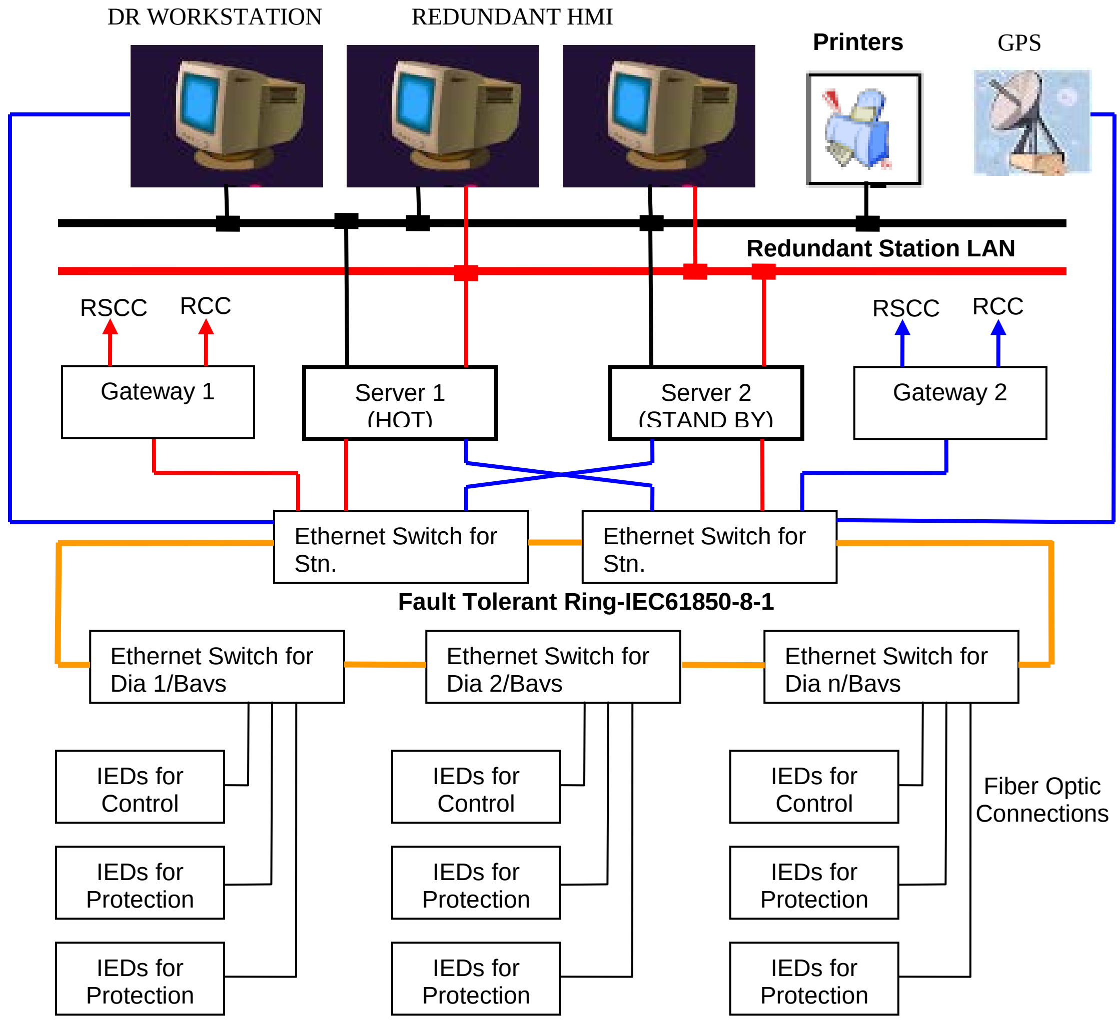
6. **Auxiliary system**
i) Incomer-I On/Off
ii) Incomer-II On/Off
iii) 400V Bus-I/II U/V
iv) 400V bus coupler breaker on/off
v) DG set bkr on/off
vi) Alarm/trip signals as listed in Section: DG set
vii) LT transformer-I Bunchholz Alarm & trip
viii) LT transformer-II Buchloz Alarm & trip
ix) LT transformer-I 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 1 ON/OFF
ii) AC Compressor 2 ON/OFF
iii) Fire Detection 1 ON/OFF
iv) Fire Detection 2 On/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 future use.

TYPICAL ARCHITECTURAL DRAWING OF SUBSTATION AUTOMATION SYSTEM



Note:

1. The redundant managed bus shall be realized by high speed optical bus using industrial grade components and shall be as per IEC 61850.
2. Inside the sub-station, all connections shall be realized as per IEC 61850 protocol.
3. For gateway, it shall communicate with Remote Supervisory Control Centre (RSCC) on IEC 60870-5-101 protocol.
4. The printer as required shall be connected to station bus directly and can be managed either from station HMI, HMI view node or disturbance recorder work station.
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 detailed engineering.

2.2 Applicable Standards

2.2.1 Environment standard

All these standards are applicable to any PCMD elements (HMI, Ethernet network and elements, RTUs, IEDs).

Type Test Name	Type Test Standard	Conditions
Insulation Resistance	IEC 60255-5	100 MΩ at 500 Vdc (CM & DM)
Dielectric Withstand	IEC60255-5 IEEE C37.90	50 Hz, 1mn, 2kV (CM), 1kV (DM)
		50 Hz, 1mn, 1kV (CM)
		G 1.4 & 1.5 500V CM G 6 :1,5 kV CM
High Voltage Impulse Test	IEC 60255-5	5kV (CM), 3kV (DM)
		2kV (CM)
		Groups 1 to 6 :5 kV CM & 3 kV DM(1)
		Not on 1.4 & 1.5 : 5 kV CM & 3 kV DM(1)
Free Fall Test Free Fall Packaging Test	IEC 60068-2-31 IEC 60068-2-32	Test Ec : 2 falls from 5cm Test Ed : 2 falls from 0,5m
		2 falls of 5 cm (Computer not powered)
		25 falls of 50 cm (1) (2) (Packaging computer)
Vibration Response – Powered On	IEC 60255-21-1	Class 2 : 1g from 2 to 150Hz
		Class 2 : Acceleration : 1g from 10 (1) to 150Hz
Vibration Response – Not Powered On	IEC 60255-21-1	Class 2 : 2g from 2 to 500Hz
		Class 2 : Acceleration : 2g from 10 (1) to 500Hz
Vibration Endurance – Not Powered On	IEC 80068-2-6	Class 2 : 1g from 10 to 150Hz
		Class 2 : Acceleration : 1g from 10 (1) to 500Hz
Shocks – Not Powered On	IEC 60255-21-2	Class 1 : 15g, 11 ms
Shocks – Powered On	IEC 60255-21-2	Class 2 : 10g, 11 ms

Type Test Name	Type Test Standard	Conditions
Bump Test – Not Powered On	IEC 60255-21-2	Class 1 : 10g, 16ms, 2000/axis
Seismic Test – Powered On	IEC 60255-21-3	Class 1 : Axis H : 3,5mm – 2g Axis V : 3,5mm – 1g
		Class 2 : Acceleration : 2g Displacement : 7,5mm axis H Acceleration : 1g Displacement : 3,5mm axis V
Damp Heat Test - Operating	IEC 60068-2-3	Test Ca : +40°C / 10 days / 93% RH
Cold Test - Operating	IEC 60068-2-1	Test Ab : -10°C / 96h
		Test Ab : - 25°c / 96 H
Cold Test - Storage	IEC60068-2-1	Test Ad : -40°C / 96h Powered On at –25°C (for information) Powered On at –40°C (for information)
Dry Heat Test – Operating	IEC 60068-2-2	Test Bd : 55°C / 96h
		70°C / 2h
		70°c / 24 H
Dry Heat Test – Storage	IEC 60068-2-1	Test Bd : +70°C / 96h Powered On at +70°C
Enclosure Protection	IEC 60529	Front : IP=52 Rear : IP=30
Inrush current (start-up)		T < 1,5 ms / I < 20 A T < 150 ms / I < 10 A T > 500 ms / I < 1,2 In
Supply variation	IEC 60255-6	Vn ± 20% Vn+30% & Vn-25% for information
Overvoltage (peak withstand)	IEC 60255-6	1,32 Vn max 2 Vn during 10 ms (for information)
Supply interruption	IEC 60255-11	From 2,5 ms to 1 s at 0,8 Vn 50 ms at Vn, no malfunction (for information)
40 s interruption	IEC 60255-11	
Ripple (frequency fluctuations)	IEC 60255-11	12% Vn at f=100Hz or 120Hz 12% Vn at f=200Hz for information

Type Test Name	Type Test Standard	Conditions
Supply variations	IEC 60255-6	Vn ± 20%
AC Voltage dips & short interruptions	EN 61000-4-11	2ms to 20ms & 50ms to 1s 50 ms at Vn, no malfunction (for information
Frequency fluctuations	IEC 60255-6	50 Hz : from 47 to 54 Hz 60 Hz : from 57 to 63 Hz
Voltage withstand		2 Vn during 10 ms (for information)
High Frequency Disturbance	IEC 60255-22-1 IEC 61000-4-12 IEEE C37.90.1	Class 3 : 2.5kV (CM) / 1kV (DM)
		Class 2 : 1kV (CM)
Electrostatic discharge	IEC 60255-22-2 IEC 61000-4-2	Class 4 : 8kV contact / 15 kV air
Radiated Immunity	IEC 60255-22-3 IEC 61000-4-3	Class 3 : 10 V/m – 80 to 1000 MHz & spot tests
	IEEE C37.90.2	35 V/m – 25 to 1000 MHz
Fast Transient Burst	IEC 60255-22-4 IEC 61000-4-4 IEEE C37.90.1	Class 4 : 4kV – 2.5kHz (CM & DM)
		Class 3 2 kV - 2,5 kHz MC
		Class 3 : 2kV – 5kHz (CM)
Surge immunity	IEC 61000-4-5	Class 4 : 4kV (CM) – 2kV (DM)
		Class 3 : 2kV (CM) on shield Class 4 : 4kV (CM) for information
		Class 3 : 1 kV MC
High frequency conducted immunity	IEC 61000-4-6	Class 3 : 10 V, 0.15 – 80 MHz
Harmonics Immunity	IEC 61000-4-7	5% & 10% de H2 à H17
Power Frequency Magnetic Field	IEC 61000-4-8	Class 4 : 50 Hz – 30 A/m permanent – 300 A/m short time

Type Test Name	Type Test Standard	Conditions
Immunity		Class 5 : 100A/m for 1mn 1000A/m for 3s
Power Frequency	IEC 61000-4-16	CM 500 V / DM 250 V via 0.1 μF
Conducted emission	EN 55022	Gr. I, class A and B : from 0.15 to 30 MHz
Radiated emission	EN 55022	Gr. I, class A and B : from 30 to 1000 MHz, 10m

2.2.2 Communication Standard

IEC 61850:

- IEC 61850-8-1: *Communication networks and systems in substations – Part 8-1: Specific communication service mapping (SCSM) – Mapping to MMS(ISO/IEC 9506 Part 1 and Part 2*
- IEC 61850 shall be used as reference standard to model substation switchyard and associated protection and automation functions. As a consequence, IEC 61850 protocols are mandatory for the communications between the SAS bays, Gateways, the Bay IEDs and HMI. Within a bay this permits to suppress wiring between IEDs such as start of the disturbance recorder, initiation of the circuit breaker failure protection, Re-closer coordination, etc.
- IEC61850 shall be used for the time synchronisation, control, reports, peer-to-peer exchanges and disturbance records file transfers. No private protocol is allowed for such exchanges. IED setting may use a private tunnelling mechanism since this part is not part of the IEC61850 standard. The supplier shall state the exact profile intended to be used.
- The SAS shall offer 99.8% network availability based on redundancy principles.

- IEC 61850 is based on Ethernet 100 Mbps. The communication between bays shall use fibre optic. The architecture shall be a redundant loop so that the damage on one fibre will not affect the SAS. The switching time from one loop to the other shall be less than 1 ms in order to keep the peer-to-peer exchanges performances in case of a network failure. There shall be one switch per bay so that the failure of one switch will not affect more than one bay. The switch shall preferably be a board integrated within the protection and control devices. The switch must have at least 1 spare port reserve for future enhancement at the bay level and temporary HMI connection.

Tele-Control Protocol:

- IEC 608670-5-101
- IEC 608670-5-104.

2.3 Automation standard

- IEC 61131-3

2.3.1 Communication Interfaces

- The communication with the remote control centre is using a duplicated IEC 60870-5-101 or IEC 60870-5-104 link.
- The communication with the remote HMI is using a standard telecom arrangement. Connection.
- The SAS must be able to interface third party IEDs and integrate them into the standard bay. The communication is done through IEC 61850 or IEC - 60870-5-103 (profile defined in a later section).
- The time synchronization is acquired from a GPS receiver.
- The Tele-protection interfaces are project specific. Sufficient Ethernet ports shall be required to communicate with the following:
    a) Main/Backup Smart Grid Control Centres
    b) Main/Backup SLDC/ALDC

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 220kV Bus
d) All Breakers
e) All isolators
f) Tap Position for all transformers
g) Master protection signal for all feeders, transformers Units and Bus Bar
h) Loss of Voltage signal for Bus bar
i) All the points identified in point (e), (h) and (i) above as GPS Time stamped.
j) Temperature value per substation.
k) Any other point decided during detailed engineering

BASIC REQUIREMENT OF MASTER CONTROL CENTER AT BANESHWOR SUBSTSTION

1. The scope of work includes construction of Master Control Center at Baneshwor substation complete with server room, control room with monitoring screen, airconditioning.
2. The control center building shall be built over existing RCC structure building at Baneshwor Substation. The construction shall be PES (Pre-engineered structure or RCC).
3. The control center is to be designed such as to Supervise, monitor and control all substation within Kathmandu Valley. There is 14 substation in operation in Kathmandu valley, 5 substation under construction and 3 substation is proposed.
4. The existing substation is equipped with the SAS system of ABB, India make. The contractor is required to provide all necessary servers, hardware, software, switches etc which are required for satisfactory completion of work and for future requirement. The contractor is required to provide all necessary document, design to prove the capacity of the equipment provided.

CHAPTER 8: POWER AND CONTROL CABLE

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CHAPTER 9: POWER & CONTROL CABLES

1. POWER & CONTROL CABLES[FOR WORKING VOLTAGES UP TO AND INCLUDING 1100 V]

CRITERIA FOR SELECTION OF POWER & CONTROL CABLES

1.1.1. Aluminium conductor XLPE insulated armoured cables shall be used for main power supply purpose from LT Aux. Transformers to control room, between distribution boards and for supply for colony lighting from control room.

1.1.2 Aluminium conductor PVC insulated armoured power cables shall be used for various other applications in switchyard area/control room except for control/protection purposes.

1.1.3 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.

1.1.4 Employer has standardised the sizes of power cables for various feeders. Bidders are to estimate the quantity of cables and quote accordingly. The minimum sizes of power cables to be used per feeder in different application shall be as follows:

S.No.	From	To	Cable size	Cable type
1.	Main Switch Board	LT Transformer	2-1C X 630 mm^2 per phase 1-1C X 630 mm^2 for neutral	XLPE
2.	Main Switch Board	AC Distribution Board	2-3½C X 300 mm^2	XLPE
3.	Main Switch Board	Oil Filtration Unit	1-3½C X 300 mm^2	XLPE
4.	Main Switch Board	Colony Lighting	1-3½C X 300 mm^2	XLPE
5.	Main Switch Board	HVW pump LCP	1-3½C X 300 mm^2	XLPE
6.	Main Switch Board	Main Lighting distribution board	2-3½C X 300 mm^2	XLPE
7.	AC Distribution Board	D.G. Set AMF Panel	2-3½C X 300 mm^2	XLPE
8.	AC Distribution Board	Emergency Lighting	1-3½C X 70 mm^2	PVC

		distribution board		
9.	AC Distribution Board	ICT MB	1-3½C X 70 mm^2	PVC
10.	AC Distribution Board	Bay MB	1-3½C X 70 mm^2	PVC
11.	Bay MB	AC Kiosk	1- 3 ½ x 70 mm^2	PVC
12.	AC Distribution Board	Battery Charger	1-3½C X 70 mm^2	PVC
13.	DCDB	Battery	2-1C X 150 mm^2	PVC
14.	DCDB	Battery Charger	2-1C X 150 mm^2	PVC
15.	DCDB	Protection/PLCC panel	1-4C X 16 mm^2	PVC
16.	Main Lighting DB	Lighting panels(Indoor)	1-3½C X 35 mm^2	PVC
17.	Main Lighting DB	Lighting panels (outdoor)	1-3½C X 70 mm^2	PVC
18.	Main Lighting DB	Receptacles (Indoor)	1-3½C X 35 mm^2	PVC
19.	Main Lighting DB	Receptacles (Outdoor)	1-3½C X 70 mm^2	PVC
20.	Lighting Panel	Sub lighting panels	1-4C X 16 mm^2	PVC
21.	Lighting Panel	Street Lighting Poles	1-4C X 16 mm^2	PVC
22.	Lighting Panel/ Sub lighting panels	Lighting Fixtures (Outdoor)	1-2C X 6 mm^2	PVC
23.	Bay MB	Equipments	1-4C X 16 mm^2 /1-4C X 6 mm^2 /1-2C X 6 mm^2	PVC

1.1.5 Bidder may offer sizes other than the sizes specified in clause 1.1.4. In such case and for other application where sizes of cables have not been indicated in the specification, sizing of power cables shall be done keeping in view continuous current, voltage drop & short-circuit consideration of the system. Relevant calculations shall be submitted by bidder during detailed engineering for purchaser's approval.

1.1.6 Cables shall be laid as per relevant IEC/International Standards.

1.1.7 While preparing cable schedules for control/protection purpose following shall be ensured:

1.1.7.1 Separate cables shall be used for AC & DC.

1.1.7.2 Separate cables shall be used for DC1 & DC2.

1.1.8 For different cores of CT & CVT separate cable shall be used

1.1.9 Atleast one (1) cores 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.

1.1.10 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 2.5 sq.mm. size shall be provided.

1.1.11 Technical data requirement sheets for cable sizes are being enclosed at Annex-I**.**

1.2. TECHNICAL REQUIREMENTS

1.2.1. General

1.2.1.1. 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.

1.2.1.2. They shall be designed to withstand all mechanical, electrical and thermal stresses under steady state and transient operating conditions. The XLPE /PVC insulated L.T. power cables of sizes 240 sq. mm. and above shall withstand without damage a 3 phase fault current of at least 45 kA for at least 0.12 second, with an initial peak of 105 kA in one of the phases at rated conductor temperature (70 degC for PVC insulated cables and 90 degC for XLPE insulated cables). The armour for these power cables shall be capable of carrying 45 kA for at least 0.12 seconds without exceeding the maximum allowable temperature of PVC outer sheath.

1.2.1.3. 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.

1.2.1.4. 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.

1.2.1.5. 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.

1.2.1.6. Progressive sequential marking of the length of cable in metres at every one metre shall be provided on the outer sheath of all cables.

1.2.1.7. Strip wire armouring method shall not be accepted for any of the cables. For control cables only round wire armouring shall be used.

1.2.1.8. 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.

1.2.1.9. All the cables shall pass fire resistance test as per IEC: 60502 (Part-I)

1.2.1.10. The normal current rating of all PVC insulated cables shall be as per IEC: 60502.

1.2.1.11. Repaired cables shall not be accepted.

1.2.1.12. Allowable tolerance on the overall diameter of the cables shall be plus or minus 2 mm.

1.2.2. XLPE Power Cables

1.2.2.1. The XLPE insulated cables shall be of FR type, C1 category conforming to IEC: 60502 (Part-I) and its amendments read alongwith 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 to type ST-2 of IEC: 60502. When armouring is specified for single core cables, the same shall consist of aluminium wires/strips. The outer sheath shall be extruded PVC to Type ST-2 of IEC: 60502 for all XLPE cables.

1.2.3. PVC Power Cables

1.2.3.1. The PVC (70°C) insulated power cables shall be of FR type, C1 category, conforming to IEC: 60502 (Part-I) and its amendments read alongwith 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 IEC: 60502. 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 IEC: 60502 for all cables.

1.2.4. PVC Control Cables

1.2.4.1. The PVC ***(70°C) insulated*** control cables shall be of FR type C1 category conforming to IEC: 60502 (Part-1) and its amendments, read alongwith this specification. The conductor shall be stranded copper. The insulation shall be extruded PVC to type A of IEC: 60502. 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 IEC: 60502 and shall be grey in colour .

1.2.4.2. Cores shall be identified as per IEC: 60502 (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 IEC: 60502 (Part-1).

2. HV POWER CABLES[FOR WORKING VOLTAGES FROM 3.3 kV AND INCLUDING 33 kV]

2.1. *HV* POWER CABLE FOR AUXILIARY POWER SUPPLY

The HV cable of 1Cx185 mm^2 (Aluminium Conductor) or 1Cx120mm^2 (Copper Conductor) of voltage class as specified for 630 kVA LT transformer for interconnecting 630kVA LT transformer to the NEA feeder shall be, XLPE insulated, armoured cable conforming to IEC: 60502 (Part-2).

Terminating accessories shall conform to IEC 61442-1997/IEC60502-4 1998.

2.2. Bidder may offer sizes other than the sizes specified in clause 2.1. In such case sizing of power cables shall be done keeping in view continuous current, voltage drop & short-circuit consideration of the system. Relevant calculations shall be submitted by bidder during detailed engineering for purchaser's approval.

2.3. Constructional Requirements

Cable shall have compacted circular Aluminium conductor, Conductor screened with extruded semi conducting compound, XLPE insulated, insulation screened with extruded semi conducting compound, armoured with non-magnetic material, followed by extruded PVC outer sheath (Type ST-2), with FR properties.

2.4 Progressive sequential marking of the length of cable in metres at every one metre shall be provided on the outer sheath of the cable.

2.5 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.

2.6 Allowable tolerance on the overall diameter of the cables shall be plus or minus 2 mm.

3 CABLE DRUMS

3.1 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.

3.2 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 nonstandard lengths of cable size(s) may be supplied in drums for completion of project.

3.3 A layer of water proof paper shall be applied to the surface of the drums and over the outer most cable layer.

3.4 A clear space of at least 40 mm shall be left between the cables and the lagging.

3.5 Each drums 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.

3.6 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.

4 TYPE TESTS

4.1 All cables shall conform to all type, routine and acceptance tests listed in the relevant IEC.

4.2 XLPE INSULATED POWER CABLES (For working voltages up to and including 1100V):-

4.2.1 Following type tests (on one size in a contract) as per IEC: 60502 (Part 1) 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

4.2.2 Contractor shall submit type test reports as per clause no. 9.2 of Technical Specification, Chapter 2: GTR 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.

4.3 PVC INSULATED POWER & CONTROL CABLES (For working voltages up to and including 1100V)-

4.3.1 Following type tests (on one size in a contract) as per IEC: 60502 (Part 1) 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.

4.3.2 Contractor shall submit type test reports as per clause no. 9.2 of Technical Specification, Chapter 2: GTR for the following-

a) High voltage 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.

4.4 XLPE INSULATED HV POWER CABLES(For working voltages from 3.3 kV and including 33 kV)-

4.4.1 Contractor shall submit type test reports as per clause no. 9.2 of Technical Specification, Chapter 2: GTR for XLPE insulated HV power cables (as per IEC: 60502 Part-2).

4.5 Terminating/jointing accessories as per IEC 60840:1999/ IEC62067

Chapter 9

Technical Specification for SCADA Central Control System

Table of Contents

1. Introduction

The SCADA Centralized Control System (hereinafter referred to as CCS) is introduced by NEA for the first time. The CCS will connect to several substations via IEC 101/IEC 104, and as work as a master control center for there substations, so the connected substations can be unattended substations.

The CCS shall also have the provision to report to LDC system in Kathmandu.

The Contractor is required to give complete solution with full functionality of MCC, with requirement as mentioned, supported by the design calculation etc.

2. System Architecture

This chapter describesthe configuration and operation mechanism of SCADA Centralized Control System, the remote communication solution of substations, the detailed strategy of network security scheme.

The proposed system shall be designed to use the latest and well proven solution developed by the manufactuere to meet the requirement of CCS. Special care was taken to select state of the art systems with advanced capabilities adapted to the operation of dispatching center with integration solutions with other systems. The system architecture and design offer high scalability and extensibility with the capacity to accommodate user'sfuture expansions, function upgrade and migration.

CCS system structure scheme is shown in the following figure 2.1:

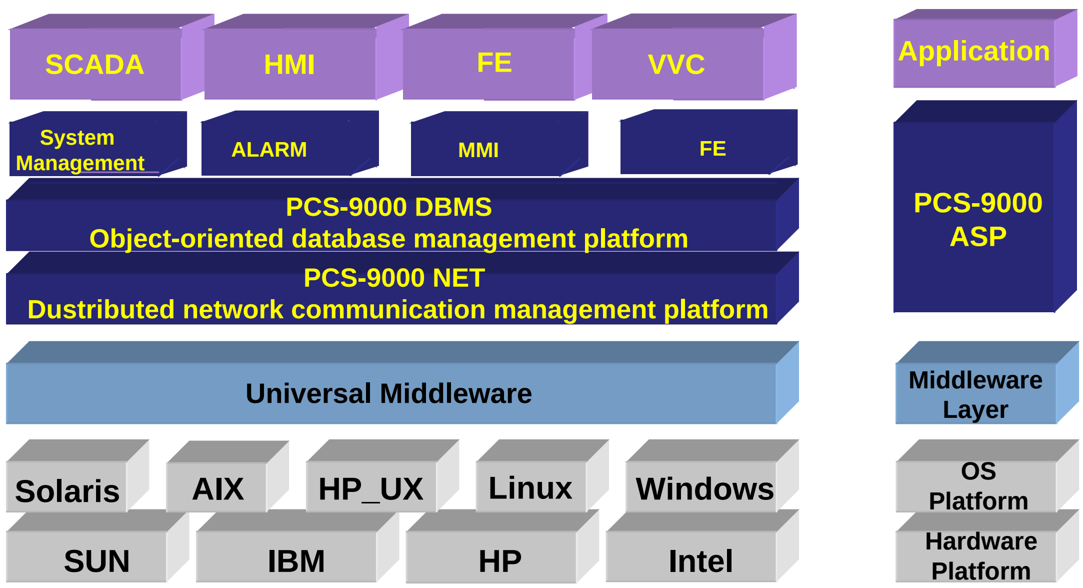

Fig. 2.1CCS system structure schemes

CCS shall provide flexible interface capabilities to satisfy user's external data exchange needs (such as ICCP). The proposed system offers interface capability for data exchange with other control center if required. Detailed interface design and implementation can be discussed in detail during Statement of Work based on the interface capabilities of user's control centers.

1.1 SCADACENTRALIZED CONTROL SYSTEM CENTER

1.1.1 Overview

1.1.2 GeneralStructure

The CCSwill be implemented inone substation. The control centerhas directdata communication connection to power system RTUs and other control centers.
The structure of SCADA CCSisshown in figure 2.2.

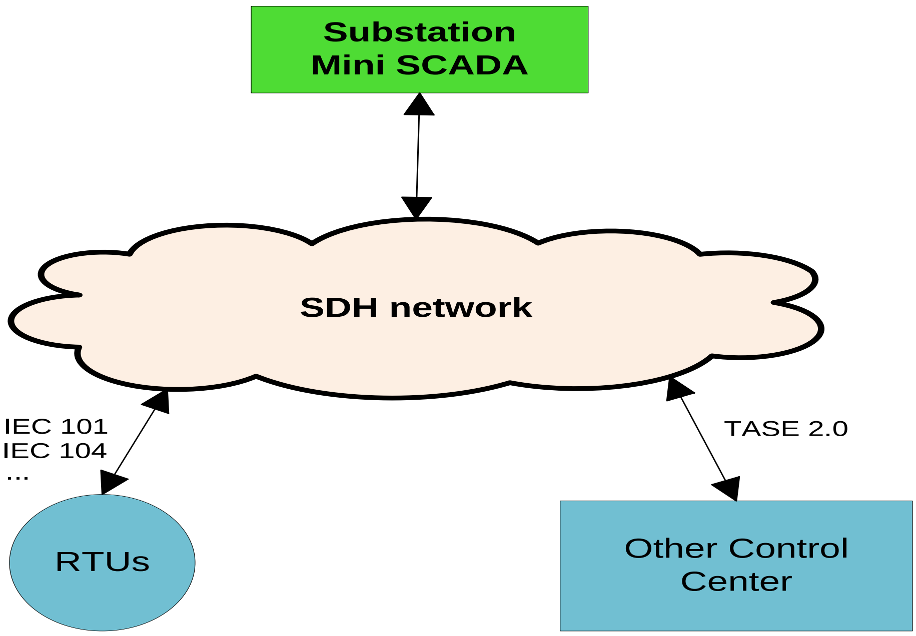

Fig.2.2 theStructure ofSCADA CCS System

1.1.3 Data acquisition of SCADA CCScenter

In SCADA CCS system, via the communication network, the independent front-end (abbreviated FE) module can directly acquire data via data acquisitionEthernetswitch. Redundant structure can be achieved by hot/standby operation mode in the system via two Servers.

The communication network is described as following in detail.The communication network contains two sub-structures. One structure is called RTU LAN and it is used to connect the RTUs/Gateways with the SCADA system. The RTU LAN shall be able to exchange data with theSCADA dispatching centers which has been described in previous graph. The secondone provides dedicated communication between SCADAcontrol center and other control centers via ICCP protocol if requested.

The RTU LAN is used to connect the RTUs with SCADACCS center. In this project, the SCADA CCS shall be implemented to monitor and control all of these substations of transmission grid. The RTU and other control center'sconnections are listed as following table 2.1:

Table 2.1 RTU and other control center Connections

	SCADA/CCS
Station RTUs	IEC 101/ 104 channel IEC 61850 IEC 60870-103

1.1.4 SCADA CCS Structure

TheSCADA CCS is shown as Fig 2.3.It is a fully redundant control center system with dual Main LAN Switches configuration.The main servers and devices are also redundant configuration on which critical redundancy function could be deployed. SCADACCS system, which will be implemented with fully redundancy configuration, will take the responsibility of data collection, processing and real-time data storage. Any data in the real-time database of SYSTEMis available for collection, calculation andstorage by the HIS Servers, in this way, the real-time data could be saved to be historical data for long-term storage. The office LAN zone include a office PC on which Web serverscan be deployed that support data access and displaysfor external authorized users.

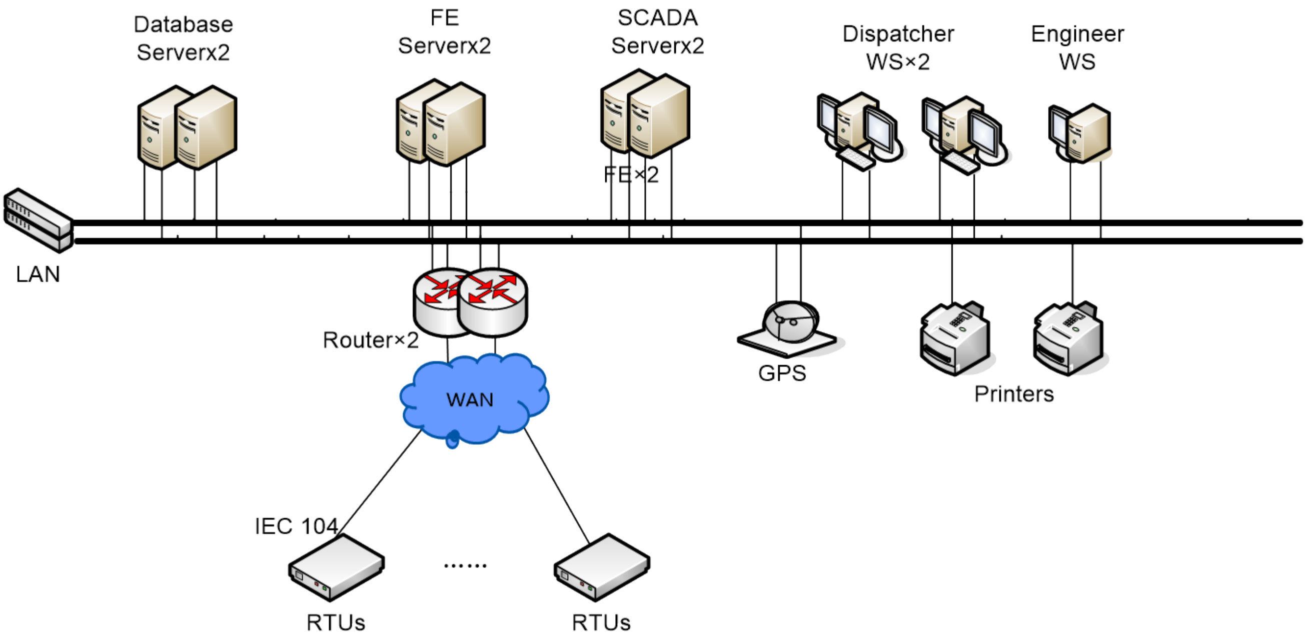

Fig.2.3 Structure ofSCADA CCS

1.1.5 Basic SCADA Functions

SCADA functions are the foundation of CCS system. Main functions include data acquisition, supervision, control, and alarm of system abnormity.

Features

1) Distributed database and distributed functions enable the maximum use of system resources;

2) Multistate design of applications makes the system suitable for personnel of different nature and different disciplines online, offline, for research and for planning. Further, system operation is more reliable and richer and more powerful functions are provided.

3) "1+N" redundant technology that ensures system normal operation even there is only one node.

4) Compatible with many communication protocols, such as IEC60870 and IEC61850, to facilitate the update of communication from data communication to the higher level model communication;

5) Integrative Diagram Model Library technology based on CIM for the establishment of primary models and secondary models;

6) Multi-source data processing function to increase data reliability;

7) Perfect post fault review function to restore event scenario;

8) Intelligent avalanche treatment technique to minimize the effect on system normal operation.

1.2 Data Acquisition

The Front-End system is responsible for SCADA system data acquisition and data communication, and constitutes the bridge of real-time communication between the whole SCADA system and others. Main functions of FE system include management of various acquisition channels, explanation of various acquisition protocols, and distribution (publishing) of acquired data information to various applications according to data acquisition demands (subscribing) of each background application.

The FE system features are high scalability. According to scale of communication data, the following work mode issupported.

Separated SCADA monitor program into different process and thread, which can avoid overload condition effectively. And CSS shall havelarge capability of 1024 channels to communicate with RTUs

1.2.1 Multiple FE Servers Working Mode

The multiple FE servers working mode is suitable for centralized control system or large regional dispatching center. Under this mode, configuration of several FE servers for operation in a cluster is permitted. An FE cluster permits simultaneous operation of 3, 4, or more FE servers, and provides larger system throughput and more reliable communication quality. Besides, standby nodes can be configured. During normal operation, these standby nodes will not work. When all FE nodes in the cluster fail to work, the standby nodes will be automatically put into operation and temporarily take over work of FE. When FE nodes are restored to normal, standby nodes will actively transfer communication back to FE nodes. This further improves system reliability.

1.2.2 Reliability of FE System

1) Redundant communication using several communication channels

2) Multi-node communication backup

3) Communication with terminal servers using dual network redundant mode

4) In FE cabinet, MODEM, opto-electronic isolator, and dual channel/dual computer switching device all adopt 2 sets of power supply. In this case, 2 sets of UPS can be used as power supply to ensure normal operation of equipment. All communication hardware supports hot plugging.

5) Multi-process communication service design is adopted. SCADA CCS can provide the function multi-source data acquisition and processing.

1.2.3 Support Protocols

The front-end (abbreviated FE) module of SCADA CCSsupports main remote control protocols. They are listed as following:

- IEC60870-5-101 remote communication protocol
- IEC60870-5-104
- IEC60870-5-103
- IEC60870-6-TASE.2 network communication protocol
- IEC61850
- DL476-92
- CDT
- Modbus
- OPC

……

1.2.4 Processing Functions

1. Statistics of channel operation: Include channel bit-error ratio (abbreviated BER) and RTU operation ratio etc.
2. Automatic detection and check of data;
3. Automatic/manual dual channel switching (not affecting data acquisition; with no data loss);
4. Automatic/manual host-standby node switching (not affecting data acquisition; with no data loss);
5. Support more than 3 front-end nodes; Distributed front-end system is adopted and acquired loads are balanced.
6. Separated SCADA CCS monitor program into different process and thread, which can avoid overload condition effectively.

1.3 Data Processing

1.3.1 Data Quality

The system configures data quality flags for all remote measurement values, BI value and calculated value to indicate degree of data reliability and current data operation condition. Quality attribute name is set up in the same name if an attribute name has been configured in the measurement quality type in IEC61970-301 and if not, the related part of IEC61970-303 or IEC61850 can be referred to or it can be self extended. SCADA CCS acquired data shall have abundant quality information and several of these pieces of quality flag information can exist simultaneously, including

Quality flags of analog values are listed as below:

Unacquired: if it is T (the same below), it refers to that this data point value has not been acquired in the update time limit after acquisition module is triggered. If not acquired, it does not send an alarm or participate in calculation etc.

Standby: data out of service.

oldData: within the designated time, the system fails to receive the effective data of this point from data source (e.g. RTU, SAS, computer communication);

test: indicate communication test is performing;

suspect: bad data detected by state estimation;

questional: e.g. corresponding CB is open, but the values of currents/voltages is normal;

badReference: meter accuracy is insufficient;

outofRange: beyond measuring range;

failure: Communication failure;

Alarmdisabled: no alarm signal will be issued in case of measurement abnormality or over-limit;

Maintaining: alarms/refreshing/control are all disabled;

ForcedMeasurement: indicate that data value displayed at this point is configured manually. Updating is disabled;

TempForcedMeasurement: the value is configured manually but once acquisition becomes normal, data will be updated;

Abnormal level 1: over-limit monitoring level 1

Abnormal level 2: over-limit monitoring level 2

Abnormal level 3: over-limit monitoring level 3

Abnormal level 4: over-limit monitoring level 4

Abnormal level 5: over-limit monitoring level 5

Abnormal level 6: over-limit monitoring level 6

Use network value: used for multi-source data. It indicates the data source adopts network value.

Use calculated value: used for multi-source data. It indicates the data source adopts calculated value.

Use state estimationd value: used for multi-source data. It indicates the data source adopts state estimationd value.

Use opposite-side value: used for multi-source data. It indicates the data source adopts the value on the opposite side of the line.

Remote regulation disable: indicating online manual control of remote regulation is enabled/disabled.

Remote regulation busy: remote regulation is performing

Printdisabled: the flag of not triggering immediate printing at abnormal alarm

Bypass substitution: bypass substation is performing

Over-limit monitoring: flag for over-limit monitoring of this point

Calculated value: refers to that this point is calculation point;

Quality flags of binary inputs are listed as below:

Open/close: current status;

Validity: acquired data is valid;

oldData: if not updated after configured time limit, it is regarded as old data;

questionable: acquired electrical energy may have a problem;

bouncing: state changes too frequently and exceeds the threshold;

failure: Communication failure;

test: indicates this point is being tested at this moment and transmission result is placed in the test mode for alarm, which does not affect operation and record of real-time system and the normal work of dispatchers;

Maintaining: no alarm, no update and remote control not allowed;

Planned state: indicate break/make state in planned operation;

Simulated state: indicate break/make state in simulated operation;

Printdisabled: the flag of not triggering immediate printing at abnormal alarm

RemoteControldisabled: flag of online manual blocking equipment remote control function enabling/disabling;

Alarmdisabled: no alarm signals will be issued when there is binary input status change;

ForcedMeasurement: indicate that data value displayed at this point is configured manually. Updating is disabled;

TempForcedMeasurement: the value is configured manually but once acquisition becomes normal, data will be updated;

Flashing: indicate occurrence of status change;

Bypass substitution: bypass substation is performing

De-energized: this equipment is de-energized;

Grounding: earthing state

Main network: T is main network; F is sub-network

Island 1: topological island 1

Island 2: topological island 2

Island 3: topological island 3

Island 4: topological island 4

Island 5: topological island 5

Double-point CB state error: the status of CB is unacknowledged.

Use network value: used for multi-source data. It indicates the data source adopts network value.

Use calculated value: used for multi-source data. It indicates the data source adopts calculated value.

Use state estimationd value: used for multi-source data. It indicates the data source adopts state estimationd value.

Calculated value: refers to that this point is calculation point;

Quality flags of electrical energy values are listed as below:

Validity: acquired data is valid

oldData: data not updated

questionable: acquired electrical energy may be error

overFlow: acquired reading overflow

outofRange: beyond measurement range

badReference: meter accuracy is insufficient;

Communication failure: failure of a communication stage acquired, including those detected by acquisition device;

Testing: indicate that test is performing.

Level of the above data quality flags ascends in the optional arrangement. If a data value has several data qualities, the highest level quality flag identification is displayed or printed with this value and can be disabled/enabled by user setting. Level and display color of each data quality can be easily modified manually. Unreasonable data can be displayed and printed.

1.3.2 Analog Process

Processing of analog quantities mainly are listed as below:

1) Conversion of engineering values

    Linear conversion and nonlinear conversion of engineering values can be performed.

    Linear conversion adopts conversion factor and intercept.

    Nonlinear conversion makes use of points on a group of curves that are provided in sequence, and will work according to the method of linear interpolation.

2) Check of validity range

If a measurement quantity exceeds validity range configured by the user, real-time database will not be refreshed, and acquisition timestamp will be kept at time of last effective acquisition. At the same time, corresponding alarm message can be generated or not according to configuration.

3) Zero drift

4) Taking absolute value

5) Invert: Invert the analog, but the absolute value remains unchanged.

6) Multi-source data processing

7) Bypass substitution

Automatic bypass substitution function is realized by judgment of network topological structure. During bypass substitution, values (P, Q, I, etc.) of the transferred feeder will be automatically substituted by the values of the bypass, and these will be recorded in the bypassing table for statistic calculation of electrical energy quantities.

8) “Manual enforcement” and “Cancel manual enforcement”: stop/restore refreshing of measuring points of a channel/substation/device or only this point.

9) Disable/enable alarm: disable/enable alarm signal for a channel/substation/device or only a point.

10) Setup of control disable/enable: prohibit/permit control of single channel, substation, device, or measuring point.

11) Supervising of line load flow over-limit;

Percent bar chart calculation of line load flow

12) Over-limit supervising and alarm

Each analog quantity can be provided with over limit supervising less than 6 groups of high/low limit values. These limit values can be divided into different durations. Data over limit can generate alarm events, and alarm mode can be configured flexibly.

Reasonable delay and dead zone can avoid frequent alarms. In case supervised value exceeds limit value for a period (delay), over limit is acknowledged. If the supervised value is restored within dead zone from over-limit, over-limit will disappear.

This can also be used to supervise some overload lasting for a period, e.g. line overload, transformer overload, and delayed alarm etc.

13) Supervising of bouncing data

Data bouncing status can be supervised. An alarm signal will be issues in case of frequent bouncing of some data. A “duration configuration for bouncing frequency calculation” can be taken as timing unit.

If the number of bouncing data in this period exceeds corresponding threshold, bouncing data alarm signal will be generated.

Data bouncing is judged according to comparison of the value before this data refreshing and the value after this refreshing, and the criterion is whether the changing speed or absolute value of change exceeds a threshold.

This function can be used to supervise sudden change of some measured quantities and alarm of some signals based on times.

14) Supervising of unchanged data

Permanent data of the system are supervised. If continuous period of unchanged data equals to or exceeds corresponding threshold, a permanent data event is acknowledged, and an alarm signal will be issued.

In case of large quantity of permanent data, fault of some equipment is judged, e.g. fault in acquisition device.

15) Supervising of load factor of transformer and line

Percent load factor is calculated for specified transformers/lines, and used for display and over-limit supervision. A number of groups (the number is not limited) of percent limit values can be configured for overload supervision. Up to 6 colors can be used to differentiate degrees of overload. Display of a list on the graph is permitted to show degrees of overload.

16) Statistical data invalidity time, used to calculate validity ratio.

17) According to user requirements, define and obtain statistics of maximum/minimum value of some quantities.

18) Load factors of transformer and lines are automatically calculated, and can be displayed on man-machine interface in sequence.

19) Automatic calculation for busbar balance and balance between both ends of a line. This can be combined with processing of multi-source data, to preliminarily judge measurement data quality flag. (Calculated in automation information assessment).

1.3.3 Digital Process

Processing of status quantities are listed as below:

1) Various quality flags are provided and status quantities can be represented by various colors/symbols on graph according to different quality flags.

2) Polarity processing of status quantities.

3) Multi-source data processing;
4) BI status change processing and alarm: fault BI status change and normal operation BI status change can be distinguished.
5) Double point BI processing and alarm: Besides status change alarm, alarm shall be provided for signals of uncertain status.
6) CB fault signal judgment: fault is judged according to corresponding general fault signal, protection operation signal, or operation of nearby CB.
7) Statistics of numbers of normal tripping and fault tripping of CB; prompting the user that CB needs maintenance.
8) Status change filtering (debouncing): the function of filtering of “BI bouncing” signal shall be provided, with alarm and prompt. At the same time, correct status of BI can be automatically identified.
9) Signal synthesis: operations of several signals are synthesized to form operation of one signal.
10) Event induction: several associated events will trigger a new event.
11) “Manual enforcement” and “Cancel manual enforcement”: stop/restore refreshing of measuring points of a channel/substation/device or only this point.
12) Disable/enable alarm: disable/enable alarm signal for a channel/substation/device or only a point.
13) Disable/enable control (for a channel/substation/device or only a point)
14) Maintenance/restore: no alarm is generated and control is not permitted during maintenance.

1.3.4 Accumulator Process

1) Storage and processing of pulse electrical energy and electrical energy with timestamp.
2) Obtain integral electrical energy from active power integral and reactive power integral, ans can be saved as a “reading”. Integral electrical energy can be used for statistical calculations.
3) According to bypass substitution record table, perform bypass processing during electrical energy statistical calculation.
4) Multi-source data processing for electrical energy

   The concept of multi-source data processing of electrical energy is different from that of analog quantities. For analog quantities, main processing is automatic selection of data of high credibility for dispatcher analysis and subsequent analysis and storage. With electrical energy, however, multi-source data sources of electrical energy are mainly: main meter, backup meter, integral, calculations, and acquisition of remote end electrical energy. Electrical energy acquired through other means can also be included, e.g. electrical energy acquired by TMR system. Data of these sources are stored, and for statistical calculations, the more reliable data are taken.

5) Engineering value conversion for electrical energy

6) Replacement of Watt-hour Meter

7) Alarm on inconsistent main meter and backup meter

1.3.5 Real-time Calculation

CCS shall providehigh performance General calculation functions configured in each application, and can also provide comprehensive cross-platform General calculation functions.

In this way, CCScan perform General calculation for any table/attribute /object. It can provide flexible and convenient calculation formula definition interfaces and support multi-level and multi-bracket formula analysis. Formulae can be managed in self defined folder mode.

CCSshall provide dedicated General calculation formula definition interfaces, supports various operations such as +, -, x, /, triangle operations, logarithm operations, integration operations, arithmetic operations, logic operations, function operations, lookup-table operations, supports multi-level and multi-bracket formula analysis and provides judgment of operation conditions. It can compute without compilation and can define formulae at any node, and can realize formulae sharing by the whole system.

It provides periodic, timed, conditioned trigger and manually triggered operation starting modes.

It provides calculation formulae and calculation and statistical methods commonly used in power system,so that users only need to select objects to be calculated instead of repeatedly defining formulae.

It provides various statistical calculation and assessment functions and flexible and convenient definition interfaces.

It provides more complicated calculation and assessment for the user, such as desulfurationsupervision.

Commonly-used Calculation Functions

CCS shall provide commonly-used calculation formula and calculation/statistical method,so that users only need to select objects to be calculated instead of repeatedly defining formulae.

They include the following calculations:

Voltage (abbreviated U) calculation;

Frequency (abbreviated f)/U qualification ratio calculation;

Calculate apparent power (abbreviated S) from active power (abbreviated P) and reactive power (abbreviated Q);

Calculate S from current (abbreviated I)/U;

Calculate I from P, Q and U;

Calculate Q from P, I and U;

Calculate power factor from P and Q;

Calculate the system or regional load (converted to the condition that f=50Hz);

Select a proper value from optional values as the system value in the designated sequence, i.e.: 1) select system frequency; 2) select voltage.

Maximum value, minimum value, occurrence time of maximum value, occurrence time of minimum value, average value statistics;

Load factor calculation;

Total sum calculation;

Transformer tap position calculation (including BCD code mode or other modes)

Overload and underload value calculation;

Power factor calculation;

Automatic balance factor calculation;

RMS value of current calculation;

Table lookup operation;

Electrical energy integral;

Bypass substitution;

RTU service ratio, operation time and channel bit error rate statistics;

Logical calculation;

Other calculations.

For calculated values, their data quality flags are indicated in addition to the operation results of original data.

General Calculation Functions

General calculation supports various mathematical operations that can be expressed by formula. Calculation results and operators can be any application, database, class and attribute, and calculation also can show their data quality flags.

General calculation can be used for real-time calculation and history calculation and maintain the consistence between real-time and history calculation formulae and unified maintenance.

General calculation can be configured with high performance in various applications or provide cross-platform and trans-database operations. Data can be taken from commercial database, files and other database interfaces etc.

The following calculation functions are provided:

Arithmetic operations;

Algebraic operations;

Trigonometric operations;

Logical operations;

Function operations;

Triggering mode of calculation functions:

1) Cycle

Unit of the cycle can be: second, minute, hour, day.

2) Timed

Calculation can be triggeredevery week, ten days, month, quarter and year.

3) Trigger by events

Can define an event (e.g. BI change) occurring in the system to trigger calculation.

4) Trigger manually

The system provides convenient and friendly off-line calculation definition interface and on-line display interface. For calculated values, their data quality flags are indicated in addition to the operation results of original data.

Considering system real-time performance and its implementation, the real-time calculation is divided into three parts: common calculations, general calculations and customized calculations.

Common calculations are binding to each application to process power system common formulacalculations，such as compute power factor throughP and Q.

General calculations support various mathematic calculations by formula analysis and operation management. It is compatible with all types of database applications.It support any data type (such as int,float,bool) from any realtime database of any application.

Customized calculations provide customized programmable functions realized by programming script.3.2.1Control and Regulation.Programe script such as if,else,while to control the dataflow.

SCADA control and regulation function refers to the remote control of breaker status, change of transformer tape position, capacitors switchover and the regulation of generator outputs. Specific program logic is integrated to avoid mal-operations during control and regulation so as to ensure operation reliability.

It shall support predefined and programmed control sequences. Control sequence include control command (control a status point to one of its states and send a set point), condition check and manual confirm. Control sequence can execute one by one automatically or confirmed step by step by operator. Control sequence can be predefined or defined temporarily.

1.3.6 Sequence of Event (SOE)

When a fault occurs in the power grid, CCS acquires general faultsignal, CB closing/opening/tripping signal and protection operation signal, etc. After receiving theSOE records of grid CB and relay protection device actuation accurately recorded in millisecondsent by different RTUs , SAS and other SCADA systems, the CCS arranges theseevents in time sequence (considering system reality, some RTU times may not be correct. Thetime acquired by master station is added to these events and sequence arrangement is thecomprehensive sequence arrangement of all substations in a certain period), generates, records,prints and displays on LCD display a comprehensive record report of system SOE.

SOE data information can be displayed on LCD display, printed by printer and stored as historyinformation in history database.

The following functions are provided to the user by using event retrieval tool:

1) SOE information storage time.

2) SOE is arranged and displayed in recording time sequence of respective substations or inacquisition time sequence.

3) SOE information of any day and any time period can be retrieved.

4) All SOE information can be permanently stored as disk files, and can be transferred andeasily imported into the system. After importing, the history information can be easily retrieved,displayed and printed.

1.3.7 Trend Record

1.3.7.1 Trend Record

Data for trend curve can be those from real-time database, history database and application software database, and daily plan data and forcasting data can also be used.

Trend record stores the relatively real data change process in a period (at least 60 days, expandable) and sampling period can be defined, which can be second/minute/hour. Sampling density is 1s maximum.

The number of trend records is not limited and the user can define it depending on the need.

Trend record is mainly displayed in curve form. It is allowed to drag the stored measuring point arbitrarily in the substation diagram for superimposition or replacement display in the trend curve display template, and up to 20 curves can be displayed.

It is possible to use the ruler to mark the curve value of each moment and display all point values and moments on the curve in list.

Curve comparison and analysis can be made and curve area can be calculated.

1.3.7.2 Trend curve display tool

Curve is a data description mode and analysis tool commonly used in MMI module of the power system and its advantage is that the trend of data varying with time can be displayed vividly, which help the user grasp data variation rule and analyze statistical information. Curve editor provides abundant operations and humanized design is made for some operations, thus the user can better and more conveniently use it.

1) Integrated tool

System curve editor is a perfect graphic system integrated with curve definition, display and storage. Different from the ordinary curve editor that can only display some static and simple curves, the curve editor can refresh data in real-time according to the user's will and store some well defined curves for recall at any time.

Selection of multiple coordinate axis modes

Coordinate axis of curve editor is multiple coordinate axis mode (each curve corresponds to one longitudinal coordinate axis) and single coordinate axis mode (all curves correspond to one longitudinal coordinate axis). The user can choose the corresponding coordinate axis mode depending on need.

2) Rapid operation mode

After storage function of the curve editor is combined with the system Online tool, a simpler and more rapid operation mode is produced. The user can directly take the displayed object from Online tool after plotting a template. Only with one step of mouse operation, can the user easily see the interested curve, thus omitting considerable defined operations.

3) Built-in listing tool

The curve editor also has value listing tool built in and the user can more accurately know the data information of all curve points. Different from the display functions of ordinary curve, the curve editor enables the user to modify the values in the corresponding database through it if the database permits.

4) Power system-oriented design

In the light of power system features, the curve editor provides four limit values (upper limit, ultra upper limit, lower limit and ultra lower limit) and the user can configure the out-of-range color for each limit value.

1.3.8 Post Disturbance Analysis

Post disturbance analysis function records the power system operating conditions in a long period before and after a disturbance, facilitating the analysis, study and reconstruction of system disturbance by dispatchers. Detail given in follow section Post Distrurbance Replay.

1.3.9 Post Disturbance Replay

ThePDR database recorded by panoramic PDR has a time tag. In playback, it automatically matches with the previous graph version, database mode model and application program, to completely reproduce the graphs and data at the time of fault recording.

Review and playback are completed by the special player,with simple and visibleoperation, similar to movie player. All playback processes can be controlled, including forward, backward, pause, play, stop and exit functions; demonstration modes include single step and continuous; demonstration point can be searched by time.

1) Triggering PDR

In normal conditions, SCADA system will periodically record the data needed by PDR and SCADA system section in the opened up hard disk, and storage area has the capacity required for periodically recording all continuously changing data in the system in first M minutes. Each PDR record includes all data and the then scene within M minutes before and N minutes after trigger event occurrence. Time M and N can be modified online without value limitation. As long as there is sufficient disk capacity, M minutes before trigger can be as long as 10 days to facilitate manual trigger. After stored, it can be manually edited to store the most necessary part.

PDR can be triggered by manual trigger or by defined event trigger. Trigger events can be:

Measurement over-limit;

Grid frequency deviation over-limit;

Status signalschange;

CB emergency trip;

Protection operation;

Other pre-defined events.

In manual trigger, the user can inputtriggering reason.

PDR supports multi-event triggering function. The number of events is unlimited.

2) PDR data view and playback

The dispatcher can perform fault playback at any workstation (UNIX workstation or microcomputer platform), and it is permissible to perform fault playback at several workstations simultaneously.

PDR data is stored in a disturbance file (including pre-disturbance/post-disturbance data) and used to rebuild and store data. PDR data can be used to play back the whole event process in screen, and one line diagram, table and curve can be used to play back the then change and change process of the disturbance data.

In PDR playback, there is convenient and simple demonstration control interface. Review can be done in single steps or continuous demonstration, fast forward, fast backward and pause can be realized. It can be configured to start review from a moment and view speedcan be configured as high and low. With drag bar, the user can easily drag it to any moment point to play back.

It provides dynamic network topological coloring in PDR playback process, and network structure change process is dynamically displayedon one line diagram.

During PDR playback, it is possible to pause at any moment (pause timecan be manually inputted) and start PAS software to perform various network analysis functions performed at the time.

PDR playback process does not affect online function at this node. PDR playback can be operated simultaneously with SCADA online functions and on one line diagram, different operation modes can be used to show the difference from online environment. PDR alarm and online alarm tools are distinguished by different window style and titles.

During PDR playback, the then graphs and database model are used for playback and change of graphs, network, database model and network structure does not affect PDR data before playback.

In order for the user to easily know the related information in this PDR, alarm report and list of main events are provided when playback starts:

Alarm report refers to the record summary of alarm items occurred in this PDR. It is generated in the environmental preparation prior to PDR playback start so that the user can know the main items occurring in this PDR before PDR playback starts:

The list of main events is a list of causes triggering this PDR.

3) PDR data editing

It provides concise and friendly management tool interface and the user can:

View the important events and labels of the whole PDR process;

In combination with PDR player, quickly select a section at the fixed point to play and make a flag;

Cut and edit PDR scene;

Save as or cover the original PDR scene. Several versions can be edited, to choose the one after playback.

4) PDR scene data management

It provides concise and friendly management tool interface and the user can:

Realize memorandum management and give remarks to each PDR scene and indicate PDR description;

Store PDR scene in the other storage media and import it for re-playback;

Manually delete PDR scene file functions;

When disk is overloaded, automatically delete PDR scene file functions and those without remarks will be deleted first as low grade PDR scene;

Enable the function of automatically deleting PDR scene by time (e.g. half a year ago) and time is configurable.

Deletion methods can be combined.

1.3.10 Topological Coloring

Topological coloring function judges the real-time grid connection mode according to the equipment interconnection relation and current CB and DS state, colors are painted to various equipment in different status. Topological coloring module can judge the number of topological islands in the present system, equipment composition of topological islands and equipment energization information according to the real-time CB status and express them in different colors.

Network topology analysis includes 2 steps:

Busbar analysis: To combine the nodes that connect closed circuit breakers together and define it as 1 busbar;

Topological island analysis: To combine the busbars which connect lines/transformers together and define it as one "island". The island that has both power supply and load is significant for calculation and called "Energized Island" and physically corresponds to the live part; otherwise it is called "De-energized Island" and physically corresponds to dead part.

Topological coloring module realizes the following functions:

Judge the real-time connection mode of the power grid according to the network component correlation defined in network model type and the current switch and DS state.

It can deal with any connection mode, e.g. single busbar, double busbar, double busbars with transfer busbar;

It can judge the number of topological islands of the current system, equipment composition of topological island and energization.

It can analyze and deal with topological island situation and determine de-energized island and energized island state, and can distinguish different islands with different colors when there are several islands;

It can realize topology for earthing network;

It can handle manual enforcement and binary inputs;

It can realize network topology according to control and handling range and perform topology for the specific range;

It can distinguish grounding equipment, energized equipment, de-energized equipment, grounding, tagging and wrong grounding with different colors;

It can realize equipment power supply tracking and equipment power supply range tracking according to network state.

1.3.11 Historical (HIS) Functions

The CCS HIS subsystem is designed to provide storage, processing and retrieval of large amount of historical information for CCS system. HIS system acquires real-time data and alarm messages processed by SCADA system, stores this information in historical database, and automatically performs calculations, statistics and verifications according to user defined categories, so as to providing various comprehensive and detailed historical information for MMI, WEB and MIS etc.

1.4 Supervisory Control

CCS shallsupport predefined and programmed control sequences.

Control and regulation are mainly used to remotely control CB open/close in substations, changetransformer tap position, enable/disable capacitors and regulate generator output. During control and regulation, CCS uses many strict measures to ensure the safety and reliability ofcontrol operations and prevent maloperation.

All the objects can be controlled are saved in database, so user can select a few of them into a group .After that ,user can select the group out from database ,and give every command the control target value to execute .

Bidder can provide simulation RTU software to play the role of real RTU in substation, so user can execute the control sequence with the simulation RTU as the off-line test.

1.4.1 Control Triggering Mode

Control can be triggered by 3 modes introduced as below:

1) Triggered by API: control execution is triggered by command issued in application program;
   Control command can be send by program such as AGC(Automatic Generation Control) or AVC(Automatic Voltage Control) module ,to control the power transformer tap, circuit breaker , generator and so on.

2) Triggered by condition: dispatchers can configure some events (e.g.: CB status change,analog over-limit) as conditions to trigger control execution;

3) Triggered by invoking: dispatchers can trigger control by operating on some menus.

1.4.2 Control Types

Control can be divided into single control, sequential control and conditional control.

Single control is to control the single point; sequential control function is to use the pre-definedcontrol command to control a group of related equipment.

For sequential control, a group of control commands are pre-defined and generated by thedispatcher and submitted at a time, for execution in the defined sequence or in selected steps.

Conditional control is to manually set conditions for control initiation and when conditions are met, and command is issued automatically.

The system has full graphic interactive means to enable dispatchers to conveniently define,generate, store and modify sequential control command files.

Sequential control command is described in a visual and legible form. Sequential controlcommand contains the following information:

- Operation object;
- Operation content;
- Operation time configured previously;
- Final status/value of operation object;
- Blocking condition configuration;
- Enable/disable sequential control command;
- Automatic/step-by-step execution, etc.

When sequential control command is executed, check conditions of operation content/time/objectand blocking condition involved in each step are recorded in the corresponding file for inquiry.

Sequential control can also be auto execution and multi-step execution. Various conditions thatreason incomplete blocking need to be properly intervened by the dispatcher and sequentialcontrol can be executed in multi-step mode.

Control commands in sequential control are interrelated and execution of the next step ofcommand often depends on the execution result of the previous command and interrelation between control points. System engineering allows defining the corresponding blocking conditionsfor each step of command and providing very friendly man-machine interface for dispatchers toeasily define and modify the corresponding blocking conditions.

Blocking conditions are described visually. When all conditions are met, blocking conditionevaluation module obtains the result of operation approval and allows for execution of this step ofoperation. Otherwise, the execution of control sequence is terminated and the reason fortermination (why conditions are not met) is recorded in detail for analysis. Blocking conditionvalidity/invalidity can be configured online.

Triggering conditions of conditional control can be status signal change, analog over-limit, eventtriggering etc. The system provides full graphic interactive mode for operators to easily define,generate, store or modify a conditional control file.

1.4.3 Controlled Objects

- CB/DS/ES open/close control;
- Regulate transformer tap;
- Enable/disable generator unit;
- Enable/disable capacitor;
- Generator P/Q regulation;
- Enable/disable and regulate Var compensator;
- Sequential control.

1.4.4 Control Command Execution Result Display

CCSshall provide friendly man-machine interface to display execution result of controlcommand on the workstation, mainly including:

- Control process and check result display;
- Control operation and result record table;
- Abnormal control termination record;
- Control success ratio statistics.

1.4.5 Anti-maloperation Function

CCSshall provide graphic mode anti-maloperation condition definition functionexpressed in logic diagram form, to support complicated logic blocking conditions and supportblocking condition definition of status signal and analog, which is simple and easy to understand.

The system can be configured for whether to enable anti-maloperation function and, to allowdisabling individual anti-maloperation function during control.

If blocking conditions are not met during control, the unsatisfied conditions can be analyzed and displayed.

1.4.6 Other Safety Supervision Functions

In the CCS system, measures shall be taken to ensure safety and reliability of controloperations to prevent maloperation.

Control must be executed in the workstation with control authority.

Operators must have the operation authority.

Each step in operation is started with corresponding prompt and result of each step hascorresponding response display.

Whether there is control check can be configured for control. If there is control check, execution isdone in three steps of point selection, check and execution. When point is selected, if one of thefollowing cases occurs, point selection is automatically canceled to wait for selection again:

1) No subsequent operation is done in 30s (configurable) after point selection;

2) The “Cancel”key was pressed;

3) The equipment is already forbidden to be operated;

4) Control check fails;

5) No command is executed within 30s (configurable) after a successful control check.

For remote regulation control of analog, perform regulation value limit check.

When different operations are done on the same equipment at the same time, it will be blocked.

When different workstations control the same equipment simultaneously, it will be blocked.

During operation, RTU and channel operation state is supervised.

Equipment control prohibition can be configured and tagged.

It provides detailed records including operator’

1.5 Permit to Work (PTW)Recording

SCADA CCS tagging shall provide a means for adding, modifying, removing, and displaying protective or informational tags on power system devices, such as breakers, modeled in the SCADA system. By tagging function, PTW Recording requirement could be achieved. Detail of tagging function is given in the following section.

1.6 Tagging

SCADA CCS tagging shall provide a means for adding, modifying, removing, and displaying protective or informational tags on power system devices, such as breakers, modeled in the SCADA system. Tags are normally placed on devices to warn or inform operators of special conditions in the power system, and they usually prohibit or constrain the operation of the device. Tags can also be placed at substations for informational purposes.

When a tag is placed on a device, the user is prompted to enter an appropriate comment. An event message is generated each time a tag is placed or removed.

Tagged devices appear on the tag summary displays, with a notation of the date and time the device was tagged. If an attempt is made to control a device with a preventative tag, the control is cancelled. For restrictive tags, the user receives a warning, but can override it and issue the control anyway.

Annotations are managed as characteristics or properties of a tag. Therefore, the two concepts of tags and annotations can be used to describe the state of the control system.

Different tags shall be supported in SCADA CCS. Such as :

Warning tag to remind the dispatcher,

Repairing tag to remind the dispatcher the equipment is repairing and alarm will generated but show in another windows, and control is prohibit.

Ground tag to remind the dispatch that the equipment is connected with ground, and this tag can be put only on equipment with no power.

Other tag can be defined by user .

1.7 TASE.2 Data Exchange

ICCP is an international standard (IEC 60870-6) for Telecontrol Application Service Elements (TASE.2). ICCPdefines a model for control centers, including the various processes, operations and actions that can beperformed. ICCP also provides a set of communication services, based upon the same MMS protocols(ISO9506) referenced in EPRI's Utility Communications Architecture (UCA™) and IEC61850, that can be usedto exchange data values and data sets between control centers, substations, and devices in real-time. BecauseICCP is supported by many of the leading EMS/SCADA vendors, it offers a wide range of interoperability withother EMS/SCADA systems. And, because ICCP is based upon MMS, other applications like power qualitymonitoring, substation automation, and process monitoring can share the same network infrastructure.

ICCP consists of a broad range of functions from simple device control to real-time exchange of account informationfor real-time pricing and wheeling functions. The specific functions performed by a given implementationis dictated by the ICCP conformance blocks that the implementation supports. The following is a brief descriptionof these ICCP conformance blocks and their associated objects and services:

- **Block 1 - Basic Services**

  Association Objects:

  P Services to control communications sessions between ICCP clients and servers

  Data Value Objects:

  Get/Set Data Value

  Get Data Value Name/Type

  Data Set Objects:

  Create/Delete Data Set

  Get/Set Data Set Element Values

  Get Data Set Names/Element Names

  Transfer Set Objects:

  Start/Stop Transfer

  Data Set Transfer Set Condition Monitoring(Interval time-out and operator requestconditions)

  Next Transfer Set Object:

  Get Next Transfer Set Value

- **Block 2 - Extended DS Condition**

  Monitoring

  Object Change, Integrity Time-out and External Events for Data Set Transfer Sets.

- **Block 3 - Blocked Transfers**

  Support for Transfer Reports with Block Data†

- **Block 4 - Information Message**

  Information Message Objects (operator messages) and services.

- Block 5 - Device Control

  Device Objects:

  Select/Operate

  Get/Set Tag

Time-out

Local Reset

Success/Failure

- **Block 6 - Programs**

Program Objects:

Start/Stop/Reset/Resume/Kill

Get Attributes

- **Block 7 - Events**

Device Objects:

Success/Failure

Event Condition Objects:

Event Notification

Event Enrollment Objects:

Create/Delete Event Enrollments

Get Event Enrollment Attributes

- **Block 8 - Accounts**

Transfer Account Objects:

Condition Monitoring and Reporting

- **Block 9 - Time Series**

Time Series Transfer Set Objects:

Condition Monitoring and Reporting

Not currently supported by the ICCP Toolkit for MMS-EASE

CCS manufacturer shall be fully compliant with the latest version of TASE.2 protocol.

1.8 Intelligent Alarm system

1.8.1 Display Alarm Information in Different Levels

The display of alarm signals is the basis for implementation of intelligent alarming. As the remote information, protection signal information, etc., which are connected to the control center are divided into different levels manually previously, the alarm service is used to transmit the alarm attributes of different binary inputs into the alarm list. The alarm display window will display the alarms according to the levels.

Alarm Information Classification Rules

5levels for all BI points are provided by default, i.e.

1) Fault level:It mainly consists of the protection operation signals and primary equipment blocking signals, etc., e.g. protection operation, CB tripping, pressure blocking, cooling system power failureof transformer, etc.

2) Abnormal level:It mainly consists of the abnormality signals of the primary/secondary equipment, etc., e.g. voltage over-limit alarm,overload alarm, CB low gas pressure alarm, DC earthing fault, etc.

3) Reference signal level:It mainly includes: CB control open/close signal, enabling/disabling of isolator links, tap position regulation signals of transformer, etc.

4) Supervisory control level: Short-time over-limit signals for analog inputs, etc.

5) General signal level: CTS/VTS/TCCS…, i.e.: the signals generated during normal operations.

Display Alarm Information by Levels

MMI alarm window displays the alarm signals in different Tab pages according to the attributes of acquired status signals.

1) Topmost tactics:The contents of very important alarms configured to be topmost. The topmost mode is used to ensure that the important alarm contents shall not be annihilated. The alarm contents to be set up at the top can be defined by the user, e.g. the main protection operation information and the fault diagnosis results. The analysis results which are considered to be very important shall always be set up at the top position as long as they are not acknowledged by the dispatcher.

2) Prior display of information of high emergency level: When no fault tripping phenomenon is actually found during real-time operation of the power system, as the BI alarms are displayed on the classified basis in case of sending out multi-level signals simultaneously, the important alarm information that occurs can be displayed by the means of red-light flashing to remind the user to view it and prompt the dispatcher to view the most emergent alarm information, so as to restrain the fault in the bud.

   When the fault tripping phenomenon is actually found during real-time operation of the power system, as the BI alarms are displayed on the classified basis in case of sending out multi-level signals simultaneously, the dispatcher is helped to locate rapidly the most important protection operation signal, the abnormality signals of equipment and devices, and switching enabling/disabling operation of CBs, providing help in making the fault diagnosis.

3) Prior display of alarm information of“current duration”: The“current duration”can be defined by the user at random according to the actual conditions. There are 2 definition modes:

   (1) The duration threshold

   The configured duration will be applied as the time range.

   (2) Time difference threshold

   When the difference in occurring time of any 2 adjacent faults exceeds a certain range, the faults will be regarded as that they belong to the different fault duration.

   The user can define the current duration by setting these two values.

4) “Red-light flashing” will prompt the level of current alarm information. Once the operation personnel have acknowledged all alarm signals of this level, the red-light flashing will disappear.

1.9 Fault Abalysis application

Fault analysis application is used to simulate and study power system behavior under various fault conditions. Normally, not only single phase fault can be simulated, but also 2-phase and 3-phase faults. Both short circuit fault and broken line fault, and both single and complicated fault can be simulated. By means of fault location application, Each branch current and bus voltage caused by grid fault can be determined to check equipment fault withstand capability and protection settings. For example, calculated fault current can be used for calculation of circuit breaker rated capacity, and protection action settings can be determined and protection scheme rationality and coordination etc. can be further analyzed by calculation of fault current.

1.9.1 Fault Diagnosis Method

After a fault is found in the power network, the information received by the control center mainly includes: the CB operation information, protection operation information, current/voltage over-limit information, recording information, etc. In view of the information contents, the CB operation information and the current and voltage over-limit information are from the EMS system, and at present, they are available completely. The protection operation information and the recording information are from the tele-protectionsystem, and only those sub-stations that have been installed with a tele-protectionsystem and that send the protection information to the control center can be provided with such information. In view of information time characteristic, the CB operation information, protection operation information and the current and voltage over-limit information have a strong real-time characteristic, while the recording information has a relatively poor real-time characteristic.Therefore, in view of the observation object characteristics of power transmission network and taking into consideration of enhancing the real-time characteristic and using the information flexibly, it is recommended to make the rapid fault diagnosis based on the CB tripping information and local network topological technology.

3.10.1.1 Diagnosis Pre-processing Based on Breaker Information

After fault signals are received, the alarm pre-processing function analyzes and identifies the acquired relevant digital signal information and set up the flag bit of fault diagnosis starting.

Bur for signals simulated by CCS FE system (e.g.: CB status change signal, or the remote control signal), it is unnecessary to set up the fault diagnosis starting flag.

3.10.1.2 Diagnosis Topological Processing Based on CB Fault

In case the fault is found in the power system, either a single fault or multiple faults, or a miss operation of CB, finally the fault elements will be isolated in a small/passive/isolated network one by one. These passive, isolated networks are called as fault power failure areas. The multiple faults can also be simplified as a single fault in one or several small areas. Therefore, the fault diagnosis can be made only based on these blocked power failure area, so as to reduce the range of fault diagnosis greatly.

After the fault is found in the power network, the whole power system can be divided into the electrification area and the power failure area according to the network topological results. The electrification area is the normal operation section, while the power failure area is classified as 3 types:

1) The normal power failure area where the elements were out of service and de-energized due to some reasons (e.g.: maintenance, etc.);
2) The power failure area due to maloperation.
3) The power failure is resulted from the maloperation of CB protection;
4) The power failure area due to fault.

Fault is found in this area, so that the relevant elements are cut off. As for the relevant elements in the fault power failure area, a portion of them refers to the fault elements while the another portion of them refers to the non-fault element, e.g. the element that causes the power failure just because the adjacent upper-level element is cut off by the protection after it is found to have a fault. The purpose of fault diagnosis is to find out the fault element in the fault power failure area.

When making fault diagnosis based on the network topography and CB tripping information, it is necessary to take pre-processing of the CB status change information into consideration. Based on the operation principles of protection, reclosing and automatic transferring, the CBs operated after the fault is found may have 1~3 status changes. The information of CB status, protection automation device, analog input values, etc., can be used to make pre-processing of the CB status change information in order to identify the correct meaning of information of each bit shift, or identify the erroneous report and missed report of information accurately so as to acquire the correct bit-shifted CB information.

1.9.2 Display of Fault Diagnosis Results

After the fault diagnosis completed, the system can automatically create the network fault diagnosis report and display it.

The main contents of power network fault diagnosis are listed as below:

Fault occurring time;

Fault element set;

Fault probability of suspicious elements;

Time sequence signal when is CB is tripped/closed;

1.10 Load Shedding and Restoration

Emergency Procedures and Load Shedding can receive alarms, events or critical conditions which occurred on the pre-defined network, detect the specific alarm or event depending on the pre-defined conditions and show the dispatcher the strategy associated with the specific alarm. The actions of the strategy include a list of breakers recommended for load shedding and description for the load values and total MW amount of load to be shed. The strategy is pre-defined to meet the required secure state of the network. The triggering conditions and the actions of the strategy can be flexible enough to contain any combination of SCADA data point or the other results provided by network security analysis functions such as CA and DSA and a single action such as the breaker switching or combination actions explained by the strategy such as load priority order. Triggering conditions, detection procedures and control actions are all can be created, modified and stored using specified editor tools kit. Automatic Load Shedding function can assist the Dispatcher in analyzing the alarms or events received by SCADA and locate the specified tripped circuit breakers according the alarms or events.

Based on the origin of the event and the preliminary actions, the Dispatcher can use ALS processing lists to restore individual loads by manual SCADA commands. In order to better assist the Dispatcher understanding the ALS processing lists, the power value estimation of the loads that could be restored can be presented to the Dispatcher.

2. Information Management

2.1 Database Platform

2.1.1 Object-oriented Model

Basic object-oriented characteristics such as enclosure, inheritance and incidence etc. are supported, essentially ensuring support of IEC61970 standard CIMmodel; Strong expandability capable of constructing complicated data models and powerful expansion/evolution of database modes/models; in addition to support of various fundamental data structures, this platform provides definitions and use of various self-defined types, e.g. enumeration type and structural type etc.; Effective object sequencing mechanism shall be provided to support dual characteristics of database permanent memory and dynamic object limited life cycle. Modeling tool provides object-oriented application modeling mode to generate corresponding database files and database method dynamic library files.

2.1.2 Distributed System Structure

The same database can be distributed on each node in the system as required. Perfect consistency strategy ensures synchronizing and update of copies and multiple copies of database avoid single point fault, thus increasing system reliability;Database system also realizes connection and distribution strategy of database; flexible connection, distribution and multi-copies of database realize system load balance and ensure system operation performance;Based on connection and distribution, database system also adopts advanced connection pool management, realizing multiplexing of database connection and greatly reducing system overhead. In case of database server failure, the system will automatically reconnect to the server with lighter load according to connection and distribution strategy; once local server is restored usable, the connection will be switched to local again to maintain high data access speed; Corresponding to transparent database access mode, 2 database connection modes Client Only and Client/Server are provided, allowing both highly efficient access of local database and transparent remote access;Unified management of real-time data and historical data is realized and access of database is made by unified interface without the need to consider real-time data or commercial database for data storage.

2.1.3 Highly Efficient/Convenient Object Access Mechanism

Rich data access interfaces satisfying demands by different layers of applications and providing object-oriented access mode, so that access to database is as convenient and fast as memory operation; While ensuring unique identification of objects, database **OID** mechanism provides pointer level access speed, effectively ensuring system real-time;Conditional retrieval function combining navigation search and association query allows an application to search any object satisfying conditions from any point of the model and along association path;Data access interface meeting **CIS (Component Interface Specification, It is one of the IEC 61970 series that define an application program interface for an energy management system)**standard allows application program to not only easily access data from external data source, but also easily pack them to “plug-and-play”components that can be plugged or unplugged on each application frame;Unified real-time/historical query: unified query of real-time and historical data is supported without the need of differentiation.

2.1.4 Others

There shall be two real time databases in CCS system. One is offline database and the other one is online database. Usually, model maintenance is operated in offline database. When the maintenance operation is finished, the system will check whether the operation is correct and the model is reliable. The mistake information can be displayed if the examination didn't pass and all errors can be solved before publish the operation. When the result of verification is correct, the offline database will be loaded into the online database, and then the real time database will switch to the new database seamlessly. There are many advantages of this strategy: 1) security: all of the maintenance operations are completed in offline database, so that any mistake won't directly affect the running system. System will check automatically after maintenance and make sure that all the operations are reasonable before they are loaded into the online database. 2) Online maintenance. When the publish operation finished, the system will switch the online database to new version seamlessly without system stopping.

The SCADA point name should use the international abbreviation, i.e. "Ia", "Ib", "Ic" for phase current, "P" for active power, "Q" for reactive power etc . And the length of SCADA point name shouldn't over 20 characters.

2.2 Rich Tool Software Package

2.2.1 Database schema tool (dbschema)

Dbschema is mainly used by application development personnel in visualized database mode management, including database mode definition, modification, issuance and version management etc. Its features are as follows:

Object-oriented modeling that provides easy and fast browsing and modification of modes, and relatively high availability;

Self-contained inspection mechanism for integrity and consistency that ensures correct database mode;

Powerful mode import/export mechanism providing relatively high reusability of modes.

Database model modification (add new field in one table, remove existing field, change field size, adjust table size…) to deploy these model change to online database, system will restart the online database service, for some circumstance, some program may need to re-compile as these programs access some fields directly. Resizing the ems system(databae, program) may be necessary by modifying the database structure.

2.2.2 Database I/O tool (dbiol/dbiop)

Dbiol is one of the important tools for system data maintenance. **Dbiol** integrates each operation step of database maintenance, e.g. maintenance data modification, data verification and database loading function and features the following:

- Safety: Unverified maintenance operation can not act on operation system;
- Convenience: Display based on views shall be provided for easy operation and data maintenance;
- Generality: Unified general data editing function that allows maintenance of most system data;
- Flexibility: Special data maintenance requirements for each application can be flexibly supported, as well as triggering method, easy database completeness and consistency inspection, and other special requirements.

Highly efficient online database loading function: Database being serviced or verified offline can be directly loaded in online system without the need to interrupt normal operation of online system.

Dbiop is one of the database tools for online database editing, for database which shall have both offline and online database.

Dbio tool shall have the functionality to record database change log, the log item includes the user login information, database record change information (insert/delete/update operation, old value/new value) and all the log infos are stored in a log file, we can use the log analyse tool to open database log file to view and analysis the database operation logs.

Dbio tool shall have the functionality to export all records in a database table into a csv(comma separated values) file, it can also use the well defined csv files to batch import records into database by using database importing functionality.

Dbio tool can also define default values for each database field, when user inserts a record, if one field in the record is not assigned to some specific value, it will be assigned to the default value which is defined by the dbio tool.

For user input, it also check if the input value can pass the value validity, if it fails the input value will be dismissed and user need to input the valid value.

2.2.3 Object Retriever dbsearch

Dbsearch is the graphic tool for visualized retrieval database information and features the following:

Object retrieval function based on grid model and fully considering dispatch system data retrieval characteristics;

Unified retrieval of real-time and historical information shall be provided with memory function to reproduce retrieval process;

Flexible and configurable retrieval mode that can meet various special retrieval requirements;

Retrieval process based on conditions shall be provided and retrieval conditions can be automatically generated at the same time.

All the tools support multi-user login, each user can retrieve data, modify database simultaneously.

Real-time data, application data(system management, mmi..) calculated data is stored in different database, users can dbio tool to open corresponding database to view data. For historical data, there is a tool hisdbBackTool can query/backup historical data.

2.3 System message log storage retrieval

There are two categories of events in the system: log type event and alarm type event.

Log type events are normally just used to check ordinary conditions of program operation. At present, these are stored in the form of log files. The program can also pop out alarm type events for processing by alarm server.

Alarm type events will be saved in real-time database and displayed to relevant personnel. At the same time, these events will be saved in relation database for long-term storage that allows query and archiving. Processing mode for each type of alarm can be configured to order, e.g. required instant printing, audible, graphics popup, voice and short message alarms etc.

In case of burst of events (referred to as avalanche), system resources maybe exhausted, thus affecting functions and performance of the whole system. For this reason, alarm weakening treatment shall be provided for avalanche. This is mainly reflected in communication resources, voice functions, printing functions, graphics popup functions, **BP** machine short message function and saving in relation database etc.

2.4 Report

Technical features:

The report system shall be 100% developed by pure Java language. Various operating systems such as **Windows** and **UNIX/LINUX** are supported. Very good cross-platform property and portability shall be provided.

The report engine provides Excel style table widgets and richAPI interfaces and GUI designer. Report forms generated by the system can be saved as true Excel file compatible with Excel.

The report system allows easy addition and deletion of rows and columns, adjustment of height of row and width of column, setting of cell font, display format and border style etc.; copying, paste and clipping functions are supported; Undo andRedo functions are supported; electronic worksheet formula are supported; mixing of graphics and tables are allowed to provide a rich presentation. Operation style andmode are similar to Excel, hence easy to learn and use.

Report forms can not only be associated with history data foreground, but also real-time data foreground.When associated with history data foreground, generation of serial foreground is supported, that is to say, one definition can generate a batch of foreground points of the same object. When associated with real-time data foreground, one definition can generate foreground points of a number of objects with the same property. Foreground definition also supports copying, pasting, clipping, Undo andRedo functions.

The report system provides report auto generation function for fast generation of report forms. In less than a minute, a very typical daily report or monthly report can be generated.

During the design of report, results of report can be previewed online to facilitate better design.

When browsing a report, data can be retrieved from database according to latency time of report. Data in report can be modified and inserted. Historical data can be permanently saved in historical database. Real-time data foreground points in report can be dynamically refreshed.

Reports are consistent on the whole grid and report generated by any computer can be viewed on all other computers in a real-time and unified manner.

The report system supports timed printing and called printing.

After modification of historical data, re-calculation for report can be triggered for re-generation of report.

To enter the report system, certain privilege is required. Personnel who want to edit reports must have report maintenance privilege and personnel who want to browse reports must have report browsing privilege.

The CCS report tool shall have report template and report browser. Defining report template is used to edit and generate different styles and different types of report template, such as operation log (daily), monthly statistics (monthly), statistics (annual report) and various management reports. Report browser could generate and display the final reports from the database automatically according to the setting of the report template; users do not need to know where the data is derived from, historical library or real-time database. Reports can be saved as Excel file, or a text file, for WEB publishing and archiving.

Reporting tool supplies all kinds of statistics function for all applications, the sources of data include SCADA, PAS, DTS and other application. For example monthly substation voltage report, assessment index statistics of state estimation report, daily system power consumption assessment report.

2.5 Historical Function

CCSsystem shall adopt combination of real-time database and historical database, to provide **EMS** applications with unified and general DBMS platform, and satisfy special requirements for real-time, consistent, complete and open database. **DBMS** can use historical **database schema tool** to ensure consistency in mode definitions in historical database and real-time database. By means of general unified access interface, real-time/historical crossing transparent data access can be realized so as to well integrate real-time database and historical database.

HIS subsystem makes full use of Oracle database features such as high safety, high processing speed, large memory and standard and open SQL data access interface etc. to provide a platform of storage, processing and retrieval of large amount of historical information for **CCS**system. **HIS** system acquires real-time data and alarm messages processed by **SCADA** system, store them in historical database, and automatically performs calculations, statistics and examination according to user defined categories, so as to provide various comprehensive and detailed historical information for**MMI**,**WEB** and MIS, etc.

HIS subsystem adopts dual shared disc array structure based on Oracle OPS. Its main functions include the following:

1) Data acquisition: including periodic sampling storage mode and event-triggered storage
mode etc.;

2) Data processing: including various statistics and calculation functions that can be flexibly defined by user;

3) Data maintenance: realizing automatic maintenance of historical database data by means of archiving backup functions;

4) Data access: provides unified real-time/historical retrieval to realize transparent access to real-time and historical data.

2.6 PDR Function

PDR Replay truly represent system change process in a period before and after the event in a panorama mode; graphic display and alarm process scenario are identical to what happened during the event.

Any workstation can be used for **PDR Replay**, which will not affect online functions of this node; **PDR Replay** data can be played back on single line diagrams, network diagrams, block diagrams, curves and charts;Event that triggered **PDR Replay** can be browsed and time point can be easily positioned for playback;Playback and partial playback functions are provided and capable of all characteristics (e.g. alarm) during the event;Playback speed, forward/backward, pause, setting of start time etc. can be set;Dynamic network topological coloring can be performed during **PDR Replay** playback for dynamic display of network structure change process on single line diagram;Curves of each measurement point can be recorded during playback;Sections can be intercepted as **DTS** teaching material.

3. User Interface

CCS UI features shall be fully graphic, intelligent based man-machine subsystem. Graphic user interface can refresh graphs in real-time, even in case of peaks or sudden events. It enables setup of authorities, to control user access to system graphs, and obtain higher security.

4.1 Features

1. Cross-platform use of system
2. The system adopts object-oriented analysis method and programming language.
3. Component technology is used to provide powerful man-machine integration functions.
4. Substation graph, list, bar chart, instrument graph, pie chart, and curve can be integrated for display.
5. The graph dictionary manages graph files of the whole system.
6. Distributed, multi-backup, multi-version, node-transparent management of graphs shall be provided.
7. The graphic system provides graph-model-database integrated function. time.
8. Equipment model adopts CIM standard.
9. Man-machine system provides template and wizard functions to help the user to customize various graphs.
10. Report functions are powerful and adopt easy design. Tables as good as Excel tables can be created by the user.
11. With component technology, unified maintenance of local application programs and WEB browsing functions can be realized. User can browse the same graphs and use the same operation mode at client side as local.
12. Operation environment and interface style can be customized. Different application can be differentiated distinctly by different display style.
13. Interface setup and operations adopt WINDOWS style.
14. Fully graphic, high resolution, multi-window, fast response graphic display is supported.
15. Multi-screen, multi-window management is supported.
16. LED large screen projection and graph combination are supported.

4.2 Security of operator interface

4.2.1 Overview

Unified access security management (i.e.: authority management) shall be provided in CCS. With unified authority management software, authorities of various granularities can be controlled. For expansion of authorities for applications, much participation by the management system is not required. In case of authority modification, few operations are required for the management system.

User authority management mainly includes definition, storage and validation of user authorities. Domain, function, role and user are basic concepts in user authority management. In detail, a domain is an object for which authority control is required. Domain is a flexible concept, e.g.: the SCADA application can be regarded as such a domain.A function is an operation that can be executed within a domain, e.g.: remote control is a function of SCADA domain.A role is a group of functional authority defined in a domain, and it is a logic set of personnel who operate this domain. A role can inherit authorities of another role.A user is an operator. A user can be a set of various of roles, i.e. authorities of various domains can be assigned to the user.

Each user can be assigned with various roles in various domains, each role has various functions and authorities in corresponding domain. Therefore, each user is assigned with configurable functions and authorities.

That is to say, by authority management, the system can be divided into a number of domains, each including different functions defined (e.g. in SCADA domain, functions of remote control, force measurement, and tagging are provided), and different roles defined. Each role can be associated with a subset of functions in the domain, and each user can be associated with roles in different domains. One user can correspond to a number of roles, so as to feature functions in corresponding domain.\When a user opens a tool or perform an operation in the system, corresponding authority check will be performed, to ensure system security.

User of an area of responsibility can only perform operations permitted for this area on the nodes of this area. An area of responsibility can be trusted and migrated. Settings of an area of responsibility in the jurisdiction of control center can be modified, to automatically adjust information stream in this area of responsibility and user authorities of this area of responsibility. Also, each operation workstation only processes information to be processed in this area of responsibility, and irrelevant graphs, reports, and history data will not appear on this workstation. Central control station can monitor and control areas using necessary security techniques such as authority setup and information diversion. Also, the alarm information window only displays alarm information related to this area of responsibility, and dispatcher operations of remote control, force measurement, blocking, and tagging etc. are only effective for equipment in this area of responsibility. On the graphs, equipment and information not belonging to this area of responsibility will be hidden or screened, allowing layering of information and effective security isolation among workstation nodes.

4.2.2 Access Rights

The SCADAshallprovide the possibility to define different types of access rights both for separate groups of consoles and operators.

The system shall provide system administrator level, administrator level, main dispatcher level, dispatcher level, and ordinary personnel level access rights management and control. Through access right levels, user access to the system and user scope of operation and control can be managed.

Through measures such as user access right management and access right levels, security and reliability of system operation is ensured and maloperation is prevented. Anti-maloperation blocking via dual password login (“operator” and “guardian” shall be provided. Operation security is ensured by control of operation rights and operation nodes: before user operation, the system will verify user identity and access rights.

The process of operation can be recorded and searched, and operator is prompted of remaining time of operation in a visualized manner. Contents include operator name, object of operation, operation contents, operation time, workstation used by operator, and operation results etc.

5.2.2.1 Console-specific access rights

Console-specific access is a configured assignment controlling the use of different functions or diagrams at a specified console.

The access rights can be controlled by a console function assignment display.

5.2.2.2 Operator-specific access rights

Similar to console-specific access, operator-specific access can control use of different functions or diagrams by a specified operator.

These access rights can be also definable as operator-specific by applying a “console function assignment” display.

After login (see next chapter), the effective access rights of an operator - it can be a combination of operator specific and console-specific access rights - shall be indicated by special color on a console function assignment display.

Console-specific access rights that are not allowed for an operator can be indicated / displayed in a different color.

5.2.2.3 Login and logoff

Operator access to the SCADA, can be defined by applying user names (at least up to 8 characters) and a password (at least up to 8 characters).

The user name can identify the person gaining access to the system. Later, all events (manual update, tagging etc.) which are results of operator actions shall be logged with his/her individual user identification.

When an operator completes work, a logoff can be issued. For security reasons, all successful login and logoff events, can be recorded in summaries.

4.3 Area of Jurisdiction (AOJ)

To establish permission settings, the system analyst divides the monitored system into several broad areas called areas of responsibility for purposes of limiting access. These areas are defined when building the system databases, and represent logical divisions such as operating areas. Within the application databases, entities are assigned to these areas. In CCS system, a tool called “aortool” shall be provided to define AOJ of the database objects. The system can be divided up to 32 AOJs and every user, every node and almost every database object can be defined to any AOJ.

The system can define different areas of responsibility according to substations and voltage levels, which are named by the system. These areas can be all substations or a set of some substations, or various combinations of substations and different voltage levels. All these can be easily and flexibly defined using a setup interface. The system can also set area of responsibility for a particular equipment item.

Each node in the system corresponds to a defined area of responsibility. Besides, definition of area of responsibility can be combined with user access right management. For each user, area of responsibility to which user belongs and nodes that user can log in are defined. In this way, user is associated with node, and node is associated with area of responsibility. User can only work in the scope of the node of his area of responsibility, preventing user login beyond user access right, and improving system security. User access rights and area of responsibility can be easily and flexibly set. Management can be carried out using personnel access right groups. At the same time, the system features a number of areas of responsibility for each node.

This system supports definition of areas of responsibility according to region, substation, voltage level, bay, equipment, and measuring point (minimum granularity is measuring point). Areas of responsibility can be defined in batches according to region, substation, and voltage level. Convenient interface tools are provided for setup of area of responsibility. These tools provide the following functions:

- Definition and editing of system area of responsibility
- Setup of user area of responsibility
- Setup of node area of responsibility

- Setup of object (including graph, curve, report, and equipment etc.) area of responsibility
- Editing of area of responsibility objects
- Check of area of responsibility

4.4 Curve Functions

Curves are a common data description method and analysis tool used in power system man-machine interface. Advantages of curves include straightforward display of data trend change with time. It helps user to master rule of data change and analyze statistic information.

4.5 Report Functions

CCS report tool shall provide 2 major functions: "creation of report templates" and "report browsing", used for creation, management, browsing, and periodic printing of report templates. Template creation function is used to edit and generate report templates of different types and different styles, e.g. operation log (daily report), monthly statistic report (monthly report), annual statistic report (annual report), and various management reports. The report browsing function automatically obtains history data and real-time data according to configured time, and user needs not to know where they are from (history database or real-time database), so that final reports will be directly generated. Generated reports can be saved as Excel files, used for publishing on WEB or archiving.

4.6 Event and Alarm

Events are often caused by grid status change or abnormity in SCADA system (or some predefined status change). In CCS , events shall be monitored, and corresponding event record or alarm signal will be issued immediately. Events can be classified into different types according to the cause and features, so as to facilitate retrieval and management. Events mainly include: CB status change, SOE, operation information, measurement over-limit, operation status change of channels (RTU or SAS), operation status change of SCADA and etc.

Alarms are often caused by grid abnormity, values to be monitored for grid operation assessment, or abnormal status of SCADA system. Alarms mainly include: status change due to grid incident, measurement over-limit, grid operation assessment data over-limit, equipment faults in SCADA system and etc.

Grid events and SCADA system events shall be recorded/saved/printed separately. Records can be kept for up to 3 years, and can be retrieved according to record types. Equipment operation conditions and event/incident alarms can be recorded. Events/alarms are displayed and printed according to the following rules:

- Random
- Requirements of system control engineers
- According to event/alarm features

Whether events/alarms will be printed or not can be defined/selected according to type, group, or substation name of event/alarm.

In case of measurement over-limit, over-limit duration and maximum/minimum values will be recorded. Daily/monthly/yearly statistics of over-limit times/duration are provided.

1) Causes of events/alarms:
    - Status change of grid equipment
    - Measured and calculated data over-limit
    - Abnormity of RTU and SAS
    - Abnormity of communication channel
    - Equipment abnormity of SCADA system

- Grid control operation
- Various user-defined events/alarms

2) Types of events/alarms:

All events/alarms can be sorted with different types/priorities by the user.

3) Alarm approaches:

Different approaches introduced as below can be selected by the user:

- Display alarm information in alarm window or CLI.
- Alarming equipment symbol flashes on graph or LED Large Screen
- Color change of alarming equipment symbol on graph or LED Large Screen
- Select different colors for alarm records, so as to differentiate various alarm types
- For different types, different audio alarms are generated and can be connected to audio equipment in system control room.
- Automatic popup of relevant incident/event graph, and auto-trigger of LED Large Screen
- Enable PDR
- Automatic recording/printing
- Voice alarm
- Electronic watching system

CCS shall provide automatic/manual acknowledgment for single alarm, a type of alarms, a group of alarm, and all alarms. When an alarm is acknowledged, audio and flashing will be eliminated. For user-defined alarm signals, audio and flashing can be enabled/disabled.

Alarms can be enabled/disabled according to the alarm substation, alarm region or alarm type.

The alarms and events function in our system support different priority of different event type, and different priority events/alarms list will show with different icon and color.

Events/alarms can be seperated into many types, such as analog over limit alarm, status change alarm, control event etc. And it shall support AOJ, so that operator can only see events/alarms which he must response for. The alarm list windows support many filter condition, the operator can see alarm he care for.

In alarm window, user can add a comment to the line of an alarm or event.

4.7 Remote Console

The system can adopt third party tool Xmanager to realize remote console functions. Using Xmanager, user can log in any X11 workstation or server (Linux or Unix operating system) from Windows node, to obtain the same display effect and operation experience as local. Login check and authority check are also consistent with local. This prevents illegal user from accessing this system.

Mutual access between Linux/Unix systems can adopt SSH (Secure Shell) complete with the system. SSH is a security protocol established on application level and transmission level. SSH is a relatively reliable prevailing protocol dedicated to remote login dialog and other network services. Using SSH protocol, disclosure of information during remote management can be effectively prevented, and all transmitted data can be encrypted. In addition, DNS fraud and IP fraud can be prevented using SSH.

All servers/workstations are installed with Linux/Unix operation systems and communicate with other computers by TCP/IP protocol.

5. Capacity and Performance

5.1 Capacity

The capacity of SCADA database shall be enough to cater all requirement of MCC and it shall be expanded conveniently. So the expansion of CCS to 1.25 times ultimate sizes is surely without the regeneration of the operating system or application software.

Table 7.1 Historian Data Save CAPACITY in CCS (Minimum)

Type	Now Quantity	Ultimate Quantity	Periodicity	Retention Period
Alarms, Events, Switching Status	10000/day	20000/day	On occurrence	12 months
Analogues or Counters Analogues or Counters Analogues or Counters	4000/day 10000/day 5000/day	8000/day 20000/day 15000/day	1min 5min 15min	30days 12 months 36months
Disturbance Data Files	20	40	On occurrence	20 days
Reports	30	60	Daily	3 years

Note: The calcultions shall be proiveded to substantiate the requiment of data save capacity.

Table 7.3 EMS Model Capacity in CCS

SCADA Data	Design Capacity
Substation	**100**
Bus	1000
Line(include t-line and)	1000
Hvdc-line	
Power transformer	500
SVC	100
Bay	3000
Compensator& Capacitor	3000
Generating units	2000
Load	2000
Breaker& Switch	10000
Analog input	30000

Analog Value	60000
Analog	30000
Status input	60000
Status Value	30000
Status	60000

Table 7.4FunctionsCapacityin CCS

Application Parameters	Quantity
HIS Simultaneous Users Maximum number of user accounts	 50 (related ORACLE Lisence) 50 (related ORACLE Lisence)
Emergency Strategies and Load Shedding Number of Emergency Strategies	 500
Outage Scheduling Number of Outage Schedules Maximum duration (days) Retention time (days) Maximum future time (days)	 300 365 365 365
Scheduling Simultaneous users Maximum number of Load Forecast Areas Time interval (minutes) Maximum length of scheduling period (hours)	 3 50 60 336

5.2 Performance

The following tables show the CCS performance requirement in normal running environment, including base performance, PAS performance and DTS performance.

Table7.5CCS Basic Performance Requirement

Item		Performance
Time for status quantity change transmitting to master station		≤2s
Time for measurement change which exceeds settings(over dead zone) transmitting to master station, or time for key measurement update, under cyclic transmission mode		≤3s
Transmission time for control command selection, execution, or cancelling		≤3s
Transmission time for regulation command		≤3s
Response time for calling out full screen real-time data graph on man-machine interface screen	85% of graph	≤2s
	Rest of graph	≤3s
Response time for calling out full screen real-time data graph on electronic simulative screen	85% of graph	≤3s
	Rest of graph	≤5s
Graph data refreshing interval		1s～10s(adjustable)
Simulative screen data refreshing interval		6s～12s
Synchronization time for data refreshing between Zone I and III		≤5s
Real-time data transmission time during computer remote network communication		≤5s
Automatic switching time between FE host and standby channels		≤3s
Automatic switching time between host and standby devices		≤3s
Major node CPU load(1min mean value)	Under normal status of power grid	≤20%
	Under fault status of power grid	≤40%
Local area network load under normal status of power grid		≤20%
Major performance indexes of remote terminal devices		Comply with IEC standards
System availability		≥ 99.95％

Item	Performance
Mean time between failures of all kinds of equipment at master station(MTBF)	≥ 40000h
Mean times of automatic warm start-up due to chance failure	<1 time/3600h
Under the condition of no hardware fault on the on-duty equipment and non-manual intervention, automatic switching shall not occurred on the equipment for host and stand-by redundant configuration	Can be satisfied
Comprehensive error of analog quantity measurement	≤1.0%
Correct rate of BI	≥ 99.9％
Time resolution of SOE between substations	≤20ms
Correct rate of control	100%
Correct rate of regulation	≥ 99.9％

Table7.6CCS Basic Performance under " Burst scenario"

Item		Performance
Time for status quantity change transmitting to master station		≤2s
Time for measurement change which exceeds settings(over dead zone) transmitting to master station, or time for key measurement update, under cyclic transmission mode		≤3s
Transmission time for control command selection, execution, or cancelling		≤3s
Transmission time for regulation command		≤3s
Response time for calling out full screen real-time data graph on man-machine interface screen	85% of graph	≤2s
	Rest of graph	≤3s
Response time for calling out full screen real-time data graph on electronic simulative screen	85% of graph	≤3s
	Rest of graph	≤5s
Graph data refreshing interval		1s～10s(adjustable)
Simulative screen data refreshing interval		6s～12s
Synchronization time for data refreshing between Zone I and III		≤5s
Real-time data transmission time during computer remote network		≤10s

Item	Performance
communication	
Automatic switching time between FE host and standby channels	≤30s
Automatic switching time between host and standby devices	≤30s
Major node CPU load(1min mean value)	≤50%
Major performance indexes of remote terminal devices	Comply with IEC standards
System availability	≥ 99.95％
Mean time between failures of all kinds of equipment at master station(MTBF)	≥ 40000h
Mean times of automatic warm start-up due to chance failure	<1 time/3600h
Under the condition of no hardware fault on the on-duty equipment and non-manual intervention, automatic switching shall not occurred on the equipment for host and stand-by redundant configuration	Can be satisfied
Comprehensive error of analog quantity measurement	≤1.0%
Correct rate of BI	≥ 99.9％
Time resolution of SOE between substations	≤20ms
Correct rate of control	100%
Correct rate of regulation	≥ 99.9％

Chapter 10

MAINTENANCE AND SUPPORT SERVICES

Contents

Maintenance & Support services

1.0 Introduction

The scope of work shall include a comprehensive maintenance of all the software and hardware provided by the contractor for the SAS at various substtions and various systems viz SCADA/EMS including DSA, Video Projection System at MCC along with the future integration and support services for meeting the expansion requirement envisaged. The maintenance practices to be followed shall be as per ISO 2000 Standard. The essence of the maintenance and support services is to provide maintenance support for the designated hardware and software, with the goal of meeting the availability as set forth herein.

1.1 Maintenance support

The period of maintenance support shall be the three year Warranty (Defect Liability) period commencing from Operational Acceptance. The nature of maintenance support required for the different type of systems and components are described in the **Table 4-1** below:

Table 4-1 Maintenance support and Availability requirements

Sl. no.	System	Scope	System Availability requirements
1.	All Systems such as (SCADA,EMS, DSA, ICCP, Web, Historian, VPS & NMS Supplied with this project including Cyber security system)	Hardware and software in Control centres and SAS at Substations	99.99%

The system availability shall be measured control center wise, for example the availability of Main & Backup Control Centre shall be considered separately. For all third party equipment (Hardware & Software) Contractor shall have back to back support along with supply of spare with appropriate response time from OEM or OEM Authorized representatives. Contractor shall be responsible for coordination with the OEM for all matter related to that equipment. The Contractor shall also be responsible for meeting the overall response times and availability requirements specified in the Specification.

The maintenance of the System shall be comprehensive and shall comprise of the following category of works which is further elaborated for each of the different subsystems:

(a) Preventive Maintenance Activity (performance monitoring, system backup, patch management, updates, emergency response and troubleshooting).
(b) Maintaining a minimum no. of specified spares.
(c) Integration of new equipment (Workstations, Printers, Switch, Router, ICCP connection etc.) with Main and Backup Control centre System.

1.2 Preventive Maintenance Activity

The preventive maintenance activity would involve activities to be performed by the Contractor to keep the system running at optimum level by diagnosis and rectification of all hardware and software failures and would broadly include

- Repair / replacement of defective equipment. The Contractor shall be responsible for repair/replacement of all the hardware including consumables required for the various systems. Only replacement of printer cartridge and paper rim shall be excluded from the scope of the Contractor.
- Configuration of the replaced hardware and software, periodic routine checking as part of a preventive maintenance program (as described in further detail in this document) which would include checking of functionality of hardware and software.
- Monitoring of the performance of the system and doing necessary tuning for optimum performance to accommodate any changes such as addition of new components.
- Providing all necessary assistance to Owner for addition and modification of database and displays.
- Database sizing activities including Backup and restore of the system. Any replacement or upgrade of hardware and/or software to meet the power system sizing as per table in appendix would be the responsibility of the vendor at its own cost.
- Restoration of the systems upon its failure and to restore the functioning of the various systems at the different Control Centres.

Routine works like database building, addition of analog and status points and other such day-to-day operational activity would primarily be the responsibility of Owner and in case of any difficulty in this regard the same shall be referred to the contractor for support.

1.2.1 Hours of Cover

The Contractor shall provide engineers who have desired experience and skill to maintain the SCADA/EMS system to the desired level of availability. The contractor’s on-site support for Main Control centre shall be standard hours of service i.e. Monday to Saturday- 9:00 am to 5:30 pm local time (IST), excluding Public and Owner Company holidays, throughout a year. At least one Software Engineer and One Hardware Engineer having expertise in SCADA/EMS system shall be available during the standard hours of service at each Main Control Centre. The timings for Emergency Support would be 24 hours a day, 7 days a week throughout the year.

The support personnel so deployed shall be qualified personnel having at least 4 years of experience in the delivered SCADA/EMS system. Persons deputed shall be a permanent employee on the direct pay roll of the vendor. The contractor shall submit the CV’s to Owner/Employer for approval before deployment at site. The Owner can ask the Contractor to replace the personnel deployed for maintenance support if his performance is not found to be satisfactory.

Contractor and its personal have to follow all rules and regulations of owner’s office premises.

1.2.2 Service Response requirements

The severity levels are defined in coming sections and the requirement of response time for various severity levels is defined below:

Emergency Support for Severity 1 issues are to be provided 24 hours a day, seven days a week. The on-call support team shall include all key technical competencies so that any aspect of a system failure can be attended. The team shall comprise of experienced technical staff that are skilled in troubleshooting of the various systems covered under AMC. Severity 1 problems shall be reported by telephone for rapid response; target response times are defined in this section. The bidder shall submit the process details to meet the above requirements along with the offer. For severity 1 problems, the key objective is to restore the system to an operational state as quickly as possible, including by a temporary workaround. Resolution of problems shall also be provided by an individual fix that will be installed by the contractor at no extra cost to Owner.

Severity 2, 3, and 4 problems shall be reported by Owner through a call tracking system to be provided by the contractor.

The operation and performance of the various systems under AMC shall be monitored on a fortnightly basis, the contractor personnel shall review the following, analyse the results, and communicate to Owner. Non-compliance to Monitoring of Log, Patch Management, Annual Security audit and implementation of the remedial actions suggested by the auditor will be treated as Severity 2. The contractor shall conduct at least the following monitoring, for the Control centres.

1.2.2.1 Log Monitoring

- System logs for a selected day
- System history log
- Aggregate data collection
- Events Collection
- Configuration change to core application/OS.

Log monitoring and report generation for Non-availability period of ICCP links and other communication links shall be done. Compiled report shall be generated based on the requirements. During monitoring if any defect/ abnormality is found, the contractor shall undertake corrective maintenance for the same. The bidder shall **submit the process details** to meet the above requirements with the bid.

1.2.2.2 Resource Monitoring

Resource Monitoring services comprises checking the system's major node resources, gather log data, analyse results, and advise Owner on the appropriate actions to be taken and undertake any agreed upon actions to maintain system performance. The NMS system shall be used to continuously collect the following information:

- CPU loading (Peak and Average)
- Memory utilisation (Peak and Average)
- Disk utilization (Peak and Average)
- LAN utilization (Peak and Average)
- Operating system resource utilisation reports
- System error log

The bidder shall submit the procedures details to meet the above along with the offer.

1.2.2.3 Cyber security System and Monitoring and compliance manager for Critical Infrastructure Protection

The Contractor shall also be responsible for monitoring of the cyber security system with cyber security perspective and implementing the monitoring and compliance manager for Critical Infrastructure Protection.

The logs of the system shall be analysed for exceptions and the possible incident of intrusion/trespass shall be informed to the Employer.

The monitoring shall encompass the various cyber security devices installed at Control Centres such as firewalls, Intrusion prevention system (both network based and host based), routers etc. The Centralized Monitoring Console (CMC) shall monitor and continuously collect the above logs.
The contractor shall carry out the Annual Security Audit from CERT-In Certified auditors at its own cost for the complete systems under this project and implement the recommendation given by auditor in consultation with the owner.

1.2.3 Patch Management

The contractor shall also be responsible for providing updates/patches for the software products supplied under the project. All other patches of third party product like Operating System and Anti-virus shall be tested by the Contractor prior to installing in the supplied system. Subsystems/ Devices like IPS, Network IPS, Host based IPS, Firewalls shall also be provided with secure patch management. A secure patch management and deployment system is to be established which shall be provided with single point of Internet connectivity. All the patches shall be downloaded through this single point of connection.

The Contractor shall provide a mechanism for patch management so that it is known that what patches have been applied and what all patches are pending but available with System.
The contractor shall upgrade the various applications delivered under the project through patch management and version upgrade to make it compliant with IEC standards as envisaged under the specification throughout the AMC period.

1.2.4 Physical maintenance

The contractor shall undertake physical maintenance of all Equipment and modules under the scope of this contract, in accordance with this section. The physical maintenance shall include cleaning, dusting, inspection of equipment for loose connections, damage to insulation, pest infections etc. as follows:
Activities shall include but not be limited to:
(a) Online diagnostics for servers and workstations - once every 3 months.
(b) Connection test of LAN cables for identifying potential loose contacts in machines, hubs and routers - once every 3 months.
(c) Physical hardware checks to ensure proper working of cooling fans etc. - once every 3 months.
(d) Physical inspection to check the machines and the panels for rat droppings, lizards or other vermin - once every 3 months.
(e) Cleaning and blowing for removal of dust from Servers and Workstations - once every 3 months.

<u>Exclusions</u>:

a) Interfacing panels cleaning etc. are excluded from the scope above.

b) Maintaining dust free environment and protection from rodents and vermin is the responsibility of Owner.

c) Regular cleaning of computer furniture and surroundings is the responsibility of Owner.

Planned & scheduled Equipment shutdown during preventive maintenance shall be deemed as available.

1.2.5 Video Projection system

The Video projection system shall have comprehensive maintenance contract with OEM. Any consumables like LED lamp, dust filter etc. as well as any spares required for maintaining the VPS system in fully operational condition shall be provided by the contractor.
In addition to that there shall be quarterly checks of the video projection systems in which the performance brightness uniformity, brightness level, color uniformity and other routine maintenance activities like cleaning, system tuning shall be UNDERTAKEN.

6	Firewall (One of each type)	No.	1	1
C	**VPS spares wherever applicable**			
1	One complete VPS Module without screen / frame structure	Set	1	1
2	VPS Controller with all interface cards	Set	1	1
3	VPS LED pack of three colors (red, green & blue) - one set for each module	No.	1	1
4	Dust filters	No.	24	24

1.3 Spares inventory

The Contractor shall maintain a spares inventory at his own cost to meet the spare availability requirements of the system. The spares shall be used as and when required and no separate charges are payable except the maintenance charges. All spare shall have pre-loaded softwares and required licenses in order to make it readily available for use at all times. The Contractor shall decide the items and components to be maintained as spare but a minimum number of spares as listed below in Table 4.2 shall be kept at the respective control centres. This shall be periodically verified by the Owner and unavailability of spares shall be treated as non-availability as per severity 2. If spares has been used in the system then the replenishment of the spare should be completed within 45 calendar days, otherwise it will be considered as non-availability as per **Severity 2.**

1.4 Integration of new equipment and or control centre

All future services, protocol emulations and configuration support for integration of Control Centre Integration on ICCP, Clients for OPC services, Web Services & CIM import & export utility for offline applications shall be the responsibility of contractor during maintenance period. The integration services to be provided by the bidder will include the addition of New ICCP connection & its integration and addition of interface for off-line Applications, OPC clients. Non Availability of these services at Control centre for these integration shall be treated as severirty3 support as defined below.

1.5 Problem/Defect Reporting

The bidder shall submit an appropriate problem/defect reporting procedure to meet the requirement of all severity level cases to get the approval of the same from Employer/Owner.

The problems will be categorized as follows:

1.5.1 Severity levels

The detail of the systems under different severity levels is as below:

1.5.1.1 Severity-1 (Urgent support)

This support is required when there is a complete system failure, severe system instability, the loss/ failure of any major sub-system / system or its components, which may significantly impact the system availability, performance, or operational capability at Control centre. Following outages/disruptions will be considered under Serverity-1:

- Loss of Critical functionality as envisaged in specification due to any problem software/Hardware-related in SCADA-EMS system.
- Cyber Security issues and Outage of complete Web system.
- Outage of both Routers and LAN Switches.
- Loss of data exchange with other computer systems or other control centres.
- Failure of complete UPS system resulting into loss of UPS output supply at both Output ACDBs is covered under this category.

Initially, the Owner's Engineers shall attempt to restore the system. In case the system does not come up and/or the problem is not resolved then the Owner's Engineer shall intimate the problem to the contractor. Upon receiving intimation, the representative of the contractor would immediately attend to the problem. The problem shall be attended by the contractor at the earliest, and it shall arrange all resources and take all steps to restore the data availability and functionality at the earliest.

1.5.1.2 Severity-2

The support services not defined under Severity-1 are included under this category. Coverage under this severity would be outages that do not immediately cause on line data loss but subsequently could result into Severity-1 category outage, loss of an important subsystem that may affect the day-to-day works and loss of archived data.

Following outages/disruptions will be considered under Serverity-2:

- Failure of one Data Server/ICCP server, stoppage of data collections for archiving and outage of other applications not covered under severity-1 are included in this category. However the critical functionality loss due to loss of only one component as defined here shall be treated as Severity-1.
- Failure of one output ACDB, one input ACDB, failure of one UPS system, Failure of Battery System and failure of any other system of Auxiliary Power supply not covered under Severity-1 are included in this category.
- Failure of any redundant system component affecting the critical redundancy like loss of any one Application Processor, Router also be included in this category.
- Non-availability of designated contractor's Man-power at control centre as well as required inventory of spares specified here.
- Non-compliance of Monitoring functions as specified in 4.2.2.3.
- Non-availability of any of the database modeling tools.
- Online Editing of SCADA, Network and ICCP Database.

1.5.1.3 Severity-3 (Standard support)

The support services included under this category are when the outage or loss of functionality is neither of an emergency nor priority functionalities as indicated in severity level 1 or 2 above. Problems like database reworking, failure of any one workstation, printers and integration services as defined in 4.4 would be covered under this Severity.

Category	*Definition*
Severity 1	*when there is a complete system failure, severe system instability, the loss/ failure of any major sub-system / system or its components, which may significantly impact the system availability, performance, or operational capability at Control centre*
Severity 2	*Coverage under this severity would be outages that do not immediately cause on line data loss but subsequently could result into Severity-1 category outage*
Severity 3 – Minor	*Any other system defect, failure, or unexpected operation (as described at 1.5.1.3)*
Severity 4 – General/Technical Help	*Request for information, technical configuration assistance, "how to" guidance, and enhancement requests (as described at 1.5.1.4).*

1.5.1.4 Severity-4 (General Technical Help)

Request for information, technical configuration assistance, "how to" guidance, and enhancement requests are included under this category.

1.6 Response and Resolution Time

This section describes the target times within which the contractor should respond to support requests for each category of severity. The *Initial Response Time* is defined as the period from the initial receipt of the support request (through approved communications channels) and the acknowledgment of the contractor subject to the Maximum time defined in **Table 4.4**. The *Action Resolution Time* is from the acknowledgement of support request to the contractor delivering a solution subject to the Maximum time defined in **Table 4.4**. This period includes investigation time and consideration of alternative courses of action to remedy the situation. The *Action* is defined as a direct solution or a workaround.

Except for Severity Level 1 all response and resolution times (hours and days) specified below are working hours only.

The bidder shall submit the detailed format and procedure for all the activities such as Reporting time, Resolution time, Downtime etc. along with the bid proposal**.**

Severity	Initial Response Time	Action Resolution Time	Action
1	30 minutes	2 hours	An urgent or emergency situation requiring continuous attention from necessary support staff until system operation is restored – may be by workaround.
2	2 Hours	12 Hours	Attempt to find a solution acceptable to Owner (dependent on reproducibility) as quickly as practical.
3	1 day	2 days	Evaluation and action plan. Resolution time is dependent on reproducibility, ability to gather data, and Owner's prioritisation. Resolution may be by workaround.
4	2 days	5 days	Report on the problem/query is to be furnished.

Table 4.4

1.7 Availability and Payment charges Calculation

It is the endeavour of both the contractor and Owner to maximize system availability to the extent possible. The contractor shall provide guaranteed availability for various types of Systems as specified in Table 4.1.

The non-availability hours for availability calculation shall be counted from the end of the allowed Action Resolution time. A standardized register shall be maintained at each site containing full details of each outages, actions taken by Owner to correct the problem, applicable Severity level, time of reporting to the contractor support engineer/support centres pursuant to the appropriate methods in the Agreement, allowed Response time as per the Response times defined in above section, actual Resolution time and signature of Engineer-in-charge as well as the contractor's support engineer of the site.

Duration of outages over and above the Action Resolution time, as defined in Table 4.4 in each of the Severity levels shall be counted for the non- availability computation and shall be clearly brought out in the register. The resolution may be accomplished by a work around, and such solution shall mark the end of non-availability.
In the event of frequent failures at a site, due to a common cause, the first FPR (Field problem Report) logged shall be used for the purpose of availability calculation. However, simultaneous multiple outages due to unrelated cause would be counted separately.

1.7.1 Availability computation for SCADA-EMS System including DSA

Availability would be on per quarter per site basis. The formula to be used for availability computation would be as under:

$$\textbf{Availability per quarter yearly (per site)} = \frac{THQ- (S1 \times 1+S2 \times 0.8+S3 \times 0.5)}{THQ} \times 100\%$$

Where, THQ is total hours in the quarter S1 is the total non-available hours in Severity Level-1 in the quarter. S2 is the total non-available hours in Severity Level-2 in the quarter. S3 is the total non-available hours in Severity Level -3 in the quarter. The above calculations shall be same for the Auxiliary Power supply system and VPS.

1.7.2 Payment of maintenance charges (based on SCADA-EMS System availability)

In the event of availability below a certain level, the maintenance charges would be proportionately reduced as follows:

Manpower availability for each control centre per quarter	**Deduction as % of the apportioned price of total AMC for SCADA-EMS portion of the contract applicable for that site (AMC Price)**
> 95.00 %	NIL
Less than 95.00%	Deduction of 2% of the apportioned price of the apportioned quarterly AMC for every 0.5% or part there of decrease in availability under 95.00%.

1.7.3 Computation of Availability / Non-availability

The computation of Availability / Non-availability would be rounded up to 2 decimal places at each Control Centre on quarterly basis and any deduction in the maintenance charges thereof would be calculated as stated above in Section
1.7.2 on pro-rata basis.

1.8 Contractor's Obligations

The contractor shall guarantee continuous availability of the system as indicated in Table 4.1 for the defect liability period of one year from the date of operational acceptance. The system availability shall be calculated as indicated above on monthly basis. During this period, the contractor shall take continuous actions to ensure the guaranteed availability. In case the actual availability falls short of the guaranteed availability, it would be considered as contractors default and under the provision of clause GCC 22.8 defect liability period shall be extended by a period equal to the period / months during which the availability is less than the guaranteed availability.

In order to optimise and improve the response of the system, the contractor may re-install the program modules after making the Owner engineer aware of the consequence (like data loss, database rebuild etc).

Any modification of software/Operating System required to restore functionality due to hardware upgrades, patches, or arising out of a necessity to fix FPRs (Field problem reports), would be done by the contractor at no extra cost to Owner.

The contractor will submit FSR (Field Service Report) and the steps taken to solve the problem, along with details of code changes.

1.9 Annual Training during AMC Period

The Contractor shall provide on job training ot the owners employees as part of AMC.

CIVIL WORKS

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1.0 GENERAL

The intent of specification covers the following:

Design, engineering, drawing and construction of all civil works at sub-station. All civil works shall also satisfy the general technical requirements specified in other Sections of Specification and as detailed below. They shall be designed to the required service conditions/loads as specified elsewhere in this Specification or implied as per relevant British standard codes (B S Codes)/ equivalent International Standards.

All civil works shall be carried out as per applicable Standards and Codes. All materials shall be of best quality conforming to relevant International Standards and Codes. In case of any conflict between Standards/ Code and Technical Specification, the provisions of Technical Specification shall prevail.

The Contractor shall furnish all design, drawings, labour, tools, equipment, materials, temporary works, constructional plant and machinery, fuel supply, transportation and all other incidental items not shown or specified but as may be required for complete performance of the Works in accordance with approved drawings, specifications and direction of NEA/Consultant.

The work shall be carried out according to the design/drawings to be developed by the Contractor and approved by the NEA/Consultant. For all buildings, structures, foundations etc. necessary layout and details shall be developed by the Contractor keeping in view the functional requirement of the substation facilities and providing enough space and access for operation, use and maintenance. Certain minimum requirements are indicated in this specification for guidance purposes only. However, the Contractor shall quote according to the complete requirements.

ISED CLAUSE

2.0 GEOTECHNICAL INVESTIGATION

2.1 The Contractor shall perform a detailed soil investigation to arrive at sufficiently accurate, general as well as specific information about the soil profile and the necessary soil parameters of the Site in order that the foundation of the various structures can be designed and constructed safely and rationally.

A detailed soil report including field data duly certified by site engineers of NEA/Consultant will be submitted by the Contractor for specific approval of NEA/Consultant**.** The report shall contain all soil parameters along with recommendation of soil consultant for type of foundation i.e.

pile or open type, soil treatment if any etc to be used for the design of civil foundations.

2.2 The Contractor may visit the site to ascertain the soil parameters. Any variation in soil data shall not constitute a valid reason for any additional cost & shall not affect the terms & conditions of the contract. Field tests must be conducted covering entire substation area including all the critical locations i.e. Control Room and GIS Building, township buildings, Lightning Mast. Towers, transformer/Reactor etc.

2.3 SCOPE OF WORK

This specification covers all the work required for detailed soil investigation and preparation of a detailed report. The work shall include mobilisation of necessary equipment, providing necessary engineering supervision and technical personnel, skilled and unskilled labour etc. as required to carry out field investigation as well as, laboratory investigation, analysis and interpretation of data and results, preparation of detailed Geo-technical report including specific recommendations for the type of foundations and the allowable safe bearing capacity for different sizes of foundations at different founding strata for the various structures of the substation. The Contractor shall make his own arrangement for locating the co-ordinates and various test positions in field as per the information supplied to him and also for determining the reduced level of these locations with respect to the benchmark indicated by the NEA/Consultant. The soil investigation for substation extension in existing switch yard has not been envisaged. Soil data of existing substation shall be referred for the design of foundations in switch yard extension under present scope of work.

All the work shall be carried out as per latest edition of the corresponding relevant British standard codes (B S Codes)/ equivalent International Standards. The Agency carrying out the soil investigation work must have the experience of carrying out soil investigation successfully in the relevant field. NEA shall assess the capability of the agency for soil investigation work for which technical inputs may be furnished by consultant to NEA.

2.3.1 Bore Holes

Bore holes of Minimum 150 mm diameter in accordance with the provisions of relevant international standards/British standards(BS) at the rate of minimum one number bore hole per hectare up to 25meter depth(Minimum) or to refusal which ever occur earlier shall be drilled for new areas (220 kV Yards and 220/132/33 kV yards wherever applicable).

In any case number of boreholes shall not be less than five. By refusal it shall mean that a standard penetration blow count (N) of 100 is recorded for 30 cm penetration. Number of boreholes may be increased in case soil strata are varying from borehole to borehole in order to have fair idea of soil profile. In case of deep pile foundations soil investigation is to be carried out up to 30 m depth from ground level or refusal whichever is earlier. In case rock is encountered, coring in all the boreholes shall be carried out up to 3 meter in rock.

Performing Standard Penetration Tests at approximately 1.5 m interval in the borehole starting from 1.5 m below ground level onwards and at every change of stratum. The disturbed samples from the standard penetrometer shall also be collected for necessary tests. Standard Penetration Test shall be performed as per relevant British standard codes (B S Codes)/ equivalent International Standards.

Undisturbed samples shall be collected in accordance with the recommendation of relevant British standard codes (B S Codes)/ equivalent International Standards. Or an alternative recognize method as agreed by NEA/Consultant. Undisturbed samples shall be taken in cohesive material or weak cemented granular material where ever possible at 1.0 m interval or at each change in stratum.

The depth of Water Table, if encountered, shall be recorded in each borehole. In case the soil investigation is carried out in winter/summer, the water table for rainy season shall be collected from reliable sources and recorded in the report.

All samples, both disturbed and undisturbed, shall be identified properly with the borehole number and depth from which they have been taken.

The sample shall be sealed at both ends of the sampling tubes with wax immediately after the sampling and shall be packed properly and transported to the Contractor’s laboratory without any damage or loss.

The logging of the boreholes shall be compiled immediately after the boring is completed and a copy of the bore log shall be handed over to the Engineer-in-change.

2.3.2 Trial Pits

The Contractor shall excavate two number trial pits per substation (New) as and where directed by NEA/Consultant, of Plan area 10 sq.m. and not exceeding 4 m depth. Undisturbed samples shall be taken from the trial pits as per the direction of the NEA/Consultant. All Trial Pits shall be refilled with approved material after the tests are complete and shall be compacted in layers of not more than 500mm.

2.3.3 Electrical Resistivity Test

This test shall be conducted to determine the Electrical resistivity of soil required for designing safety-grounding system for the entire station area. The specifications for the equipments and other accessories required for performing electrical resistivity test, the test procedure, and reporting of field observations shall confirm to relevant British standard codes (B S Codes)/ equivalent International Standards. The test shall be conducted using Wagner's four electrode method as specified in relevant British standard codes (B S Codes)/ equivalent International Standards.. Unless otherwise specified at each test location, the test shall be conducted along two perpendicular lines parallel to the coordinate axis. On each line a minimum of 8 to 10 readings shall be taken by changing the spacing of the electrodes from an initial small value of 0.2 m up to a distance of 50.0 m.

2.3.4 Plate load test

Two number of Plate load tests shall be conducted each at the location of control room / GIS building and township area as applicable only to determine the bearing capacity, modulus of sub grade reaction and load/settlement characteristics of soil at shallow depths by loading a plane and level steel plate kept at the desired depth and measuring the settlement under different loads, until a desired settlement takes place or failure occurs. The specification for the equipment and accessories required for conducting the test, the test procedure, field observations and reporting of results shall conform to relevant BS standard. Plate load test shall be performed at the proposed foundation depth below finished ground level for bearing capacity.

Undisturbed tube samples shall also be collected from the pit at 1.0 m depth and bottom of pit from natural ground level for carrying out laboratory tests.

The size of the pit in plate load test shall not be less than five times the plate size and shall be taken up to the specified depth. All provisions regarding excavation and visual examination of pit shall apply here.

Unless otherwise specified the reaction method of loading shall be adopted. Settlement shall be recorded from dial gauges placed at four diametrically opposite ends of the test plate.

The load shall be increased in stages. Under each loading stage, record of Time vs. Settlement shall be kept as specified in relevant British standard codes (B S Codes)/ equivalent International Standards.
Backfilling of the pit shall be carried out as per the directions of the NEA/Consultant**.** Unless otherwise specified the excavated soil shall be used for this purpose. In cases of gravel-boulder or rocky strata, respective relevant codes shall be followed for tests.

2.3.5 Water Sample

Representative samples of ground water shall be taken when ground water is first encountered before the addition of water to aid drilling of boreholes. The samples shall be of sufficient quantity for chemical analysis to be carried out and shall be stored in air-tight containers.

2.3.6 Back Filling of Bore Holes

On completion of each hole, the Contractor shall backfill all bore holes as directed by the NEA/Consultant. The backfill material can be the excavated material.

2.3.7 Laboratory Test

1. The laboratory tests shall be carried out progressively during the field work after sufficient number of samples has reached the laboratory in order that the test results of the initial bore holes can be made use of in planning the later stages of the field investigation and quantum of laboratory tests.

2. All samples brought from field, whether disturbed or undisturbed shall be extracted/prepared and examined by competent technical personnel, and the test shall be carried out as per the procedures laid out in the relevant British standard codes (B S Codes)/ equivalent International Standards.

   The following laboratory tests shall be carried out
   a) Visual and Engineering Classification

   b) Atterberg limits Tests.

   c) Natural moisture content, bulk density and specific gravity.

   d) Grain size distribution analysis.

   e) Swell pressure and free swell index determination.

f) California bearing ratio.

g) Consolidated drained test with pore pressure measurement.

h) Chemical tests on soil and water to determine the carbonates, sulphates, nitrates, chlorides, Ph value, and organic matter and any other chemical harmful to the concrete foundation.

i) In case rock is encountered, the soil test required for rock as per relevant British standard codes (B S Codes)/ equivalent International Standards including following tests shall also be conducted.
   (i) UCC test.
   (ii) Point load index test.

2.3.8 Test Results and Reports

The Contractor shall submit the detailed report in two (2) copies wherein information regarding the geological detail of the site, summarised observations and test data, bore logs, and conclusions and recommendations on the type of foundations with supporting calculations for the recommendations. The contractor shall also submit the bearing capacity calculation in editable soft copy to NEA/consultant. Initially the contractor shall submit draft report and after the draft report is approved, the final report in four (4) copies shall be submitted. The field and laboratory test data shall bear the signatures of the Investigation Agency, Contractor and also site representative of NEA/Consultant.

The report shall include, but not limited to the following:-

a) A plan showing the locations of the exploration work i.e. bore holes, trial pits. Plate load test, electrical resistivity test, CBR sample location etc.

b) Bore Logs: Bore logs of each bore holes clearly identifying the stratification and the type of soil stratum with depth. The values of Standard Penetration Test (SPT) at the depths where the tests were conducted on the samples collected at various depths shall be clearly shown against that particular stratum.

   Test results of field and laboratory tests shall be summarised strata wise as well in combined tabular form. All relevant graphs, charts tables, diagrams and photographs, if any, shall be submitted along with report. Sample illustrative reference calculations for settlement, bearing capacity, pile capacity shall be enclosed.

Recommendations: The report should contain specific recommendations for the type of foundation for the various structures envisaged at site. The Contractor shall acquaint himself about the type of structures and their functions from the NEA/Consultant. The observations and recommendations shall include but not limited to the following:

a) Geological formation of the area, past observations or historical data, if available, for the area and for the structures in the nearby area, fluctuations of water table etc.

b) Recommended type of foundations for various structures. If piles are recommended the type, size and capacity of pile and groups of piles shall be given after comparing different types and sizes of piles and pile groups.

c) Allowable bearing pressure on the soil at various depths for different sizes of the foundations based on shear strength and settlement characteristics of soil with supporting calculations. Minimum factor of safety for calculating net safe bearing capacity shall be taken as 3.0 (three). Recommendation of liquefaction characteristics of soil if applicable shall be provided.

d) Recommendations regarding slope of excavations and dewatering schemes, if required.

e) Comments on the Chemical nature of soil and ground water with due regard to deleterious effects of the same on concrete and steel and recommendations for protective measures.

f) If expansive soil is met with, recommendations on removal or retainment of the same under the structure, road, drains, etc. and thickness of treatment shall be given. In the latter case detailed specification of any special treatment required including specification or materials to be used, construction method, equipments to be deployed etc. shall be furnished. Illustrative diagram of a symbolic foundation showing details shall be furnished.

g) Recommendations for additional investigations beyond the scope of the present work, if considered such investigation as necessary.

f) In case of foundation in rocky strata, type of foundation and recommendation regarding rock anchoring etc. should also be given.

3.0 CONTOUR SURVEY, SITE LEVELLING

3.1 **CONTOUR SURVEY & SITE LEVELLING**:

The land for construction of substation will be handed over to the successful bidder as on where basis progressively after award of work. The contractor shall carry out survey work by taking spot level at 05 m x05 m grid interval with respect to temporary bench mark transferred from permanent bench mark in the locality if available either on bridge , government buildings of local authorities or any other permanent structure. The contractor shall submit the spot levels (in grid format) in editable soft copy in excel format and contour map with contour interval of 0.5 m in editable auto cad soft drawing.

The contractor will level the area required for construction of substation work either at single level, multi level or gradual slope with the finished ground level as approved by NEA/Consultant during detailed engineering based on highest flood level. The levelling area shall be decided by NEA/Consultant during detailed Engineering stage.

The layout and levels of all structure etc shall be made by the Contractor at his own cost from the general grids of the plot and benchmarks set by the Contractor and approved by NEA/Consultant. The Contractor shall provide all assistance in instruments, materials and personnel to NEA/Consultant for checking the detailed layout and shall be solely responsible for the correctness of the layout and levels.

3.2 **SCOPE**

This clause covers clearance of site, contour survey, site levelling, maintaining finished ground level by cutting/filling in all types of soil and soft/ disintegrated rock, supplying and compaction of fill material if required. Cutting/felling of trees and their disposal has not been envisaged under the present scope.

3.3 **GENERAL**

Site shall be cleared, surveyed and levelled/sloped by the contractor as per approved general arrangement drawing or levelling area decided during detailed engineering after award of work.

Work covered under this clause comprises the site clearance, survey work/setting out and making profiles (preparation of plot plan, setting up Bench Mark and taking spot levels at 05m x 05 m interval, preparation of contour plan with contour interval of 0.50 m), Earth work in Excavation &

filling in specified area with all lifts and leads and earth work in filling with borrowed earth with all leads and lifts (Borrow areas including payment of royalty for borrowed earth shall be arranged by the contractor at his own cost). During detailed engineering stage, the contractor will prepare the levelling proposal for optimum levelling and submit to NEA/Consultant for approval. Contractor shall submit the hard copy and editable soft copy of levelling proposal (levelling quantity calculation in Excel form and levelling drawing in Auto CAD) to NEA/Consultant for approval.

3.4 Filling material shall conform to relevant British standard codes (BS Codes)/ equivalent International Standards. Unsuitable filling material if any shall be removed and replaced by suitable fill material. The filling shall be compacted in layers to achieve 95% of standard Proctor's density at Optimum moisture contents (OMC). Cohesion less material shall be compacted to 70% relative density (minimum). Levelling/Filling shall be carried out as per relevant British standard codes (B S Codes)/ equivalent International Standards.

3.5 All materials involved in excavation shall be classified by NEA/ Consultant in the following groups:

3.5.1 **All kinds of soils and soft/disintegrated rocks (Not requiring blasting):** The material which can be quaried/excavated with pick, shovel, jumpers, scarifiers, crowbars and mechanical implements and will include various types of soils, plain cement concrete, shingle, river/nallah boulders, soling of road/foot path, stone masonary, soft conglomerate and laterite stone, lime stone and hard conglomerate etc.

3.5.2 **Hard Rocks**: All kinds of rocks which can only be excavated by machines and requires blasting, chiselling in edging or in another agreed method and will also include reinforcement cement concrete.

3.6 The quantity of excavation in all types of soils and soft/disintegrated rock shall be worked out by using initial and final level and no void deduction shall be made to calculate net quantity of earth work with 95% compaction.

3.7 The volume of hard rock shall be computed on the basis of stack of excavated rubble after making 50 % deduction for voids.

3.8 The surface of excavation or filling shall be neatly dressed to the required formation level with tolerance of (±) 100 mm.

4.0 SITE PREPERATION, EXCAVATION, BACKFILL & DISPOSAL OF SURPLUS EARTH.

4.1 SITE PREPERATION

The layout and levels of all structure etc shall be made by the Contractor at his own cost from the general grids of the plot and benchmarks set by the Contractor and approved by the NEA/Consultant. The Contractor shall give all help in instruments, materials and personnel to the

NEA/Consultant for checking the detailed layout and shall be solely responsible for the correctness of the layout and levels.

4.2 SCOPE

This clause covers clearing of the site, maintaining the finished ground level with available surplus excavated suitable back fill material generated from foundation works etc.

4.3 GENERAL

1) The Contractor shall develop the site area to meet the requirement of the intended purpose. The site preparation shall conform to the requirements of relevant sections of this specification or as per stipulations of relevant British standard codes (B S Codes)/ equivalent International Standards.

2) The fill material shall be suitable for the above requirement. The fill shall be with such a material that the site so designed shall not be affected by erosion from wind and water from its final compacted position or the in-situ position of undisturbed soil.

3) Material unsuitable for founding of foundations shall be removed and replaced by suitable fill material to be approved by the NEA/Consultant.

4) Backfill material around foundations or other works shall be suitable for the purpose for which it is used and compacted to the density described under Compaction. Excavated material not suitable or not required for backfill shall be disposed off in areas as directed by purchaser up to a maximum lead of 2 km.

4.4 EXCAVATION AND BACKFILL

SCOPE

This clause covers excavation for foundation works of Towers, Equipment support structures, Transformer/Reactor foundations, External Lighting poles, Cable trenches, Buildings, Car parking shed, Fire Wall, DG set, Water tanks, etc, backfilling of Foundations Works.

1. Excavation and backfill for foundations shall be in accordance with the relevant British standard codes (B S Codes)/ equivalent International Standards.

2. Whenever water table is met during the excavation, it shall be dewatered and water table shall be maintained below the bottom of the excavation level during excavation, concreting and backfilling.

3. When embankments are to be constructed on slopes of 15% or greater, benches or steps with horizontal and vertical faces shall be cut in the original slope prior to placement of embankment material. Vertical faces shall measure not more than 1 m in height.

4. Embankments adjacent to abutments, culverts, retaining walls and similar structures shall be constructed by compacting the material in successive uniform horizontal layers not exceeding 15 cm in thickness. (Of loose material before compaction). Each layer shall be compacted as required by means of mechanical tampers approved by the Purchaser. Rocks larger than 10 cm in any direction shall not be placed in embankment adjacent to structures.

5. Earth embankments of roadways and site areas adjacent to buildings shall be placed in successive uniform horizontal layers not exceeding 20 cm in thickness in loose stage measurement and compacted to the full width specified. The upper surface of the embankment shall be shaped so as to provide complete drainage of surface water at all times.

4.5 COMPACTION

1. The density to which fill materials shall be compacted shall be as per relevant BS and as per direction of NEA/Consultant. All compacted sand filling shall be confined as far as practicable. Backfilled earth shall be compacted to minimum 95% of the Standard Proctor’s density at OMC. The sub grade for the roads and embankment filling shall be compacted to minimum 95% of the Standard Proctor’s density at OMC. Cohesion less material sub grade shall be compacted to 70% relative density (minimum).

2. At all times unfinished construction shall have adequate drainage upon completion of the road’s surface course, adjacent shoulders shall be given a final shaping, true alignment and grade.

3. Each layer of earth embankment when compacted shall be as close to optimum moisture content as practicable. Embankment

material which does not contain sufficient moisture to obtain proper compaction shall be wetted. If the material contains any excess moisture, then it shall be allowed to dry before rolling. The rolling shall begin at the edges overlapping half the width of the roller each time and progress to the centre of the road or towards the building as applicable. Rolling will also be required on rock fills. No compaction shall be carried out in rainy weather.

4.6 REQUIREMENT FOR FILL MATERIAL UNDER FOUNDATION

The thickness of fill material under the foundations shall be such that the maximum pressure from the footing, transferred through the fill material and distributed onto the original undisturbed soil will not exceed the allowable soil bearing pressure of the original undisturbed soil. For expansive soils, the fill materials and other protections etc. to be used under the foundation is to be got approved by the NEA/Consultant.

4.7 DISPOSAL OF SURPLUS EARTH

The surplus earth generated from foundation work shall be disposed away from levelling area boundary at low lying areas within 2Km lead. The surplus earth if disposed within substation main boundary, the same shall be spread in uniform layers and compacted with suitable compacting equipment to achieve 95% compaction at O.M.C.

5.0 ANTIWEED TREATMENT & STONE SPREADING

5.1 SCOPE OF WORK

The Contractor shall furnish all labour, equipment and materials required for complete performance of the work in accordance with the drawings, specification.

Stone spreading along with cement concrete layer shall be done in the areas of the switchyard under present scope of work within fenced area. However the stone spreading along with cement concrete layer in future areas within fenced area shall also be provided in case step potential without stone layer is not well within safe limits.

5.2 GENERAL REQUIREMENT

The material required for site surfacing/stone filling shall be free from all types of organic materials and shall be of standard quality, and as approved by the Purchaser.

The material to be used for stone filling/site surfacing shall be uncrushed/crushed/broken stone of 40mm nominal size (ungraded single size) conforming to relevant BS. Hardness, flakiness shall be as required for wearing courses shall be as are per relevant BS.

(a) Hardness
Abrasion value as per relevant BS.
Impact value as per relevant BS.

(b) Flakiness Index
One test shall be conducted as per relevant British standard codes (B S Codes)/ equivalent International Standards.

After all the structures/equipments are erected, anti weed treatment shall be applied in the switchyard where ever stone spreading along with cement concrete is to be done and the area shall be thoroughly de-weeded including removal of roots. The recommendation of local agriculture or horticulture department may be sought where ever feasible while choosing the type of chemical to be used. The anti weed chemical shall be procured from reputed manufacturers. The doses and application of chemical shall be strictly done as per manufacturer's recommendation. Nevertheless the effectiveness of the chemical shall be demonstrated by the contractor in a test area of 10MX10M (appx.) and shall be sprinkled with water at least once in the afternoon every day after forty eight hours of application of chemical. The treated area shall be monitored over a period of two to three weeks for any growth of weeds by the NEA/Consultant. The final approval shall be given by NEA/Consultant based on the results.

NEA/Consultant 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 approved drawing.

After anti weed treatment is complete, the surface of the switchyard area shall be maintained, rolled/compacted to the lines and grades as decided by NEA/Consultant. The sub grade shall be consolidated by using half ton roller with suitable water sprinkling arrangement to form a smooth and compact surface. The roller shall run over the sub grade till the soil is evenly and densely consolidated and behaves as an elastic mass.

In areas that are considered by the NEA/Consultant to be too congested with foundations and structures for proper rolling of the site surfacing material by normal rolling equipments, the material shall be compacted by hand, if necessary. Due care shall be exercised so as not to damage any foundation structures or equipment during rolling compaction.

The sub grade shall be in moist condition at the time the cement concrete is placed. If necessary, it should be saturated with water for not less than 6 hours but not exceeding 20 hours before placing of cement concrete. If it becomes dry prior to the actual placing of cement concrete, it shall be sprinkled with water and it shall be ensured that no pools of water or soft patches are formed on the surface.

Over the prepared sub grade, 75mm thick base layer of cement concrete in 1:5:10 (1 cement :5 sand : 10 Stone aggregates) shall be provided in the area excluding roads, drains, cable trenches as per detailed engineering drawing. For easy drainage of water, the slope of 1:1000 is to be provided from the ridge to the nearest drain. The ridge shall be suitably located at the centre of the area between the nearest drains. The above slope shall be provided at the top of base layer of cement concrete in 1:5:10. A layer of cement slurry of mix 1:6 (1 cement: 6 sand) shall be laid uniformly over cement concrete layer. The cement consumption for cement slurry shall not be less than 150 kg. Per 100 sq.m.

A final layer of 100mm thickness of uncrushed/crushed/broken stone of 40mm nominal size (ungraded size) shall be spread uniformly over cement concrete layer after curing is complete.

6.0 SITE DRAINAGE

Preparation of overall drainage layout, design, drawing and providing rain water drainage system within the substation boundary under the present scope including connection at one or more points to the outfall point located outside the substation boundary wall is in the scope of contractor. Invert level of drainage system at outfall point shall be decided in such a way that the water can easily be discharged outside the substation boundary wall. In case outfall point is more than 50M away from boundary wall, only 50 metre drain outside the boundary wall is in the scope of contractor. Outfall point shall be got approved from NEA/Consultant before commencement of construction. While designing the drainage system following points shall taken care of:

(a) The surface of the switchyard shall be sloped to prevent accumulation of water.

(b) Drain shall be constructed at suitable locations in such a way that substation is not flooded and roads are not affected with ponding of surface water. In the switchyard maximum spacing between two drains shall not be more than 100 meter. It will be ensured that no area is left undrained.

(c) Open surface drains having 300mm bottom width and 300mm depth at starting point of drain shall be provided. The depth of drain shall be measured with respect to finished ground level of switch yard i.e. from bottom of switch yard stone filling.

(d) Longitudinal slope shall not be less than 1 in 1000.

(e) Open surface drains shall be constructed with brick masonry or concrete blocks. As per design of contractor. PCC (1:2:4) shall be laid over 40mm thick layer of PCC 1:4:8 (1 cement: 4coarse sand: 8 stone aggregate 20mm nominal size.)

(f) The side wall of the drains shall be 25 mm above the gravel level to prevent falling of gravel into drain. Groove of 125 mm width shall be provided at 2000 mm spacing with suitable mild steel grating..

(g) The maximum velocity for pipe drains and open drains shall be limited to 2.4m/sec and 1.8m/sec respectively. However, minimum non-silting velocity of 0.6m/sec shall be ensured.

(h) Pipe drains shall be provided in areas of switchyard where movement of crane will be necessary in operating phase of the substation.

(i) For pipe drains, concrete pipe of class NP2 shall be used. However, for road crossings etc. higher strength pipe of class NP3 shall be provided. For rail crossings, RCC pipes of class NP4 shall be provided. For design of RCC pipes for drains and culverts, relevant British standard codes (B S Codes)/ equivalent International Standards. Shall be followed.

(j) Two Nos. of portable pumps of 5 hp capacity for drainage of water shall be provided by the Contractor.

(k) Pipe drains shall be connected through manholes at an interval of max. 30m.

(l) If the invert level of outfall point is above the last drain point in the substation boundary, sump of suitable size has to be constructed with in the substation boundary.

(m) The drainage scheme and associated drawings shall be got approved from NEA/Consultant before commencement of construction.

6.1 RAINWATER HARVESTING:

In addition to drainage of rainwater in accordance with above clause 6.0, the contractor shall design, prepare drawings and provide rainwater harvesting system also. Rainwater harvesting shall not be done if the depth of underground water table is within 8.0m from finished ground level or as per provision of relevant British standard codes (B S Codes)/ equivalent International Standards. While designing the rain water harvesting system, following points may be taken care of:

Rainwater harvesting shall be done by providing two numbers recharge structures with bore wells. The recharge structures shall be suitably located within the sub-station. Branch drains from the main drain carrying rainwater from entire switchyard, constructed in accordance with clause 5.0, shall be connected to the recharge structures.

The internal diameter of recharge shafts shall be 4.5 meter with 230mm thick lining of brick work up to a depth of 2.0 meter from ground level and 345mm thick brickwork below 2.0 meter depth. The brick/concrete block work shall be constructed with cement mortar 1:6 (1 cement: 6 coarse sand). The overall depth of shaft shall be 5.0 meter below invert level of drain. The shaft shall be covered with RCC slab for a live load of 300 kg. Per sq.m. Two openings of size 0.7 x 0.7 meter shall be provided in the RCC cover slab as shown in the drawing. An iron cover made of 5mm thick chequered plate with hinges shall be provided on the openings. Galvanized M.S. rungs of 20mm diameter at spacing of 300 mm shall be provided in the wall of shaft below the opening in the RCC slab to facilitate cleaning of shaft.

A 300 mm diameter bore well shall be drilled in the centre of the shaft. The depth of bore well shall be 5.0 meter more than the depth of sub soil water.

A 100 mm dia medium duty MS pipe conforming to relevant BS shall be lowered in the bore well keeping bail plug towards bottom of bore well. The pipe shall have 1.58mm holes for 4.0 meter length starting from 1.0 meter from bottom of bore well. Holes of 3.0mm dia shall be provided for a length of 2.0 meter starting from the bottom level of coarse sand and down wards. The overall length of pipe shall be equal to total depth of bore well plus depth of shaft.

Gravel of size 3mm to 6mm shall be filled around 100 dia MS pipe in the borewell. The shaft shall be filled with 500 mm thick layers each from the bottom of shaft with boulders of size 50mm to 150mm, gravel of size 5mm to 10mm, coarse sand having particle size 1.5mm to 2.0mm and boulders of size not less than 200mm respectively.

7.0 ROADS

a). All the roads as shown in the General Arrangement drawing for the substation issued along with the tender documents are in the present scope. Adequate turning space for vehicles shall be provided and bend radii shall be set accordingly. Road to the Transformer /Reactor shall be as short and straight as possible.

b) All concrete roads within substation boundary wall shall be with 3.75 m RCC concrete pavement of suitable thickness and 1.3 m wide earthen shoulder on either side of the road. Below RCC concrete pavement, water bound macadam of adequate thickness as per design (WBM) shall be laid.

c) All black top (Bituminous/Asphalt) roads within substation boundary wall if any shall be with 3.75 m asphaltic pavement of suitable thickness and 1.3 m wide earthen shoulder on either side of the road. Below black top pavement, water bound macadam of adequate thickness as per design (WBM) shall be laid.

d) Strengthening of existing roads as applicable (as shown in General Arrangement Drawing) shall be carried out with 2.5 cm thick premix carpet and 100 mm thick compacted layer of WBM (Water Bound Macadum) after filling the pot holes of existing roads with WBM material.

e) All roads shall be designed as per relevant British standard codes (B S Codes)/ equivalent International Standards. All drawings of road and culverts shall be prepared by the contractor.

f) All the culverts and allied structures (required for road/rail, drain, trench crossings etc.) shall be designed as per relevant British standard codes (B S Codes)/ equivalent International Standards.

16.14 Road Outside NEA boundaary

Asphalt Pavement

General
This specification covers all construction works for 4 -6 meter wide driveway road within Employer's premises.

Grading
Finish grade of roads and packing area shall be as directed by Employer.
<u>Pavement Materials</u>
<u>Sub-base</u>

Sub-base shall be a non-plastic, sandy, granular material with a C.B.R. value greater than 15. It shall be free of deleterious material and subjected to the Employer's approval. Thickness of sub-base course shall be 30cm compacted.

Base course

Base shall be of WBM (water bound macadam) using crushed aggregate with a CBR value greater than 80. The filler material for WBM shall be stone dust. It shall be free of deleterious material and subjected to the Employer's approval. Thickness of base course shall be 15cm compacted.

It shall conform to following gradation:

Sieve size	Percentage passing
1 1"/2	100
3/4"	90 - 100
3/8"	50 - 80
No.4	35 - 55
No.30	10 - 30
No.200	2 - 9

Wearing course

Wearing course shall be of asphalt concrete mixture (min. 40mm compacted).

Asphalt Concrete Mixture

Asphalt concrete shall be a mixture of mineral aggregate and paving asphalt mixed at a central mixing plant. Its components shall be as specified herein.

Paving asphalt shall be a stream -refined asphalt produced from crude asphalt petroleum or mixture of refined liquid asphalt and refined solid asphalt. It shall be homogeneous and free from water and residues of coal, coal tar or paraffin oil. It shall have a penetration grade of 85-100 when tested according to ASTM D-5.

Aggregate for asphalt concrete shall be a composition of coarse aggregate and fine aggregate. Both shall be clean and durable.

Composition of Grading

The grading of the combined aggregates and the percentage of asphalt shall be as follows.

Percentages shown are based on weight of dry aggregates.

Sieve size	Percentage passing	
	Minimum	Maximum
3/4"	100	
1/2"	95	100
3/8"	72	88
No.4	46	60
No.8	28	42
No.30	15	27
No.50	10	20
No.200	4	7
Asphalt content (%)	4.8	6.0

Road curb

Both side of road edge shall be provided with R.C.C curb having it's corner chamfered. Minimum projection of curb from road surface shall not be less than 100mm.

Payment

The unit price bid in the Price Schedule shall include the cost of design, all labor, all material, civil construction works, etc.

Payment for the Contract item "Asphalt Road" will be made at the unit price per sq.m. of finish surface bid, therefore in the Price Schedule, such unit price shall include full compensations for all costs incurred in grading, furnishing all materials, equipment and labor and all other operations.

ACCESS ROAD

The proposed substation shall be constructed within 3Km from the nearest sankhu highway. The construction site will be accessible by vehicle during fair weather. The scope of works in this section comprises construction of access road and repair and maintenance of the same during the construction period so that it shall be left in well and good condition at the end of the project construction. For this purpose, the Contractor has to lay a new layer of sub-base course of thickness of 150mm (compacted) on the existing surface with proper grading, watering and compaction as directed by the Employer and, handover the road with smooth and compacted gravel surface after the completion of the substation works.

The sub-base course shall be a non-plastic, sandy, granular material with a C.B.R. value greater than 15. The sub-base material shall be free of deleterious material and subject to the Employer's approval. The compaction of the sub-base course shall be carried out by at least 8 ton capacity steel roller with proper watering. The required density for the applied sub-base course is at least 90%.

8.0 TRANSFORMERS/REACTOR FOUNDATION, RAIL TRACK/ RAIL CUM ROAD TRACK

The Contractor shall design, prepare drawing and provide a RCC Rail cum road system integrated with the Transformer/Reactor foundation to enable installation and the replacement of any failed unit. The transfer track system shall be suitable to permit the movement of any failed unit fully assembled (including OLTC, bushings) with oil. This system shall enable the removal of any failed unit from its foundation to the nearest road. If trench/drain crossings are required then suitable R.C.C. culverts shall be provided in accordance with relevant BS.

The Contractor shall provide a pylon support system for supporting the fire fighting system.

Each Transformer /Reactor including oil conservator tank and cooler banks etc. shall be placed in a self-sufficient pit surrounded by retaining walls (Pit walls). The clear distance of the retaining wall of the pit from the Transformer/Reactor shall be 20% of the Transformer /Reactor height or 0.8m whichever is more. The oil collection pit thus formed shall have a void volume equal to 200% volume for 220 kV & above and 130% for 132 kV & below of total oil in the Transformer /Reactor. The minimum height of the retaining walls shall be 15 cm above the finished level of the ground to avoid outside water pouring inside the pit. The bottom of the pit shall have an uniform slope towards the sump pit. While designing the oil collection pit, the movement of the Transformer must be taken into account.

The grating shall be made of MS flat of size 40mmx 5mm placed at 30mm center to center and 25mmx5mm MS flat at spacing of 150mm at right angle to each other. Maximum length of grating shall be 2000mm and width shall not be more than 500mm. The gratings, supported on ISMB 150mm, shall be placed at the formation level and will be covered with 100mm thick layer of broken/crushed/non-crushed stone having size 40mm to 60mm which acts as an extinguisher for flaming oil. All steel works used for grating and support in transformer foundation shall be painted with Zinc phosphate primer (two packs) conforming to relevant British standard codes (B S Codes)/ equivalent International Standards.

Each oil collection pit shall be drained towards a sump pit within the collection pit whose role is to drain water and oil due to leakage within the collection pit so that collection pit remains dry.

8.1 MATERIALS

Complete foundation shall be made of reinforced cement concrete and shall be designed as per guidelines for design of foundations given in clause 10.0 in the specification.

8.2 DRAINAGE

One 0.5 H.P pump for each pit shall be supplied and installed by the Contractor to evacuate the fire fighting & rain water from the sump pit in to the nearest drain.

9.0 FIRE PROTECTION WALLS

9.1 GENERAL

Fire protection walls shall be provided, if required, in accordance with Local Advisory Committee (LAC) recommendations. The scope of works covers design, preparation of drawing and construction of RCC fire protection walls. While designing the wall, following points may be taken care of:

9.1.1 FIRE RESISTANCE

The firewall shall have a minimum fire resistance of 3 hours. The partitions, which are made to reduce the noise level, shall have the same fire resistance. The walls of the building, which are used as firewalls, shall also have a minimum fire resistance of 3 hours.

The firewall shall be designed to protect against the effect of radiant heat and flying debris from an adjacent fire.

9.1.2 DIMENSIONS

The firewall shall extend 600 mm on each side of the Transformer /Reactors and 600 mm above the conservator tank or safety vent.

These dimensions might be reduced in special cases, as per the approval of owner where there is lack of space. A minimum of 2.0meter clearance shall be provided between the equipments e.g. Transformer /Reactors and firewalls.

The building walls, which act as firewalls, shall extend at least 1 m above the roof in order to protect it.

9.1.3 MATERIALS

The firewall will be made of reinforced cement concrete as per the relevant British standard codes (B S Codes)/ equivalent International Standards.

10.0 CABLE TRENCHES AND CABLE TRENCH CROSSINGS

The work covered under this clause comprises of design, drawing and construction of cable trenches and cable trench crossings. While designing, following points may be taken care of:

a). The cable trenches and pre-cast removable RCC cover (with lifting arrangement) shall be constructed using RCC of M25 (Minimum) grade as per relevant British standard codes (B S Codes)/ equivalent International Standards.

b). The cable trench walls shall be designed for the following loads.

(i) Dead load of 155 kg/m length of cable support + 75 Kg on one tier at the outer edge of tier.
(ii) Earth pressure + uniform surcharge pressure of 2T/m2.

c). Cable trench covers shall be designed for self-weight of top slab + concentrated load of 150 kg at centre of span on each panel.

d). Necessary sumps shall be provided and each sump shall be provided with pumps of 5 HP capacity shall be supplied for pumping out water collected in cable trench. Cable trenches shall not be used as storm water drains.

e). The top of trenches shall be kept at least 100 mm above the finished ground level. The top of cable trench shall be such that the surface rainwater do not enter the trench.

f). All metal parts inside the trench shall be connected to the earthing system.

g). Trench wall shall not foul with the foundation. Suitable clear gap shall be provided.

h). The trench bed shall have a slope of 1/500 along the run & 1/250 perpendicular to the run.

i). Cable trenches shall be blocked at the ends if required with brick masonry in cement sand mortar 1:6 and plaster with 12mm thick 1:6 cement sand mortar.

J) Cable trench crossings shall be designed for critical load likely to be passed over the crossing. The cable trench crossing may be of either RCC box culvert type or RCC hume pipes embedded in plain concrete as per design of contractor.

11.0 FOUNDATION / RCC CONSTRUCTION

11.1 GENERAL

1. Work covered under this Clause of the Specification comprises the design ,drawing and construction of foundations and other RCC constructions for switchyard tower structures, bus supports, equipment supports, cable trenches, Transformer /Reactors, jacking pad, pulling blocks, fire protection walls, control cubicles, marshalling kiosks, auxiliary equipments, Control Room Cum Administrative building, GIS hall, Fire fighting Pump house, fire fighting water tanks, Auxiliary Building, Panel room, ,township buildings, Parking shed ,RCC retaining wall, or for any other equipment or service and any other foundation required to complete the work. This clause is as well applicable to the other RCC constructions.

2. Concrete shall conform to the requirements mentioned in relevant British standard codes (B S Codes)/ equivalent International Standards. And all

the tests shall be conducted as per relevant British standard codes (B S Codes)/ equivalent International Standards. However, a minimum grade of M25 (design Mix) concrete shall be used for all foundations and structural/load bearing members as per relevant British standard codes (B S Codes)/ equivalent International Standards.

3. If the site is sloppy, the foundation height will be adjusted to maintain the exact level of the top of structures to compensate such slopes.

4. The switchyard foundation's plinths and building plinths shall be minimum 300mm and 500 mm above finished ground level respectively.

5. Minimum 75mm thick lean concrete (1:4:8) shall be provided below all underground structures, foundations, trenches etc. to provide a base for construction.

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.

7. The design and detailing of foundations shall be done based on the approved soil data and sub-soil 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.

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 relevant British standard codes (B S Codes)/ equivalent International Standards. 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 contractor 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.

11.2 DESIGN

While designing foundations, following may be taken care of:

11.2.1. All foundations except for external lighting poles shall be of reinforced cement concrete. The external lighting pole shall be embedded in plain cement concrete (1:2:4) foundation. The design and construction of RCC structures shall be carried out as per relevant BS and minimum grade of concrete shall be M-25 (design Mix). Higher grade of concrete than specified above may be used at the discretion of Contractor without any additional financial implication to the NEA/Consultant.

11.2.2. Limit state method or any other method as per relevant British standard codes (B S Codes)/ equivalent International Standards of design shall be adopted unless specified otherwise in the specification.

11.2.3. For detailing of reinforcement relevant BS followed. Cold twisted deformed bars conforming to relevant British standard codes (B S Codes)/ equivalent International Standards. Two layers of reinforcement (on inner and outer face) shall be provided for wall & slab sections having thickness of 150 mm and above. Clear cover to reinforcement shall be as per relevant British standard codes (B S Codes)/ equivalent International Standards.

11.2.4. RCC water retaining structures like storage tanks, etc. shall be designed as uncracked section in accordance with relevant British standard codes (B S Codes)/ equivalent International Standards. However, water channels shall be designed as cracked section with limited steel stresses as per relevant BS.

11.2.5. 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 British standard codes (B S Codes)/ equivalent International Standards of foundation design. Detailed design calculations shall be submitted by the bidder showing complete details of piles/pile groups proposed to be used.

11.2.6. Design shall consider any sub-soil water pressure that may be encountered following relevant standard strictly.

11.2.7. 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.

11.2.8. RCC columns shall be provided with rigid connection at the base.

11.2.9. 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 British standard codes (B S Codes)/ equivalent International Standards 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.

11.2.10. 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 substructures of any underground enclosures, earth pressure at rest shall be considered.

11.2.11. 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, substructure of any underground hollow enclosure etc., for the vehicular traffic in the vicinity of the structure.

11.2.12. Following conditions shall be considered for the design of water tank in pumps house, channels, sumps, trenches and other underground structures:

a) Full water pressure from inside and no earth pressure & ground water pressure & surcharge pressure from outside (application only to structures which are liable to be filled up with water or any other liquid).

b) Full earth pressure, surcharge pressure and ground water pressure from outside and no water pressure from inside.

c) 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.

11.2.13. Base slab of any underground enclosure shall also be designed for empty condition during construction and maintenance stages with maximum ground water table (GWT). Minimum factor of safety of 1.5 against buoyancy shall be ensured ignoring the super-imposed loadings.

11.2.14. Base slab of any underground enclosure like water storage tank shall also be designed for the condition of different combination of pump sumps being empty during maintenance stages with maximum GWT. Intermediate dividing piers of such enclosures shall be designed considering water in one pump sump only and the other pumps sump being empty for maintenance.

11.2.15. 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.

11.2.16. The foundations of transformer/reactor and circuit breaker shall be of lock type foundation. Minimum reinforcement shall be governed by relevant British standard codes (B S Codes)/ equivalent International Standards.

11.2.17. The tower and equipment foundations shall be checked for a factor of safety as per relevant British standard codes (B S Codes)/ equivalent International Standards for two conditions i.e. Normal condition and short circuit condition against sliding, overturning and pullout. The same factors shall be used as partial safety factor over loads in limit state design also.

11.3 **ADMIXTURES & ADDITIVES**

11.3.1. 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.

11.3.2. Admixtures in concrete shall conform to relevant British standard codes (B S Codes)/ equivalent International Standards. The water proofing cement additives shall conform to relevant BS. Concrete Admixtures/ Additives shall be approved by NEA/Consultant.

11.3.3. The Contractor may propose and the NEA/Consultant 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.

11.3.4. The water-reducing setting-retarding admixture shall be an approved brand as per relevant British standard codes (B S Codes)/ equivalent International Standards.

11.3.5 The water proofing cement additives shall be used as required/advised by NEA/Consultant.

12. CHAINLINK FENCING AND GATE

12.1 General

Work covered under this clause comprises of design, drawing, supply, fabrication, erection, painting or galvanisation as specified etc of switch yard Fencing and gate, construction of foundation of steel posts and toe wall .While providing switch yard fencing and gate, Following points may be taken care of :

12.2 Areas requiring Fencing

12.2.1 Fencing shall be provided for complete switchyard as per drawing. Separate gate shall be provided for men and equipment.

12.2.2 Internal fence surrounding the various equipments (if) mounted on ground or a height lower than 2.5m. Necessary gates shall be provided for each area so surrounded.

12.3 Product materials

The minimum requirements are as follows:
Chain link fence fabric (galvanization) in accordance to relevant British standard codes (B S Codes)/ equivalent International Standards.

12.4 Posts

The posts shall be of medium M.S. tubes of 50mm diameter conforming to grade as per relevant international /BS standard. The tubes shall also conform relevant British standard codes (B S Codes)/ equivalent International Standards. The length of tubular post shall be 2600 mm.

An M.S. base plate of size 160 X 160 X 6mm thick shall be welded with the tubular post. The post shall be provided on the top with M S plate.

The tubular post shall be welded with 8 number of M S flat of size 50 x 6mm – 75mm long at suitable locations. Two number of 13.5 mm diameter holes on each cleats shall be provided to bolt the fence fabric panel. The cleats shall be welded at equal spacing in such a way that 4 numbers of cleats are on one side and remaining 4 cleats are on the opposite side of the post. The cleats on the corner posts shall be welded in such a way that it suits the site requirement.

The whole assembly of tubular post shall be hot dip galvanized. The zinc coating shall be minimum 610 gram per sq. meter. The purity of zinc shall be 99.95% as per relevant BS.

12.5 Fence Fabric & Fence Panel

Chain link fencing shall be made of 3.15 mm diameter wire with 75 X 75 mm mesh size. Fence fabric shall be galvanised. Chain link fencing shall be fabricated in the form of panel 1300 X 2928 mm. An M.S. flat of at least 50x6 mm size shall be welded all-round fence fabric to form a panel. Four pairs of 13.5mm diameter holes on the vertical M S flat matching the spacing of holes in cleats fixed with pipe shall be provided to fix the fence panel with the tubular posts. A washer shall also be provided below each nut. The contractor, for fixing the panels, shall supply the 12mm diameter bolts including nuts and washers. All nuts, bolts and washers shall be hot dip galvanized.

The fence panel shall be provided with two or more coats of approved standard Zinc paint over approved standard steel primer.

12.6 Installation

1. Fence shall be installed along the switchyard line as shown in the approved drawings.
2. Post holes shall be excavated by approved method.
3. All posts shall be 3.0m apart measured parallel to ground surface.
4. Posts shall be set in 1:2:4 Plain Cement Concrete block of minimum 0.40x0.40x1.2m depth. 75mm thick plain cement concrete 1:4:8 shall be provided below concrete blocks. Posts shall be braced and held in plumb position and true alignment and elevation until concrete has set.
5. Fence fabric shall not be installed until concrete has cured a minimum of 7 days.
6. Fence fabric panel shall be fixed to the post at 4 nos. MS flat each of 50x6, 75 long through 2 nos. of bolts (12mm diameter) on each flat.

12.7 Gate

1. The gate shall be made of medium duty M.S. pipe conforming to relevant I.S. with welded joints. The main frame (outer frame) of the gate shall be made of 40mm dia pipe and vertical pipes of 15mm dia @ 125mm spacing (maximum) shall be welded with the main frame. Two number of 1.25 mm thich and 125 mm wide MS plates (Horrizontal) @ 500 mm centre to centre distance shall be welded on each gate leaf. Gate leaves shall be fixed with a vertical post of 2700 mm long two steel channels-150 welded together.A 8 mm thick 200X 200 mm size MS plate shall be welded at the bottom of channel frame.

2. The gates shall be fabricated with welded joints to achieve rigid connections. The gate frames shall be painted with one coat of approved steel primer and two coats of synthetic enamel paint.
3. The gates shall be provided with suitable locking arrangement welded on 4 mm thick MS plate on the gate leaf.
4. The main gate shall be 5.0m wide and shall be of double leaf type (as shown in the drawing). Next to the main gate, a men gate (1.25m wide single leaf) shall also be provided.
5. Steel roller shall be provided with the gate.
6. Gate shall be installed in location as shown in approved G.A. drawing.
7. The vertical post of gate shall be embedded in PCC foundation of 500 X500X1250 mm deep size.

13.0 BUILDINGS

13.1 GENERAL

The scope includes the design, drawing, engineering and construction including anti-termite treatment, plinth protection, DPC of Building including sanitary, water supply, electrification, false ceiling etc as applicable ,complete of control room building, firefighting building, Auxiliary building and panel room. Electrification and air conditioning of building shall be provided as detailed in other sections of electrical portion.

13.2 CONTROL ROOM CUM ADMINISTRATIVE BUILDING

GENERAL

The scope includes design, engineering and construction, including anti-termite treatment, plinth protection, DPC, peripheral drains, water supply, plumbing, sanitation, fire-fighting, electrification etc. of Control Room Building.

The Control Room Building shall be RCC Framed structure or PEB structure, as per site conditions. It shall be so designed that most of the area of switchyard is visible from the Control Room.

The building auxiliary services like air conditioning systems, fire protection and detection systems and all other miscellaneous services shall be designed in accordance with the requirements as specified in relevant section or elsewhere in this Specification. The building shall be constructed as per the design and drawings to be developed by the contractor. Tentative carpet area requirement for different rooms of control room cum administrative building is given as below for guidance to the contractor:

AREA REQUIREMENTS (Will be decided during detail engineering)

- Control Room
- Server Room
- Battery Room

13.3 DESIGN CRITERIA

The Building shall be designed:

1. To the requirements of the International standards/British Standards.

2. for the specified climatic and loading conditions.

3. To adequately suit the requirements of the equipments and apparatus contained in the buildings and in all respects to be compatible with the intended use and occupancy.

4. with a functional and economical space arrangement.

5. To be aesthetically pleasing. Different buildings shall show a uniformity and consistency in architectural design, as far as possible.

6. To allow for easy access to the equipments as well as maintenance of the equipments.

7. Wherever access to the roof is required, RCC stair case shall be provided.

8. Fire retarding materials for walls, ceilings doors etc., which would prevent supporting or spreading of fire and wherever required, shall be decided by the bidder.

9. Suitable Expansion joints, wherever required, shall be provided as per Codal Provisions.

10. All the members of the buildings frame shall be designed for the worst combination of loads as per relevant British standard codes (B S Codes)/ equivalent International Standards.

11. Permissible stresses for different load combinations shall be taken as per relevant British standard codes (B S Codes)/ equivalent International Standards.

12. Seismic coefficient Method or Response spectrum method shall be used for seismic analysis of the building for Earthquake forces, as per relevant British standard codes (B S Codes)/ equivalent International Standards.

13.4 DESIGN LOADS

1. Building structure shall be designed for the most critical combinations of dead loads, super-imposed loads, equipment loads, erection loads, wind loads, seismic

loads etc. Any other incidental load, if anticipated, shall be duly accounted for in the design, and shall be clearly mentioned by the bidder.

2. Dead loads shall include the weight of structures complete with finishes, fixtures and partitions, and shall be taken as per relevant British standard codes (B S Codes)/ equivalent International Standards.

3. Super-imposed loads in different areas shall include live loads, minor equipment loads, cable trays, small pipe racks/hangers and erection, operation and maintenance loads, wherever these loads are expected. Equipment loads shall constitute, if applicable, all load of equipments to be supported on the building frame.

AREA	**Load**
1. For Offices.	5.0 kN/m2
If higher than 5.0 kN/m2.	As per actual Requirement.
2. For Equipment Floors.	10.0 kN/m2
If higher than 10 kN/m2 (Based on Equipment weight and layout plans).	As per actual Requirement.
3. Staircases & Balconies.	5.0 kN/m2
4. Toilets.	2.0 kN/m2
5. Chequered Plate.	4.0 kN/m2
6. Cooridoors/Walkways.	3.0 kN/m2
7. Accessible Roofs.	1.5 kN/m2
8. Non-accessible Roofs.	0.75 kN/m2

4. Wind loads shall be calculated as per relevant British standard codes (B S Codes)/ equivalent International Standards. The Factors affecting the wind speed shall be taken based on the site conditions.

5. Earthquake loads shall be calculated as per relevant British standard codes (B S Codes)/ equivalent International Standards.

6. Wind forces and Seismic forces shall not be considered to act simultaneously.

7. All the load combinations to create worst combinations of loads shall be as per relevant International standards/British Standards.

8. Floors/ Slabs shall be designed to carry loads imposed by equipments, cables, piping, movement of maintenance trucks (if required) and any other load associated with the building. In general, floors shall be designed for live loads as per relevant British standard codes (B S Codes)/ equivalent International Standards. Cable and piping loads shall also be considered in addition to the live loads for floors where these loads are expected.

13.5 FLOORS, WALLS & ROOFS

1. All walls shall be non-load bearing in filled panel walls, in brickwork as per the specification. Minimum thickness of external walls shall be 230 mm (one brick) with 1:6 cement sand mortar. Partition walls if any shall be of 115 mm thick brick masonary in cement sand mortar (1:4).

2. All Floor/Roof slabs shall be regular beam slab construction. However, sunken RCC slab shall be provided in toilet areas as per the requirement.

3. False ceiling as per requirement shall be provided as detailed in Table-1 (Detailed Finish Schedule).

4. Minimum height of skirting above finished floor level shall be 150 mm. The skirting material shall match with the floor finish.

5. Minimum height of the parapet walls shall be 750 mm.

6. Ground floor finish shall be laid over 20 mm thick cement sand mortar,100 mm thick plain cement concrete (PCC) 1:4:8 (1 cement: 4 sand : 8 stone aggregates),100 mm thick local sand filling. The earth below ground floor shall be well rammed before laying sand filling.

7. First floor details shall comprise of finish as per schedule, 20 mm cement sand mortar and 50 mm thick PCC(1:4:8) over RCC slab.

13.6 DETAILS OF ROOF

Roof of the Building shall consist of Cast-in-situ RCC slab treated with a water proofing system which shall be an integral cement based treatment conforming to relevant British standard codes (B S Codes)/ equivalent International Standards. The water proofing treatment shall be of following operations:

(a) Applying and grouting a slurry coat of neat cement using 2.75 kg/m2 of cement admixed with proprietary water proofing compounds conforming to relevant British standard codes (B S Codes)/ equivalent International Standards. Over the RCC slab including cleaning the surface before treatment.

(b) Laying cement concrete using broken stone of size from 25mm to 100mm size with 50% of cement mortar 1:5 (1 cement: 5 coarse sand) admixed with proprietary water proofing compound conforming to relevant British standard codes (B S Codes)/ equivalent International Standards over 20mm thick layer of cement mortar of min 1:5 (Cement: 5 coarse sand) admixed with proprietary water proofing compound conforming to relevant British standard codes (B S Codes)/ equivalent International Standards to required slope and treating similarly the adjoining walls up to 300mm height including rounding of junctions of walls and slabs.

(c) After two days of proper curing applying a second coat of cement slurry admixed with proprietary water proofing compound conforming relevant British standard codes (B S Codes)/ equivalent International Standards.

(d) Finishing the surface with 20mm thick joint less cement mortar of mix 1:4 (1 cement: 4 course sand) admixed with proprietary water proofing compound conforming to relevant British standard codes (B S Codes)/ equivalent International Standards and finally finishing the surface with trowel with neat cement slurry and making of 300 x 300 mm square.

(e) The whole terrace so finished shall be flooded with water for a minimum period of two weeks for curing and for final test. All above operations to be done in order and as directed and specified by the Engineer-in-charge.

(f) Average thickness of water proofing shall be 120 mm and minimum thickness at khurra shall be 65 mm.

13.7 PARTITIONS

Partitions wherever provided, shall be made of powder coated aluminum frame provided with 5.5 mm thick clear glass or pre-laminated board depending upon the location of partition.

13.8 PLASTERING

External surfaces of buildings shall have 18 mm thick plaster in two layers, with the under layer 12mm thick 1:5 cement sand plaster and the top layer 6 mm thick 1:6 cement sand plaster. Inside wall surfaces shall have 12/15 mm thick 1:6 cement sand plaster. Rough surfaces shall have 15mm and smooth surface shall have 12 mm thick cement sand plaster.

All RCC ceilings shall be provided with 6 mm thick cement sand (fine) plaster (1:3) except for areas with false ceiling.

13.9 EXTERNAL PAINTING

External surfaces of the Control Room Building shall be painted with acrylic exterior flat paint as per manufacturer's specification and approval of NEA/Consultant.

13.10 DOORS, WINDOWS AND VENTILATORS

The schedule of doors, windows and ventilators of the Control Room Building shall be as per the detailed finish schedule given in Table-1 (Detailed Finish Schedule), and shall conform to the relevant British standard codes (B S Codes)/ equivalent International Standards. Rolling Steel shutters shall be provided as per the layout and requirements of the building. Main entrance door to control room building shall be made of powder coated aluminium frame with 5.5 mm thick glazing.

13.11 CABLE TRENCH INSIDE CONTROL ROOM BUILDING

All cable trenches inside the Control Room Building shall be covered with minimum 6mm thick steel chequered plate with suitable stiffeners.

13.12 PLINTH PROTECTION

750 mm wide and 50 mm thick plain cement concrete 1:2:4 (1 cement:2 sand:4 graded 20 mm nominal size stone aggregate) shall be laid over 75 mm thick dry stone aggregates well rammed and consolidated with interstices filled with local sand including smooth finishing top.

13.13 PLUMBING & SANITATION

1. All plumbing and sanitation works shall be executed to comply with the requirements of the appropriate bye-laws, rules and regulations of the Local Authority having jurisdiction over such matters. The Contractor shall arrange for all necessary formalities to be met with regards to the inspection, testing, obtaining approval and giving notices etc.

2. 'SINTEX' or an equivalent make PVC Roof water tank(s) of adequate capacity depending on the number of users for 24 hours storage shall be provided. However, a minimum of 2 nos. 1500 liter capacity shall be provided.

3. Chlorinated Polyvinyl chloride (CPVC) pipes having thermal stability for hot and cold water supply including all CPVC plain and brass threading conforming to relevant British standard codes (B S Codes)/ equivalent International Standards shall be used for internal piping works for water supply.

4. Sand C.I. pipes with lead joints conforming to relevant British standard codes (B S Codes)/ equivalent International Standards shall be used for sanitary works above ground level and RCC pipes shall be used for sanitary works below ground.

5. Each toilet shall have the following minimum fittings:

(i) WC (Western type) 390 mm high along with toilet paper roll holder and all other fittings, in toilets attached to conference room and S/S In-charge office; and WC (Indian Type) Orissa Pattern (580 x 440 mm) with all fittings shall be provided in common toilets.

(ii) Urinal (430 x 260 x 350 mm size) with all fittings and built-in-sensor for automatic flush after use.

(iii) Wash basin (550 x 400 mm) with all fittings.

(iv) Bathroom mirror (600 x 450 x 6 mm thick) with hard board backing.

(v) CP brass towel rail (600 x 20 mm) with CP brass brackets.

(vi) Soap holder and liquid soap dispenser.

(vii) Automatic Hand Dryer.

6. Water cooler for drinking water with adequate water storage facility shall be provided which shall preferably be located near pantry and away from the toilet block.

7. One no. stainless steel kitchen sink with Drain board (510 x 1040 x 178 mm bowl depth) for pantry shall be provided.

8. All fittings, fasteners, gratings shall be chromium plated.

9. All sanitary fixtures and fittings shall be of approved quality and type, manufactured by reputed manufacturers. All items brought to site must bear identification marks of the Manufacturer.

10. Contractor shall provide necessary nos. of septic tank and soak pit of adequate capacity to treat the sewage/sullage from the buildings.

11. Contractor shall undertake all other activities required to complete and commission the building.

13.14 BUILDING STORM WATER DRAINAGE

1. The building design shall provide for the collection of storm water from the roof. This water shall be drained to the main drainage system of the Sub-station.
2. Cast Iron Rainwater down comer pipes conforming to relevant International standards/British Standards with water tight lead joints or medium class galvanized mild steel pipes conforms to relevant British standard codes (B S Codes)/ equivalent International Standards shall be provided to drain off the rain water from the roofs. These pipes shall be suitably concealed with masonry work or cement concrete or cladding material. The number and size of down comer pipes shall be governed by relevant British standard codes (B S Codes)/ equivalent International Standards.
3. All drains inside the buildings shall have minimum 40 mm thick grating covers; and in areas where heavy equipment loads are envisaged, Pre-Cast RCC covers shall be provided in place of steel grating.
4. Suitable arrangements for draining out water collected from equipment blow downs, leakages, floor washings, fire fighting etc. shall be provided for each floor.

13.15 DETAILED FINISH SCHEDULE

The detailed finish schedule for Control Room Building Cum Administrative building is given below:

Table- 1: DETAILED FINISH SCHEDULE

Sl. No.	LOCATION	FLOORING & SKIRTING 150 MM HIGH	WALL(INTERNAL)	CEILING	DOOR, WINDOWS & VENTILATOR
1.	Control Room	Vitrified tiles 8mm thick size 600 x 600mm	Premium acrylic emulsion paint on smooth surface applied with plaster of paris (2 mm thick)	White wash above False Ceiling*	Windows shall be of 10mm thick toughened glass by using suitable patch fittings/spider fittings. The glass shall extend horizontally from column to column and vertically from sill level of 0.75 m to bottom of lintel/roof beam. All doors shall be glazed powder coated aluminium doors with 5.5.mm Thk. Glazing.

Sl. No.	LOCATION	FLOORING & SKIRTING 150 MM HIGH	WALL(INTERNAL)	CEILING	DOOR, WINDOWS & VENTILATOR
2.	Conference Room	Vitrified tiles 8mm thick size 600 x 600mm	Premium acrylic emulsion paint on smooth surface applied with plaster of paris (2 mm thick)	White wash above False Ceiling*	Windows shall be of powder coated aluminium with 5.5mm thick glazing. All doors shall be glazed powder coated aluminium doors with 5.5.mm thk. Glazing
3.	S/S In-charge Room.	Vitrified tiles 8mm thick size 600 x 600mm	Premium acrylic emulsion paint on smooth surface applied with plaster of paris (2 mm thick)	White wash above False Ceiling*	Windows shall be of powder coated aluminium with 5.5mm thick glazing. All doors shall be glazed powder coated aluminium doors with 5.5.mm thk. Glazing.
4	Office Rooms	Vitrified tiles 8mm thick size 600 x 600mm	Premium acrylic emulsion paint on smooth surface applied with plaster of paris (2 mm thick)	White wash above False Ceiling*	Windows shall be of powder coated aluminium with 5.5mm thick glazing. All doors shall be glazed powder coated aluminium doors with 5.5.mm thk. Glazing.
5.	Electrical/Electronics Test Lab./Telecom Room	Vitrified tiles 8mm thick size 600 x 600mm	Premium acrylic emulsion paint on smooth surface applied with plaster of paris (2 mm thick)	White wash above False Ceiling*	Windows shall be of powder coated aluminium with 5.5mm thick glazing. All doors shall be glazed powder coated aluminium doors with 5.5.mm thk. Glazing.
6.	ACDB & DCDB Room	62mm thick cement concrete flooring with metallic hardener topping . Skirting shall be of cement sand plaster.	Oil bound washable distemper on smooth surface applied with plaster of paris putty	Oil bound washable distemper on smooth surface applied with plaster of paris putty	Steel door 45mm thick double sheet 18 gauge MS steel suitably reinforced and filled with mineral wool. Windows/ventilator shall be of powder coated aluminium with 4mm glazing.
7.	Battery Room	Vitrified tiles 8mm thick size 600 x 600mm	Premium acrylic emulsion paint on smooth surface applied with plaster of paris (2 mm thick)	White wash above False Ceiling*	Steel door 45mm thick double sheet 18 gauge MS steel suitably reinforced and filled with mineral wool. Windows/ventilator shall be of powder coated aluminium with 4mm glazing.
8.	Reception/Lobby	Vitrified tiles 8mm thick size 600 x 600mm	Premium acrylic emulsion paint on smooth surface applied with plaster of paris (2 mm thick)	Oil bound washable distemper on smooth surface applied with plaster of paris putty	Windows shall be of powder coated aluminium with 5.5mm thick glazing. All doors shall be glazed powder coated aluminium doors with 5.5.mm thk. Glazing.
9.	Corridor	Vitrified tiles 8mm thick	Premium acrylic emulsion paint on	Oil bound washable	Windows shall be of powder coated aluminium with 5.5mm

Sl. No.	LOCATION	FLOORING & SKIRTING 150 MM HIGH	WALL(INTERNAL)	CEILING	DOOR, WINDOWS & VENTILATOR
		size 600 x 600mm	smooth surface applied with plaster of paris (2 mm thick)	distemper on smooth surface applied with plaster of paris putty	thick glazing. All doors shall be glazed powder coated aluminum doors with 5.5.mm thk. Glazing.
10.	Portico	Cast-in-situ 52mm thk. Cement concrete with metallic hardener .	Granite cladding	Oil bound washable distemper on smooth surface applied with plaster of paris putty	All doors shall be glazed powder coated aluminium doors with 5.5.mm thk. Glazing.
11.	Toilet	Ceramic tiles	DADO glazed tile 2100mm high, oil bound washable distemper above DADO	Oil bound washable distemper	Windows/ ventilator shall be of powder coated aluminium with 5.5mm thick glazing. All doors shall be flush door shutters made of pre-laminated particle board with powder coated aluminium frame.
12.	Janitor room	Ceramic tiles with white cement	Vitrified tiles 8mm thick size 600 x 600mm	Oil bound washable distemper	Windows/ ventilator shall be of powder coated aluminium with 5.5mm thick glazing. All doors shall be flush door shutters made of pre-laminated particle board with powder coated aluminium frame.

*Providing and fixing 15mm thick approximately 600 X 600mm Mineral fiber board panel false ceiling and making cut-outs for electrical fixtures, AC diffusers, openable access etc complete with silhouette profile system with 15mm wide flange incorporating 6mm central recess white / black main runners at 1200mm centre-centre and not greater than 600mm from the adjacent wall. The cross tees shall be provided to make a module of approximately 600mm X 600mm by fitting 600 mm long cross tees centrally placed between 1200 mm long cross tees .Cross tees also have 15mm wide flange incorporating 6mm central recess white/black. The module formed above shall be anchored to the slab with channels or angles, suspenders as per manufacturer's specifications.

13.16 SUBMISSIONS

The following information/documents/drawings shall be submitted for review and approval:

1. Structural design calculations, Structural drawings (including construction/ fabrication), both in hard and soft copies, for all reinforced concrete and structural steel structures.

2. Fully dimensioned and detailed floor plans, cross-sections, longitudinal

sections and elevations identifying the major building components.

3. Product information of building components and materials, including walls, partitions, flooring, ceilings, roofing, doors, wall paneling and windows and building finishes along with BOQ.

5. A detailed schedule of building finishes including colors schemes along with item description.

6. A door & window schedule showing door & window types and locations, lock sets and latch sets and other door hardware along with item details.

Approval of the above information shall be obtained before ordering materials or starting construction/fabrication, as applicable.

13.17 FALSE CEILING

Providing and fixing seamless ceiling with Gypsum board of 12mm thick fixed to the underside of GI frame work. The GI is fixed to the roof Slab with metal expansion fastener. The joint shall be finished with joint paper tape by using jointing Compound recommended by manufacturer with the approval of NEA/Consultant. The rate includes for all necessary cutting of ceiling for the fixing of complete fixtures.

13.18 Under deck Insulation

The method of fixing shall consist of slotted M.S. angles of appropriate size (minimum 65x50x2mm) fixed to soffit of RCC roof slab at 600mm centres in both directions by Rawl plugs of adequate strength. The slots shall have 14g G.I. tie wire drawn through them.

50mm thick insulation mat Fibreglass Crown - 100 or equivalent shall, be made out of fibre-glass or approved equivalent conforming to IS: 8183, backed with 34g aluminium foil and 22g x 12mm mesh wire netting. The net shall be stretched tightly across the slotted angles or slotted plates holding it in place by means of wires. The joints of the wire netting shall be butted and tightly laced down with 14g G.I. wire. The system shall be got approved from NEA/Consultant.

13.19 ELECTRIFICATION

All electrification shall be executed as per details specified elsewhere in the technical specification. All details shall be as per relevant British standard codes (B S Codes)/ equivalent International Standards.

14. WATER SUPPLY

(i) Water shall be made available by NEA/consultant at any feasible point within substation boundary at single point to the contractor. Contractor shall state the total water requirement both in terms of quantity and head to NEA/Consultant.

(ii) The contractor shall carry out all the plumbing/erection works required for supply of water in control room cum administrative building beyond the single point as at (i) above.

(iii) The contractor shall carry out all the plumbing/erection works required for supply of water to Fire Fighting pump house beyond the single point as at (i) above.

(iv) The details of tanks, pipes, fittings, fixtures etc for water supply are given elsewhere in the specification under respective sections.

(v) A scheme shall be prepared by the contractor indicating the layout and details of water supply which shall be got approved by NEA/Consultant before actual start of work including all other incidental items not shown or specified but as may be required for complete performance of the works. All drawings shall be prepared by the contractor for approval of NEA/Consultant.

(vi) Bore wells and pumps for water supply is not in the scope of contractor.

15. SEWERAGE SYSTEM

(i) Sewerage system shall be provided for all buildings wherever applicable.

(ii) The Contractor shall construct septic tank and soak pit suitable for 50 users each for control room building, transit camp and township buildings is constructed .If septic and soak pit system is not acceptable by local Nepal Authority, contractor will have to install suitable sewerage system as per local statutory requirement.

(iii) The system shall be designed as per relevant British standard codes (B S Codes)/ equivalent International Standards. All drawings shall be prepared by the contractor for approval of NEA/Consultant.

16. GIS HALL CUM CONTROL ROOM BUILDING

16.1 Control Room and GIS Hall

The GIS building shall be of pre-engineered steel structure. Control room building, if attached to GIS hall, shall be of pre-engineered steel structure similar to GIS hall and shall be RCC framed structure, if it is not connected with GIS hall. In case of steel control room building all walls shall be of brick masonry and roof of ground floor shall be of RCC. Internal access to the GIS hall from control room building shall be provided.

Material specification and other details for construction of Pre-engineered steel building shall be as described in subsequent paragraphs. The base plate of steel columns shall be mounted on the RCC foundation by means of hot dip galvanised foundation bolts (Galvanisation of 610 gms/Sq. M). In order to facilitate inspection and maintenance, the structures shall be provided with climbing devices. Separate fire escape doors shall also be provided in the GIS Building.

Panels shall be kept in an air-conditioned enclosure.A glazed partition made of aluminium frame and 5.5mm thick glass shall be provided between GIS hall and panel room. The glazing shall be kept at a sill level of 0.9 m above floor level. The height of glazing shall be minimum 2.1 m above sill level.

Walkway of width not less than 1.0m shall be provided at gantry girder level on the two longer side of GIS hall along with climbing arrangement to facilitate maintenance of crane.

All the material required for Pre-engineered (steel) building shall be procured from reputed manufacturer for which prior approval shall be obtained. Manufacturing of various parts of the building shall start only after approval of “Manufacturing Quality Plan to be prepared by the bidder during detailed engineering stage”. Complete material shall be offered for inspection by QA&I department of Consultant/NEA before dispatch. Inspection shall be carried out based on assembly (fabrication) drawings approved by consultant/NEA and “BILL OF MATERIAL” & Shop drawing prepared by the Manufacturer and certified by the Contractor for its correctness. Approval of BOM and shop drawing from employer is not required.

16.2 Material Specification

16.2.1 Primary members fabricated from plates and sections with minimum yield strength of 345 Mpa or to suit design by continuous welding.

16.2.2 Secondary members for Purlins and Grits shall conform to the physical specification of ASTM A570 (Grade 50) or equivalent BS/equivalent international standards having a minimum yield strength of 345 MPa. The minimum thickness of secondary members shall be 2.5mm.

16.2.3 Rod / ANGLE/pipe bracing shall conform to the physical specification of relevant BS/equivalent international standards of minimum 245Mpa Yield Strength

16.2.4 All hot rolled sections shall conform to the physical specifications of BS/equivalent international standards. All other miscellaneous secondary members shall have minimum yield strength of 250 MPa.

16.3 **DESCRIPTION**

16.3.1 **PRIMARY MEMBERS:**

Primary structural framing shall include the transverse rigid frames, columns, corner columns, end wall wind columns and crane gantry girders and Frames at Door openings.

16.3.2 **SECONDARY MEMBERS:**

Secondary structural framing shall include the purlins, girts, eave struts, wind bracing, flange bracing, base angles, clips, flashings and other miscellaneous structural parts. Suitable wind bracings sag rods to be reckoned while designing the structure.

16.3.3 **PURLINS, GIRTS,CLIPS:**

Purlins,girts and clips should be of Pre Galvanised steel of 345 Mpa having a coating thickness of 275 gms/sq. M inclusive of both sides.

16.3.4 ROOF SHEETING

Factory assembled 50mm thick puff (density 40kg/cu.m. +2 Kg/cu m as per BS/equivalent International Standards) sandwiched panels shall be provided. These panels shall be made of puff insulation sandwiched between two high tensile steel sheets each of 0.5 mm thickness. The material of sheets shall confirm to ASTM 792 M Grade 345B with minimum yield strength of 345 Mpa .The steel sheets shall be provided with hot dip coating of Zinc aluminium alloy (approximately 55% Al , 43.5% Zn and 1.5 % silicon) .Total mass of zinc aluminiym alloy coating shall be minimum 200 gm/Sq. m inclusive of both sides. The tolerance of base metal thickness (BMT) of steel sheet shall be as per BS/equivalent International Standards . After hot dip coating of Zinc aluminium alloy ,the sheet shall be provided with steel primer and silicon modified polyester (SMP) paint.The total thickness of primer and paint shall be 40 microns inclusive of both sides (TCT) comprising of 20 microns of SMP paint on top surface and 10 microns of backer coat (polyester coat) on back surface over 5 microns thick primer each on both surfaces with inorganic pigments coated free from heavy metals. Painting shall conform to BS/equivalent International Standards . In case SMP paint is not available, Super Durable Polyester paint (SDP) can also be used by the bidder without cost implication to POWERGRID.

16.3.5 **Wall Panels**

Wall panel material specifications shall be same as roof panels.

16.3.6 SHEETING FASTENERS:

Standard fasteners shall be self tapping zinc plated metal screws with EPDM bonded zinc plated washers. All screws shall be colour coated to match roof and wall sheeting.

16.3.7 SEALER:

This is to be applied at all side laps and end laps of roof panels and around self flashing windows. Sealer shall be pressure sensitive elastomeric Butyl tapes. The sealer shall be non-asphaltic, non-shrinking and non toxic and shall be superior adhesive metals, plastics and painted at temperatures from 51°C to +104°C.

16.3.8 CLOSURES:

Solid or closed cell closures matching the profiles of the panel shall be installed along the eaves, rake and other locations specified on drawings.

16.3.9 FLASHING AND TRIM:

Flashing and / or trim shall be furnished at the rake, corners, eaves, and framed openings and wherever necessary to provide weather tightness and finished appearance. Colour shall be matching with the colour of wall. Material shall be 26 gauge thick conforming to the physical specifications of sheeting.

16.3.10 **WALL LIGHTS:**

For day lighting purpose of GIS hall, minimum 2 mm thick approved translucent polycarbonate sheet shall be provided for wall lighting in addition to windows for at least 10% of wall area on upper portion of both long walls. The polycarbonate sheet shall be fixed with necessary EPDM, rubber gasket, Silicon Sealant, cold forged fastener, aluminum profile etc. including MS supporting structural steel (conforming to relevant BS/equivalent International Standards) frame to ensure water tight arrangement.

16.3.11 **GUTTERS AND DOWN SPOUTS:**

Gutters and downspouts shall be adequately designed to ensure proper roof drainage system. Material shall be same as that of sheeting with matching colour.

16.3.12 PAINTING OF BUILT UP STEEL FRAMES, CRANE GANTRY GIRDERS, FRAMES AT DOOR OPENINGS, WALK WAY STEEL AND LADDER:

The built up frame ,Crane gantry girders, frames for door openings and steel for walk way shall be applied with a priming coat of standard steel primmer followed by one coat coating of epoxy paint and final coating of PU (Minimum 100 Micron) . The steel work for aforesaid members shall be provided with suitable treatment of shot blasting before application of steel primer. The steel material of ladder shall be galvanized.

16.3.13 COLOUR SCHEME:

Colour Scheme matching with local aesthetic and best industry practices shall be submitted by vendors for approval of POWERGRID. Three alternatives of coloured isometric views with colour codes shall be submitted for approval. The monotony of external colour of sheet shall be avoided by providing vertical bands of different coloured sheet. The colour of roof sheet shall be light coloured to minimize heat absorption. External and internal masonry walls shall be painted with suitable colour matching with colour of steel sheet.

16.4 **CONNECTIONS:**

16.4.1 **SITE CONNECTIONS**

a) All primary bolted connections shall be provided with galvanized high strength bolts, washers, nuts conforming to specifications of relevant standard.

b) All secondary bolted connections shall be furnished with bolts, nuts, washers conforming to the specifications of grade 4.6 of relevant standard or ASTM-A307.

16.4.2 **SHOP CONNECTIONS**

All shop connections shall be welded with appropriate arc welding process and welding shall be in accordance with relevant standard, AWSD 1.1. as appropriate. The Webs should be welded on to the flanges at both the faces at top and bottom for columns, beams and crane girders. Weld material should have strength more than the parent metal.

16.4.3 **ROOF & WALL BRACINGS**

Roof and wall bracings shall have minimum yield strength of 250 Mpa and shall conform to the specifications of relevant standard.

16.5 INTERNAL FINISH SCHEDULE

The finishing schedule is given in subsequent clauses and table-1. Areas not specified in finish schedule shall be provided with vitrified tile flooring, and Premium Acrylic emulsion paint oil bound washable distemper over two mm thick putty. Paints used in the work shall be of best quality specified in relevant standard.

16.5.1 FLOORING

Flooring in various rooms of control room building and GIS hall shall be as per detailed schedule given in Table -1.

16.5.2 WALLS

All walls of control room building shall be non-load bearing walls. Min. thickness of walls shall be 230 mm (one brick) with 1:6 cement sand mortar. Partition walls (115mm thick) in toilets and pantry can be half brick walls with 1:4 cement sand mortar and two nos. 6mm dia MS bars at every third course.

In GIS building and the attached relay room 230mm thick brick wall shall be provided up to roof level of relay room attached to GIS hall. 50mm thick puff sandwiched panels as described above shall be provided above brick wall.

16.5.3 ROOF

(A) GIS Building and Control Room (if steel structure)

Roofing Panel: 50mm thick puff (density 40kg/cu.m.) sandwiched panels shall be provided as described in previous clauses.

16.6 CABLE TRENCH IN GIS HALL

All cable trenches in GIS hall shall be covered with minimum 6mm thick steel chequered plate with suitable stiffeners. Chequered plate shall be painted with two or more coats of Epoxy paint as per relevant standards.

16.7 EXTERNAL PLASTER AND PAINTING

External plaster 18mm thick shall be of 1:6 cement sand plaster in two layers. External surface of the control room building and GIS building (brick wall portion) shall be painted with Premium acrylic smooth exterior paint with silicon additives over and including priming coat of exterior primer as per relevant standards.

16.8 INTERNAL FINISH SCHEDULE

Internal finish Schedule for control room building and GIS hall is given in

Table - 1 below:

Table -1

S.No.	LOCATION	FLOORING & SKIRTING 150MM HIGH	WALL (INTERNAL)	CEILING	DOOR, WINDOWS & VENTILATOR
1.	Control Room	Vitrified tiles size 600 x 600mm	Premium Acrylic emulsion paint on smooth surface applied with plaster of paris (2 mm thick)	False ceiling and White wash above False Ceiling	Windows shall be of 10mm thick toughened glass by using suitable patch fittings/spider fittings. The glass shall extend horizontally from column to column and vertically from sill level of 0.75 m to bottom of lintel/roof beam. All doors shall be glazed powder coated aluminium doors with 5.5.mm Thk. Glazing.
2.	Conference	Vitrified tiles size 600 x 600mm	Premium Acrylic emulsion paint on smooth surface applied with plaster of paris (2 mm thick)	False ceiling and White wash above False Ceiling	Windows shall be of powder coated aluminium with 5.5mm thick glazing. All doors shall be glazed powder coated aluminium doors with 5.5.mm thk. Glazing.
3.	In-charge Room	Vitrified tiles size 600 x 600mm	Premium Acrylic emulsion paint on smooth surface applied with plaster of paris (2 mm thick)	False ceiling and White wash above False Ceiling	Windows shall be of powder coated aluminium with 5.5mm thick glazing. All doors shall be glazed powder coated aluminium doors with 5.5.mm thk. Glazing.
4	Other Office Rooms	Vitrified tiles size 600 x 600mm	Premium Acrylic emulsion paint on smooth surface applied with plaster of paris (2 mm thick)	False ceiling and White wash above False Ceiling	Windows shall be of powder coated aluminium with 5.5mm thick glazing. All doors shall be glazed powder coated aluminium doors with 5.5.mm thk. Glazing.
5.	Electronics Test Lab.	Vitrified tiles size 600 x 600mm	Premium Acrylic emulsion paint on smooth surface applied with plaster of paris (2 mm thick)	False ceiling and White wash above False Ceiling	Windows shall be of powder coated aluminium with 5.5mm thick glazing. All doors shall be glazed powder coated aluminium doors with 5.5.mm thk. Glazing.
6.	ACDB & DCDB Room	62mm thick cement concrete flooring with metallic hardener topping	Oil bound washable distemper on smooth surface applied with	Oil bound washable distemper on smooth surface applied with	Steel door 45mm thick double sheet 18 gauge MS steel suitably reinforced and filled with mineral wool.

S.No.	LOCATION	FLOORING & SKIRTING 150MM HIGH	WALL (INTERNAL)	CEILING	DOOR, WINDOWS & VENTILATOR
			plaster of paris putty as per relevant standards	plaster of paris putty	Windows/ventilator shall be of powder coated aluminium with 4mm glazing.
7.	Battery room	Vitrified tiles size 600 x 600mm	Premium Acrylic emulsion paint on smooth surface applied with plaster of paris (2 mm thick)	False ceiling and White wash above False Ceiling	Steel door 45mm thick double sheet 18 gauge MS steel suitably reinforced and filled with mineral wool. Windows/ventilator shall be of powder coated aluminium with 4mm glazing.
8.	Lobby	18mm thick granite flooring	Premium Acrylic emulsion paint on smooth surface applied with plaster of paris (2 mm thick)	False ceiling and White wash above False Ceiling	Windows shall be of powder coated aluminium with 5.5mm thick glazing. All doors shall be glazed powder coated aluminium doors with 5.5.mm thk. Glazing.
9.	Corridor	Vitrified tiles size 600 x 600mm	Premium Acrylic emulsion paint on smooth surface applied with plaster of paris (2 mm thick)	False ceiling and White wash above False Ceiling	Windows shall be of powder coated aluminium with 5.5mm thick glazing. All doors shall be glazed powder coated aluminium doors with 5.5.mm thk. Glazing.
10.	Portico	18mm thick granite flooring	Granite cladding	Acrylic emulsion paint over a coat of cement primer on smooth surface applied with readymade putty 1 mm thick as per relevant standards	All doors shall be glazed powder coated aluminium doors with 5.5.mm thk. Glazing.
11.	Toilet	Ceramic tiles	DADO glazed tile 2100mm high, oil bound washable distemper above DADO	Acrylic emulsion paint over a coat of cement primer on smooth surface applied with readymade putty 1 mm thick as per relevant standards	Windows/ ventilator shall be of powder coated aluminium with 5.5mm thick glazing. All doors shall be flush door shutters made of pre-laminated particle board (with powder coated aluminium frame.
12.	Janitor room	Ceramic tiles	DADO glazed tile 2100mm	Acrylic emulsion paint over a coat	Windows/ ventilator shall be of powder coated

S.No.	LOCATION	FLOORING & SKIRTING 150MM HIGH	WALL (INTERNAL)	CEILING	DOOR, WINDOWS & VENTILATOR
			high, oil bound washable distemper above DADO	of cement primer on smooth surface applied with readymade putty 1 mm thick as per relevant standards	aluminium with 5.5mm thick glazing. All doors shall be flush door shutters made of pre-laminated particle board with powder coated aluminium frame.
13.	GIS Hall	62mm thick cement concrete flooring with metallic hardener topping (DSR item code 11.5). Two coats of PU coating over the metallic hardener shall be provided. The final coat of PU shall be applied after Installation of equipments. Total thickness of PU coats shall be minimum 300 microns.	Premium Acrylic emulsion paint having Volatile Organic Compound (VOC) content less than 50 gms per liter of approved brand and manufacturer on smooth surface applied with plaster of paris (2 mm thick) over approved primer coat .	In case of RCC roof, ceiling shall be finished with Premium Acrylic emulsion paint having Volatile Organic Compound (VOC) content less than 50 gms per liter of approved brand and manufacturer over approved primer coat	Windows/ ventilator shall be of powder coated aluminium with 5.5mm thick glazing. All doors shall be flush door shutters with powder coated aluminium frame.
14.	Panel/Relay Room	Vitrified tiles 8mm thick size 600 x 600mm	Premium Acrylic emulsion paint on smooth surface applied with plaster of paris (2 mm thick)	False ceiling and White wash above False Ceiling	Windows shall be of powder coated aluminium with 5.5mm thick glazing. All doors shall be glazed powder coated aluminium doors with 5.5.mm thk. Glazing.
15.	AHU Room	62mm thick cement concrete flooring with metallic hardener topping	Premium Acrylic emulsion paint on smooth surface applied with plaster of paris (2 mm thick)	Acrylic emulsion paint over a coat of cement primer on smooth surface applied with readymade putty 1 mm thick as per relevant standards	Windows/ ventilator shall be of powder coated aluminium with 5.5mm thick glazing. All doors shall be flush door shutters with powder coated aluminium frame.

16.9 Staircase shall be provided with stainless steel railing and 18mm thick granite slab in risers and treads.

16.10 DOORS AND WINDOWS

The details of doors and windows of the control room building shall be as per finish schedule Table-1 conforming to relevant BS/equivalent

International Standards. Rolling steel shutters shall be provided as per layout and requirement of buildings. Main entrance door to control room building shall be made of powder coated aluminium frame with 5.5 mm thick glazing.

16.11 PARTITION

Partitions, if required, shall be made of powder coated aluminium frame provided with 5.5 mm thick clear glass or pre- laminated board depending upon the location of partition.

16.12 FALSE CEILING

Fifteen millimeter thick densified tegular edged eco friendly light weight calcium silicate false ceiling as per relevant standards shall be provided in the areas specified in Finish Schedule.

16.13 PLUMBING & SANITATION

(i) All plumbing and sanitation shall be executed to comply with the requirements of the appropriate bye-laws, rules and regulations of the Local Authority having jurisdiction over such matters. The Contractor shall arrange for all necessary formalities to be met in regard to inspection, testing, obtaining approval and giving notices etc.

(ii) PVC “SYNTEX” or equivalent make Roof water tank of adequate capacity depending on the number of users for 24 hours storage shall be provided. Minimum 2 Nos 1500 liter capacity shall be provided.

(iii) Galvanized MS pipe of medium class conforming to relevant standards shall be used for internal & external piping work for potable water supply.

(iv) Sand CI pipes with lead joints conforming to relevant standards shall be used for sanitary works above ground level and RCC pipe shall be used for works below ground.

(v) Each toilet shall have the following minimum fittings.

(a) WC (Western type) 390 mm high with toilet paper roll holder and all fittings in toilets attached to conference and sub-station in charge office.

and

WC (Indian Type) Orissa Pattern (580 x 440 mm) with all fittings shall be provided in common toilets.

(b) Urinal (430 x 260 x 350 mm size) with all fittings.

(c) Wash basin (550 x 400 mm) with all fittings.

(d) Bathroom mirror (600 x 450 x 6 mm thick) hard board backing

(e) CP brass towel rail (600 x 20 mm) with C.P. brass brackets

(f) CP Soap holder and CP liquid soap dispenser.

(g) All urinals and washbasins shall be provided with built in sensors.

(vi) Water cooler for drinking water with adequate water storage facility shall be provided and located near control room and not near toilet block.

(viii) 1 no. stainless steel kitchen sink with Drain board (510 x 1040 x 178 mm bowl depth) for pantry shall be provided.

(ix) All fittings, fastener, grating shall be chromium plated.

(x) All sanitary fixtures and fittings shall be of approved quality and type manufactured by well known manufacturers. All items brought to site must bear identification marks of the type of the Manufacturer.

(xi) Stoneware pipes may be used for soil, waste and drain pipes in the areas not subjected to heavy loads otherwise Heavy duty cast iron pipes may be used.

(xii) Contractor shall provide septic tank and soak pit of adequate capacity to treat the sewage / sullage from the building.

(xiii) Contractor shall implement all other jobs required to complete and commission the building.

17.00 Residential and Non Residential Buildings

All buildings shall be constructed as RCC Framed buildings. The architectural features shall match with local architecture. For preparation of architectural drawings of these buildings, the contractor shall depute local Architect of repute who must be well aware of local bye laws and statutory clearances required for residential and guest house/field hostel/Transit camp building from Nepal Authority. The buildings shall be designed for loads as applicable in accordance to relevant standards. The plumbing and sanitary works including over head water tanks placed on terrace and for each building shall also be deemed to be included in the civil works of building. Construction of man holes/chambers, connection of internal plumbing and sanitary system with external sewerage and water supply system shall be considered as a part of civil works of buildings. These works will not be measured and paid separately.

The details and approximate size of various buildings are as below:

(a) Transit Camp: One number of size 15 m X 14 m (Double Storeyed with each floor of 15 m X 14 m).

(b) D-Type Quarter: One Number with size 15 m x 14 m-Single Storeyed.

(c) C-Type Quarters: Four Numbers: One Block of four quarters having two quarters on ground floor and two quartyers on first floor. Block will have an area of about 12 m X 25 m on each floor.

(d) B-Type Quarters: Four Numbers : One Block of four quarters having two quarters on ground floor and two quartyers on first floor. Block will have an area of about 10 m X 25 m on each floor.

The area for above buildings has been indicated as tentative. The Contractor shall adopt the suitable size to accommodate various rooms and services for each type of building. The size of various rooms shall be in accordance to local laws.

The finish schedule has been tabulated as below:

Schedule of Finishes		**for Quarters**			
Floor	**Room Name**	**Flooring**	**Walls**	**Ceiling**	**Remarks**
Typical Flat	Living	Polished Vitrified Tiles	Plastered & Painted OBD Over 2mm POP Finish	Plastered & Painted with Wash Over 2MM POP	
	Living Balcony	Antiskid Vitrified Tiles	Plastered & Painted with Exterior Paint	DO	For Qrts. As applicable
	Kitchen	Antiskid Ceramic Glazed 1st Quality Floor Tiles-0.3x0.3M IS 15622	Plastered & Painted OBD Over 2mm POP Finish	DO	Ceramic Tiles UP to 0.6M Above Kitchen Platform
	Toilet	Do	Ceramic Tiles 0.2x0.3M up to 2.1M	DO	Above 2.1M Plaster & Painted OBD over 2MM POP Finish
	Bed Room	Vitrified Tiles	Plastered & Painted OBD Over 2mm POP Finish	DO	
	Bed Room Balcony	Antiskid Vitrified Tiles	Plastered & Painted with Exterior Paint	DO	
	Attached Toilet/ Bed Room Toilet	Antiskid Ceramic Glazed 1st Quality Floor Tiles-0.3x0.3M IS 15622	Ceramic Tiles 0.2x0.3M up to 2.1M	DO	Above 2.1M Plaster & Painted OBD over 2MM POP Finish
	Passage	Vitrified Tiles With Light Shade	Plastered & Painted OBD Over 2mm POP Finish	DO	
	Cupboard	1:2:4 Concrete with neat cement finish	Plastered & Painted OBD	DO	

	Staircase	Marble Stone Treads & Landings	Plastered & Painted OBD Over 2mm POP Finish	DO	Enamel Paint for M.S. Railing
	Car Parking	80mm Flexi Paver Blocks	Plastered & Painted with Exterior Paint	Plastered & Painted OBD over 2mm POP Finish	For D Type Qtrs. Only
Schedule of Finishes for Transit Camp					
Floor	Room Name	Flooring	Walls	Ceiling	Remarks
	Porch	60mm thk. Flexi Paver Blocks	Plastered & Painted with Exterior Paint	Plastered & Painted with OBD Over 2mm POP Finish	
	Drawing & Dining	Polished Vitrified Tiles 0.6x0.6M	Plastered & Painted Plastic Emulsion Paint over 2mm POP Finish	Minera Fbre False Ceiling POP Cornice & Moulding Painted with Plastic Emulsion Paint	Vitrified Tiles Skirting of 150mm high to be Provided
	Lobby	DO	DO	Plastered & Painted OBD Over 2mm POP Finish	DO
	Kitchen	DO	DO	DO	Ceramic Tiles from Floor Level to 0.6M Above Kitchen Platform
	VIP Room & Lounge	DO	DO	DO	POP Cornice & Moulding shall be Provided for Ceiling
	Attached Toilet of VIP Room	Vitrified Tiles (Antiskid) 0.6x0.6M	Ceramic Tiles 0.3x0.45M (Minimum size)up to Ceiling	DO	
	Dormitory	22mm Thk.Terrazzo Tiles Light shade	Plastered & Painted OBD Over 2mm POP Finish	DO	
	Dormitory Toilet/Bath	Antiskid Ceramic Glazed 1st Quality Floor Tiles-0.3x0.3M	Ceramic Tiles 0.2x0.3M up to 2.1M	DO	Area Above 2.1M Plaster & Painted OBD over 2MM POP Finish

	Staircase	18mm Thk. Udaipur Green Marble Stone	Plastered & Painted OBD Over 2mm POP Finish	DO	SS Hand Railing as per Drawing
	Bed Rooms	Polished Vitrified Tiles 0.6mx0.6m	Plastered & Painted with Plastic Emulsion Paint Over 2mm POP Finish	DO	
	Attached Toilets	Antiskid Ceramic Glazed 1st Quality Floor Tiles-0.3x0.3M	Ceramic Tiles 0.2x0.3M up to 2.1M	DO	Area Above 2.1M Plaster & Painted OBD over 2MM Thk. POP Finish
	Care Taker Room	Vitrified Tiles With Light Shade	Plastered & Painted OBD Over 2mm POP Finish	DO	
	Common Toilet	Antiskid Ceramic Glazed 1st Quality Floor Tiles-0.3x0.3M	Ceramic Tiles 0.2x0.3M up to 2.1M	DO	Area Above 2.1M Plaster & Painted OBD over 2MM Thk. POP Finish
	Store	Vitrified Tiles With Light Shade	Plastered & Painted OBD	DO	
	Balconies	Antiskid Vitrified Tiles Light Shade	Plastered & Painted with Exterior Paint	DO	
	Terrace	Brick Bat Coba Water Proofing	Plastered & Painted with Exterior Paint		

18.0 Boundary wall, Main Gate, Security Room and septic tank and soak pit

18.1 Boundary Wall :

RCC framed with brick masonary/concrete block/stone masonay in fill between columns shall be provided along periphery of substation. The brief description of boundary wall is given below:

(a) Height of boundary wall (Masonay portion) above ground = 2.5 m

(b) 0.5 m Heigh of Y shaped angle supports (50x50x6 mm) above each column with about 0.5 m deep grouted in column shall be provided as grill on the boundary wall

(c) C/c distance of RCC Column (230 X 230 mm size) = 2.5 m

(d) 8 rows of galvanised barbed wire with concertina coil a top of boundary wall shall be provided. 4 rows of barbed wire on each arm of Y-shaped angle is to be provided.

(e) Grade of Concrete for RCC works = M25

(f) Mix of masonary works = 1 Cement: 6 Sand

(g) 12 mm thick Cement sand plaster (1 cement: 6 Sand) over exposed portion of boundary wall along with 50mm thk CC(1:2:4) coping on the top of wall.

(h) Two coats of oil bound distemper with one coat of cement primer of approved make shall be applied over exposed portion of boundary wall.

(i) A RCC plinth beam (230 X 300 mm deep) shall be provided at ground level. A lintel beam of 230 X 230 mm shall be provided over gratings.

(j) Suitable steel grating made of 20 mm square bars shall be provided at suitable locations preferably @ 100 m to allow the flow of surface water.

(k) Suitable foundation of about 1.5 depth shall be provided for each RCC column. 75 mm thick PCC (1:4:8) layer shall be provided below all RCC works.

(l) All steel works shall be provided with two coats of synthetic enamel paint over a coat of steel primer of approved make.

(m) Twin columns with 25 mm expansion gap at every 45 meter length shall be provided.

(n) Suitable design of boundary wall shall be developed by the contractor.

The boundary wall shall be measured and paid on running meter length basis.

18.2 Main Gate

A steel gate of 2.1 m high and 6 m wide along with 1.5 m wide man gate shall be provided at entry location of substation. The gate shall be supported on steel columns. The steel support columns shall be encased with suitable RCC foundations. Suitable wheel mounting arrangement shall be provided at the bottom of gate for smooth opening of gate. All steel works shall be provided with two coats of synthetic enamel paint over a coat of steel primer of approved make.

The item shall be measured and paid on Lump sum basis.

18.3 Security Room:

A RCC framed room of size 3 m X 3m and 3 m high with 1.5 m wide veranda shall be provided near gate .An attached toilet of 1.5 m x 1.5 m size shall be provided. Suitable septic tank and soak pit for 10 users with cleaning interval of 3 years shall also be provided. A RCC platform (600 mm wide) at window sill level along with wardrobe shall be provided. All sanitary works and a PVC water tank of 1000 litre capacity shall also be provided. All finish details shall match with other buildings mentioned elsewhere in the technical specification.

The item shall be measured and paid on square meter area basis.

19.0 MODE OF MEASUREMENT

19.1 Geotechnical investigation

This shall include carrying out field tests, laboratory tests, compilation of results and preparation of soil report with recommendations for type of foundations shallow or pile type, suitability of soil for construction of substation etc. The geotechnical investigation work shall be measured on lump sum basis.

19.2 **Contour survey and site leveling.**

The Contour survey work shall not be measured and paid separately and shall be deemed to be included in the item of site leveling work.
Measurement of Earth work in all kind of soil including soft/disintegrated rock in the item of cutting and filling and item of earth work in the filling with borrowed earth shall be made in Cubic meters. No void deduction for 95% compaction.

19.3 **Earthwork**

This shall include excavation in all kinds of soil including rock, all leads and lifts including back filling with suitable earth, compacting, dewatering (if required) and disposal of surplus earth or rock to a suitable location within a lead up to 2 km. The surplus earth if disposed within substation boundary shall be spread in uniform layers each compacted with two passes of suitable compacting equipment. The quantity of excavation for foundations of towers, equipment support structures, all transformers/Reactors, DG Set, firewall, cable trenches, fire fighting water tank, buildings and underground water tanks, covered car parking, External lighting poles, control cubicles, marshalling box shall only be measured. The quantity of excavation for roads, rail cum road, drains, culverts, rainwater harvesting, septic tank, soak pit, external water supply system, site surfacing, chain link fencing (including gate) shall not be measured separately and shall be deemed to be included in the composite rates quoted by the bidder for the respective works. All other excavation required for the completion of the work including plinth protection, flooring, sewerage system, manholes, pipes, earth mat etc. shall also not be paid for. The measurement of excavation of all concrete works shall be made considering dimension of the pit leaving 150mm gap around the base pad (lean concrete) or actually excavated pit, whichever is less. The quantity shall be measured in cubic metres.

19.4 **PCC**

Providing and laying Plain Cement Concrete of all types and at all locations including all leads and lifts. The quantity shall be measured in cubic meters as per lines and levels indicated in the drawings.

19.4.1 PCC 1:2:4 (1 cement : 2 sand : 4 coarse aggregate 20 mm nominal size) shall be measured in flooring of buildings, plinth protection, fencing, transformer/reactor foundation, rail track, drain, culverts, septic tank, chain link fencing, fencing gate ,external lighting poles etc. as indicated in the approved drawings.

19.4.2 PCC 1:4:8 (1 cement : 4 coarse sand : 8 stone aggregate, 40mm nominal size) shall be measured below all foundations of towers, equipment support structures, buildings, fire fighting water tanks, covered car parking, cable trench, roads, under flooring, rail-cum-road, transformer foundation, reactor foundation, drain, cable trench crossings, culverts, fence, gate etc. as indicated in the approved drawings.

19.4.3 PCC 1:5:10 (1 Cement: 5 sand: 10 Stone aggregate, 40mm nominal size) shall be provided for site surfacing in switchyard, roof water proofing etc.

All other PCC required for the completion of the work including hold fasts of doors/windows/rolling shutters, fixing of plumbing pipes, bedding concrete for sewer lines, embedment of electrical conduits etc. shall not be measured and deemed included in the composite rates quoted by the bidder for respective works. Water proofing compound wherever specified shall be added without any extra cost.

19.5 RCC

Measurement of reinforced cement concrete at all locations shall be made and shall include all leads, lifts, formwork, grouting of pockets and underpinning, (but shall exclude reinforcement & miscellaneous structural steel like inserts etc.), of M25 design mix (Minimum). This shall also include pre-cast RCC work and addition of water proofing compound wherever required for which no additional payment shall be made. The quantity shall be measured in cubic meters as per lines and levels indicated in the drawings. No deduction shall be made for volume occupied by reinforcement/inserts/sleeves and for openings having cross-sectional area up to 0.1 Sq.M.

19.6 Steel Reinforcement

Reinforcement steel shall be measured in length (actual or theoretical as per drawing whichever is less) including hooks, if any, separately for different diameters as actually used in RCC work, excluding overlaps. From the length so measured, the weight of reinforcement shall be calculated in metric tonnes on the basis of sectional weights as adopted by British Standards/equivalent International standards. Wastage, overlaps, couplings, welded joints, spacer bars, chairs, stays, hangers and annealed steel wire or other methods for binding and placing shall not be measured and cost of these items shall be deemed to be included in the rates for reinforcement.

19.7 Stone filling over grating in Transformer/Reactor foundation

Measurement of stone (40mm nominal size) filling over gratings of transformer/reactor foundations shall be made as per theoretical volume of the space to be filled in the transformer foundation as per approved drawings. This shall be measured in Cu.M.

19.8 **Miscellaneous structural steel**

Measurement for Supply, fabrication, transportation and erection of all miscellaneous structural steel work for rails alongwith rail fixing details and gratings with supports for transformers/reactors, Cable trenches with covers (Chequered plate covers, cable supports, earthing cleats and edge protection angles etc), all other steel fittings and fixtures, inserts and embedment in concrete of transformer/reactor foundation and cable trenches shall be made as per approved drawings. The unit rate for this item shall be inclusive of cutting, grinding, drilling, bolting, welding, pre- heating of the welded joints, applying a priming coat of steel primer and anti-corrosive bitumastic paint/ synthetic enamel paint in general but with Zinc Phosphate Primer (Two packs) for grating and support for grating in Transformer foundation. (Wherever specified), setting of all types of embedment in concrete, etc. Steel required for foundation bolts, nuts and bolt, doors, windows, ventilators, louvers, rolling shutters, chain link fencing, gratings in drains, soil pipes, plumbing pipes, floor traps, embedment's required for rainwater harvesting, septic tank, soak pit, roof truss and purlins required for fire water tank, etc. shall not be considered for payment and measurements. Quantity shall be measured in metric tonnes.

19.9 **Roads**

A). The measurement for the concrete road shall be made on the basis of area in square meter (M2) of top concrete completed surface of the road and shall be deemed to include all items such as excavation, compaction, rolling, watering, WBM, shoulder, etc complete as per approved drawing but excluding concreting and reinforcement which shall be paid separately under respective items of BPS.

B) The measurement of bituminous road shall be made on the basis of area in square meter (M2), of the top bituminous completed surface of the road and shall include all items such as excavation, compaction, rolling, watering, sub base course, WBM, shoulder, premix carpet etc complete as per approved drawing.

C) The measurement of strengthening of existing road (bituminous road) shall be made on the basis of area in square meter (M2), of the top bituminous completed surface of the road including premix carpet etc but excluding item of granular sub base course which shall be paid separately under respective item of BPS.

19.10 Anti-weed Treatment and Stone Spreading

The measurement shall be done for the actual area in square metres of stone spreading provided in the switchyard .It includes providing and spreading of 100mm thickness of uncrushed/crushed/broken stone of 40mm nominal size as per relevant BS codes/equivalent International standards for the specified area. Application of anti weed treatment including material shall not be measured separately and item would be deemed to be included in the quoted rate of stone spreading in switchyard.

19.11 Chain Link Fencing and gate

The measurement shall be made in running metres of the fence provided as per approved drawing. The rate shall be including the post, fencing, MS Flat, painting, brick work and plaster of toe wall etc. complete but excluding the concrete. The switch yard gate shall be measured in numbers.

19.12 Cable Trenches and Cable trench Crossings

Earthwork, PCC, RCC, reinforcement steel, RCC hume pipes and miscellaneous steel required for construction of Cable Trenches and cable trench crossings shall be measured under respective items of Bid price schedule (BPS) as described in clauses of aforesaid paras. No additional payment for brick work, plaster and PVC pipes used for cable trench crossings and sealing of trench mouth shall be admissible.

19.13 Drains & Culverts

PCC (1:2:4 and 1:4:8) for drains and culverts shall be measured under respective items of Bid price schedule (BPS) as described in clauses of aforesaid paras . All other items like excavation, brick work, plaster and stone pitching except RCC hume pipes required for completion of drains and culverts shall be deemed to be included in the quoted rate of drain. The quantity for each type of drain section shall be measured in running meters. However, RCC hume pipes used in culverts shall be measured under under respective item of Bid price schedule (BPS) as described in clause of hume pipes.

19.14 External Finishing of RCC Framed Buildings/structures:

The item shall be measured per square meter area basis. Contractor has to assess the quantity as per requirement of Control room cum administrative building, Fire Fighting Pump House, fire fighting water tank, switchyard panel room, residential and non residential buildings, covered car parking and quote for the same separately. This shall include following items.

1) External plastering/cement wash : 18mm Cement plaster in two coats under layer 12 mm thick cement plaster 1:5 (1 cement: 5 coarse Sand) finished with a top layer of 6 mm thick cement plaster 1:6 (1 cement: 6 fine Sand) for all buildings and fire fighting water tank .
2) Providing and applying two or more coats of Acrylic smooth exterior paint over an under coat of suitable primer on new cement plaster surfaces of the control room building, auxiliary building, fire fighting pump house building, fire fighting water tank, panel room , residential and non residential buildings and covered car parking. It shall be inclusive of required tools, scaffolding, materials and other painting accessories etc. as per recommendations of manufacturer.

19.15 Hume Pipe

Hume pipe shall be measured diameter-wise and laid as per approved drawings and shall be measured in running meters. The item shall be inclusive of excavation, laying, back filling, jointing etc. but excluding concrete and reinforcement (if any).

19.16 Building

The measurement of all items except excavation, concrete, reinforcement steel of each type of buildings shall be made on area in Square Meter basis. However, the quantity of excavation, concrete, reinforcement shall be measured in respective items of BPS and described in above paras. The structural steel used for cable tray support, earthing cleat, chequered plates for internal cable trenches of building and panel room wherever applicable shall be measured and paid under miscellaneous steel item of BPS and described above paras. The structural steel and foundation bolts for fixing equipments with foundations/raft within buildings shall not be measured separately which shall be deemed to be included in the quoted rates per square meter of buildings. External Finishing shall be measured and paid in respective items of BPS and described in above paras. The rest of the entire work required to complete the building in all respect as per drawings prepared by contractor and approved by NEA/Consultant shall be deemed to be included in this item rate per square meter area basis.

19.17 **Rain Water Harvesting**

This is a lump sum item. The contractor shall be required to complete the work in all respect as per drawings prepared by contractor and approved by NEA/Consultant. All the items including excavation, miscellaneous steel, brick work, fillings of boulders, gravel, sand, pipes etc. shall be deemed to be included in this lump sum rate. However, the concrete (all types) and the reinforcement shall be measured and paid under respective item of BPS and described in above paras.

19.18 Rail cum Road

The measurement for the rail cum road shall be made in square metres of top concrete completed surface of the rail cum road and shall include all items such as excavation, compaction, rolling, watering, WBM etc. complete as per approved drawing but excluding concrete, reinforcement, structural steel and rails with rail fixing details which shall be measured separately under respective item of BPS and described in above paras.

19.19 Septic Tank and Soak Pit

This is a lump sum item. The contractor shall be required to complete the work in all respect as per drawings furnished by the contractor and approved by NEA/Consultant. All the items including excavation, masonry work, all types of fillings, all types of pipes including plumbing and vent pipes, all type of fittings etc. shall be deemed to be included in this lump sum rate. However, the concrete (all types) and the reinforcement shall be measured and paid under the respective item mentioned above.

19.20 Fire Water Tank

This is a lump sum item. The contractor shall be required to complete the work in all respect as per approved drawings. The items including brick work if any, and miscellaneous steel including steel embedment Rungs, roof truss, corrugated AC Sheet roofing, door, pipe sleeves, internal finish, etc. shall be deemed to be included in this lump sum cost. However, the items like excavation, concrete (all types), reinforcement steel, external finish shall be measured and paid under the respective item of BPS and described in above paras.

19.21 External water supply from Bore-well/ other source of water supply arrangement to Fire water tank, Control Room building ,Residential and non residential buildings

The external water supply from Bore-well shall be measured diameter-wise in running meters. It shall include all the items such as excavation, piping, pipe fittings, painting, brickwork, sand filling, concrete, valves, chambers cutting chases in walls, openings in RCC and repairs, etc. required to complete the job.

19.22 External Sewage System of Control Room Building and other Buildings of Township.

It shall be measured diameter wise in running meters. It shall include all the items such as excavation, piping, pipe fittings, manholes, gali trap, gali chamber casing in concrete and repairs etc required to complete the job. Any modification in the existing sewage system, if required, shall be done by the Contractor without any extra cost implicated to NEA/Consultant.

20.0 MISCELLANEOUS GENERAL REQUIREMENTS

20.1 Dense concrete with controlled water cement ratio as per BS-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.

20.2 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.

20.3 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.

20.4 All mild steel parts used in the water retaining structures shall be hot-double dip galvanised. The minimum coating of the zinc shall be 750 gm/sq. m. for galvanised structures and shall comply with relevant BS. Galvanizing shall be checked and tested in accordance with relevant BS. The galvanizing shall be followed by the application of an etching primer and dipping in black bitumen in accordance with BS: 3416.

20.5 A screed concrete layer not less than 100 mm thick and of grade not weaker than M10 conforming to relevant BS 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.

20.6 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 75 kg/cm2 compressive strength before submitting his offer. The contractor may use concrete blocks of equivalent compressive strength in place of brick work.

20.7 Doors and windows on external walls of the buildings (other than areas provided, with insulated metal claddings) shall be provided with RCC sun-shade over the openings with 300 mm projection on either side of the openings. Projection of sunshade from the wall shall be minimum 450 mm over window openings and 750 mm over door openings.

20.8 All stairs shall have maximum riser height of 150 mm and a minimum tread width of 300 mm. Minimum width of stairs shall be 1500 mm. Service ladder shall be provided for access to all roofs. RCC fire escape staircase if required as per local bye laws, shall be provided in control buildings.

20.9 Angles 50x50x6 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 precast cover and any other place where breakage of corners of concrete is expected.

20.10 Anti termite chemical treatment for buildings shall be given to all column pits, wall trenches, foundations, filling below the floors etc. as per relevant International/BS .

20.11 Hand-railing minimum 900mm high shall be provided around all floor/roof openings, projections/balconies, walk ways, platforms, steel stairs etc. All handrails and ladder pipes shall be 32 mm nominal bore MS pipes (medium class) and shall be galvanised (medium-class as per relevant BS). All rungs for ladder shall also be galvanised as per relevant BS.

For RCC stairs, hand railing with 20 mm square MS bars, balustrades with suitable MS flats & aluminium handrails shall be provided.

20.12 For all civil works covered under this specification, design Mix of Minimum M25 grade as per relevant International /BS shall be used. Reinforcement steel shall be of minimum Fe 500 grade.

The material specification, workmanship and acceptance criteria shall be as per relevant clauses of applicable International/BS standard.

20.13 Items/components of buildings not explicitly covered in the specification and BPS but required for completion of the project shall be deemed to be included in the scope.

20.14 Requirement of sulphate resistant cement (SRC) for sub structural works shall be decided in accordance with the International/BS Standards based on the findings of the detailed soil investigation to be carried out by the Bidder.

20.15 Foundation system adopted by Bidder shall ensure that relative settlement and other criteria shall be as per provision in relevant BS and other International Standards.

20.16 All water retaining structures designed as uncracked section shall also be tested for water tightness at full water level in accordance with relevant international/ BS standards.

20.17 Construction joints shall be as per International/BS standard..

20.18 All underground concrete structures like basements, pumps houses, water retaining structures etc. shall have plasticizer cum water proofing cement additive conforming to relevant BS. The concrete surface of these structures in contact with earth shall also be provided with two coat of bituminous painting for water/damp proofing.

In case of water leakage in the above structures, The Method shall be applied as per relevant international standard/BS standard for repairing the leakage.

20.19 All building/construction materials shall conform to the best quality specified in relevant International /BS standard.

21.0 INTERFACING

The proper coordination & execution of all interfacing civil works activities like fixing of conduits in roofs/walls/floors, fixing of foundation bolts, fixing of lighting fixtures, fixing of supports/embedment's, provision of cut outs etc. shall be the sole responsibility of the Contractor. He shall plan all such activities in advance and execute in such a manner that interfacing activities do not become bottlenecks and dismantling, breakage etc. is reduced to minimum.

22.0 STATUTORY RULES

22.1 Contractor shall comply with all the applicable statutory rules pertaining to factories act (as applicable for the State). Fire Safety Rules of Tariff Advisory-Committee and Water and sewerage Act for pollution control etc.

22.2 Provisions for fire proof doors, no. of staircases, fire escape stairs ,fire separation wall, plastering on structural members (in fire prone areas) etc. shall be made according to the recommendations of Local Advisory Committee.

22.3 Statutory clearance and norms of Local Pollution Control Board shall be followed as per Water Act for effluent quality from plant.

23.0 FIELD QUALITY PLAN

All tests as required in accordance to BS codes or equivalent International standards have to be carried out. The contractor shall prepare field quality plan for civil works as per relevant /BS codes/equivalent International Standards during detailed engineering stage and submit to NEA/Consultant for approval within ONE month after award of work.

24.0 BRITISH STANDARD CODES

Major British standard Codes for civil work have been given in the following list. This list is illustrative but not exhaustive. However, for design and engineering relevant BS codes or equivalent International standards shall be referred by the contractor. Relevant portion of BS codes or equivalent international standards referred by the contractor for the design shall be made available to NEA/Consultant if necessary during detailed engineering stage.

Sr. No.	Standard No.	Title	Year
1	BS 41	Structural steel sections. Specification for hot-rolled sections	2005
2	BS 13771	Methods of test for soils for civil engineering purposes . General requirements and sample preparation	1990
3	BS 4449	Steel for the reinforcement of concrete. Weldable rein forcing steel. Bar, coil and decoiled product. Specificati on (with A2:2009)	2005
4	BS 4482	Steel fabric for the reinforcement of concrete. Specific ation	2005
5	BS 4483	Steel fabric for the reinforcement of concrete. Specific ation	2005
6	BS EN 10210-2	Hot finished structural hollow sections of non-alloy and fine grain steels. Tolerances, dimensions and sectional properties	2006
7	BS EN 10056-1	Specification for structural steel equal and unequal angles. Dimensions	1999
8	BS EN ISO 80 0001	Quantities and units. General	2013
9	BS 5930	Code of practice for site investigations (with A2:2010)	1999
10	BS EN 19931-1	Eurocode 3. Design of steel structures. General rules a nd rules for buildings	2005
11	NA to BS EN 199311	UK National Annex to Eurocode 3. Design of steel struc tures. General rules and rules for buildings	2008
12	BS EN 19931-5	Eurocode 3. Design of steel structures. Plated structur al elements	2006

13	NA to BS EN 199315	UK National Annex to Eurocode 3. Design of steel structures. Plated structural elements	2008
14	BS EN 19931-8	Eurocode 3. Design of steel structures. Design of joints	2005
15	NA to BS EN 199318	UK National Annex to Eurocode 3. Design of steel structures. Design of joints	2008
16	BS 60732	Precast concrete masonry units. Guide for specifying precast concrete masonry units	2008
17	BS 7668	Weldable structural steels. Hot finished structural hollow sections in weather resistant steels. Specification	2004
18	BS EN 19971	Eurocode 7. Geotechnical design. General rules	2004
19	NA to BS EN 19971	UK National Annex to Eurocode 7. Geotechnical design. General rules	2007
20	BS EN 19923	Eurocode 2. Design of concrete structures. Liquid retaining and containing structures	2006
21	BS EN 19921-1	Eurocode 2. Design of concrete structures. General rules and rules for buildings	2004
22	NA to BS EN 199211	UK National Annex to Eurocode 2. Design of concrete structures. General rules and rules for buildings	2005
23	BS 75334	Pavements constructed with clay, natural stone or concrete pavers. Code of practice for the construction of pavements of precast concrete flags or natural stone slabs	2006
24	BS EN 1971	Cement. Composition, specifications and conformity criteria for common cements	2011
25	BS 743	Specification for materials for dampproof courses	1970
26	BS 8122	Testing aggregates. Methods for determination of density	1995
27	BS 952-1	Glass for glazing. Classification	1995
28	BS 952-2	Glass for glazing. Terminology for work on glass	1980
29	BS EN 12620	Aggregates for concrete	2013
30	BS 1125	Specification for WC flushing cisterns (including dual flush cisterns and flush pipes)	1987
31	BS 1188	Specification for ceramic wash basins and pedestals	1974
32	BS 1199 and 1200	Specifications for building sands from natural sources	1976
33	BS EN 13310	Kitchen sinks. Functional requirements and test methods	2003
34	BS 1245	Pedestrian doorsets and door frames made from steel sheet. Specification	2012
35	BS 1254	Specification for WC seats (plastics)	1981
36	BS 1370	Specification for low heat Portland cement	1979
37	BS EN 1008	Mixing water for concrete. Specification for sampling, testing and assessing the suitability of water, including water recovered from processes in the concrete industry, as mixing water for concrete	2002
38	BS 3505	Specification for unplasticized polyvinyl chloride (PVC-U) pressure pipes for cold potable water	1986

39	BS EN 15743	Supersulfated cement. Composition, specifications and conformity criteria	2010
40	BS EN ISO 37 66	Construction drawings. Simplified representation of co ncrete reinforcement	2003
41	BS 8666	Scheduling, dimensioning, bending and cutting of steel reinforcement for concrete. Specification	2005
42	BS 4514	Unplasticized PVC soil and ventilating pipes of 82.4 m m minimum mean outside diameter, and fittings and a ccessories of 82.4 mm and of other sizes. Specification	2001
43	BS 4551	Mortar. Methods of test for mortar and screed. Chemi cal analysis and physical testing (with A2:2013)	2005
44	BS EN 12200-1	Plastics rainwater piping systems for above ground ext ernal use. Unplasticized poly (vinyl chloride) (PVC-U). Specifications for pipes, fittings and the system	2000
45	BS EN 1462	Brackets for eaves gutters. Requirements and testing	2004
46	BS EN 607	Eaves gutters and fittings made of PVC-U. Definitions, requirements and testing	2004
47	BS 6262	Code of practice for glazing for buildings	1982
48	BS EN 14411	Ceramic tiles. Definitions, classification, characteristics , evalua tion of conformity and marking	2012
49	BS 6510	Steelframed windows and glazed doors. Specification	2010
50	BS EN 636	Plywood. Specifications	2012
51	NA to BS EN 19923	UK National Annex to Eurocode 2. Design of concrete s tructures. Liquid retaining and containment structures	2007
52	BS EN 1339	Concrete paving flags. Requirements and test methods	2003
53	BS EN 1340	Concrete kerb units. Requirements and test methods	2003

SECTION 12

TECHNICAL DATA SHEET

TECHNICAL DATA SHEET
(To Be Completed By the Tenderer)

ITEM No. 1: CONTROL AND RELAY PANEL FOR TRANSFORMER **Sheet 1 of 6**

	DESCRIPTION	UNIT		DATA to be Filled
1	**CONTROL AND RELAY PANEL TYPE**	**Duplex / Simplex**		
1.1	Manufacturer and Country of Origin			
1.2	Year of manufacturing experience	Years	5	
1.3	Manufacturing's Designation as per submitted catalogue			
2	**INDICATING INSTRUMENTS**			
5.1	**Ammeter**			
i.	Manufacturer and Country of Origin			
ii.	Type		Digital	
iv.	Accuracy class		0.5	
v.	**Scale**			
	-Type of scale			
	-Range of indication (………./1 Amp CT operated)	A	As required	
	-Overload range	%	1.5	
vi.	VA Burden			
vi.	Transducer operated	Yes/No	Yes	
2.2	**Apparent Power Meter (VA)**			
i.	Manufacturer and Country of Origin			
ii	Type		Digital	
iii	Rated voltage	kV	132/√3 : 0.11/√3	
iv	Rated current	A	………/1	
vi	Accuracy class		0.5	
vii	Scale		Centre zero	
	-Range of indication	MVA	As Required	
viii.	VA Burden Current Coil Voltage Coil			
x	Transducer operated	Yes/No	Yes	
2.3	**KWh Meter**			
i.	Manufacturer and Country of Origin			
ii.	Type		Digital, 3-phase, 4 wire	
iii.	Applicable standard	IEC	IEC	
iv.	Accuracy class		0.2	
v.	Import and Export meter provided	Yes/No	Yes	
vi.	Rated voltage	kV	132/√3 : 0.11/√3	
vii.	Rated current	A	……../1	
viii.	Operating current range	A		
ix.	Operating Voltage range	A		
x.	VA Burden Current Coil Voltage Coil	VA		

TECHNICAL DATA SHEET
(To Be Completed By the Tenderer)

ITEM No.1: CONTROL AND RELAY PANEL FOR TRANSFORMER **Sheet 2 of 6**

	DESCRIPTION	UNIT		DATA to be Filled
xi.	Impulse contact provided	Yes/No	Yes	
xii.	Programmable at Site		Yes	
xiii.	Software and optical probe provided as per Price schedule & BOQ		Yes	
2.4	**Watt meter, MW**			
i.	Manufacturer and Country of Origin			
ii.	Type		Digital	
iii.	Accuracy class		0.5	
iii	Rated voltage	kV	$132/\sqrt{3}$: $0.11/\sqrt{3}$	
iv	Rated current	A	………/1	
	-Range of indication	MW	0-50-100	
2.5	**Annunciators**			
I	Manufacturer and Country of Origin			
ii.	Type			
iii.	Manufacturer's type designation			
iv.	Catalogue furnished	Yes/No	Yes	
vi.	Number of active points	No.	24	
vii.	Number of rows	No.	4	
viii.	Number of column	No.	6	
ix.	Type of mounting		Flush	
x.	Replacement of individual inscription plates and lamps from front panel possible	Yes/No	Yes	
xi.	Sequence of operation as per specification	Yes/No	Yes	
3	**PROTECTIVE RELAYS**			
3.1	**PHASE OVERCURRENT RELAYS**			
i.	Manufacturer and Country of Origin			
ii.	Type		Numerical Non Directional	
iii.	Manufacturer's type designation			
iv.	Applicable standard	IEC	IEC	
v.	Triple pole or single pole		Triple Pole	
vi.	Current setting range	% of rated current	20-200%	
vii.	Operating time at 10 times current setting	sec	3	
viii.	Reset time	mS		
ix.	Characteristics		IDMT(standard inverse)	
x.	Instantaneous unit provided -Current setting range -Operating range -NO Contacts	Yes/No % of rated current	Yes 500-2000%	
xi.	Insulating test according to IEC	Yes/No		
xii.	Indication -Hand reset flags provided -Light emitting diode provided	 Yes/No Yes/No		
xiii.	Auxiliary DC Supply	V_{dc}	110	
xiv.	Technical literature submitted	Yes/No	Yes	

TECHNICAL DATA SHEET
(To Be Completed By the Tenderer)

ITEM No.1: CONTROL AND RELAY PANEL FOR TRANSFORMER **Sheet 3 of 6**

	DESCRIPTION	UNIT		DATA to be Filled
3.2	EARTH FAULT RELAYS			
i.	Manufacturer and Country of Origin			
ii.	Type		Numerical, Non-Directional	
iii.	Manufacturer's type designation			
iv.	Applicable standard	IEC	IEC	
v.	Triple pole or single pole		Triple	
vi.	Continuous overload capacity	x In		
vii.	Current setting range	% of rated current	10-80%	
viii.	Operating time at 10 times current setting	sec	3	
ix.	Characteristics		IDMT(standard inverse)	
x.	Instantaneous unit provided -Current setting range -Operating range -NO Contacts, Nos	Yes/No % of rated current mS	Yes 500-2000%	
xi.	Insulating test according to IEC	Yes/No		
xii.	Indication -Hand reset flags provided -Light emitting diode provided	 Yes/No Yes/No		
xiii.	Auxiliary DC Supply	V_{dc}	110	
xvi.	Technical literature submitted	Yes/No	Yes	
3.3	**Directional Overcurrent Relay**			
i.	Manufacturer and Country of Origin			
ii.	Type		Numerical Directional	
iii.	Manufacturer's type designation			
iv.	Applicable standard	IEC	IEC	
v.	Triple pole or single pole		Triple	
vi.	Current setting range	% of rated current	20-200%	
vii.	Operating time at 10 times current setting	sec	3	
viii.	Reset time	mS		
ix.	Characteristics Characteristic Angle		IDMT(standard inverse), 45°	
x.	Instantaneous unit provided -Current setting range -Operating range	Yes/No % of rated current, mS	Yes 500-2000%	
xi.	Insulating test according to IEC	Yes/No		
xii.	Indication -Hand reset flags provided -Light emitting diode provided	 Yes/No Yes/No		
xiii.	Auxiliary DC Supply	Vdc	110	
3.4	**Directional Earthfault Relay**			
i.	Manufacturer and Country of Origin			
ii.	Type		Numerical Directional	
iii.	Manufacturer's type designation			

TECHNICAL DATA SHEET
(To Be Completed By the Tenderer)

ITEM No.1: CONTROL AND RELAY PANEL FOR TRANSFORMER **Sheet 4 of 6**

	DESCRIPTION	UNIT		DATA to be Filled
iv.	Applicable standard	IEC	IEC	
v.	Triple pole or single pole		Triple	
vi.	Continuous overload capacity	xIn		
vii.	Current setting range	% of rated current	10-80%	
viii.	Operating time at 10 times current setting	sec	3	
ix.	Characteristics Characteristic Angle		IDMT(standard inverse), 45°	
x.	Instantaneous unit provided -Current setting range -Operating range	Yes/No % of rated current mS	Yes 500-2000%	
xi.	Insulating test according to IEC	Yes/No		
xii.	Indication -Hand reset flags provided -Light emitting diode provided	 Yes/No Yes/No		
xiii.	Technical literature submitted	Yes/No	Yes	
3.5	Transformer Differential relay			
i.	Manufacturer / Country of Origin			
ii.	Standard Reference	IEC	IEC	
iii.	Type of Construction			
iv.	Type		Numerical	
v.	Voltage Rating	V	110	
vi.	Type of Mounting		Flush	
vii.	Operating Time Setting, Sec	mS	<30	
viii.	Sensitivity Setting		20-50% x In	
ix.	Bias Setting			
x.	CT Ratio Compensating Range			
xi.	Burden for Current Circuit	VA		
xii.	DC Burden	VA		
xiii.	Tripping	A		
xiv.	Making current	A		
xv.	Closing Load (At 110V DC)	A		
3.6	**AUXILIARY TRIPPING & LOCKOUT RELAYS**			
i.	Manufacturer and Country of Origin			
ii.	Type			
iii.	Manufacturer's type designation			
iv.	Applicable standard	IEC	IEC	
v.	Operating time	mS	<15	
vi.	Does the lockout relay reset by the manually operated or electrically operated reset device			
vii.	Is the cut-off contact provided to interrupt the operating coil ?	Yes/No		
viii.	Contact rating at 125V DC	A		
xi.	Technical literature submitted	Yes/No	Yes	

TECHNICAL DATA SHEET
(To Be Completed By the Tenderer)

ITEM No.1: CONTROL AND RELAY PANEL FOR TRANSFORMER **Sheet 5 of6**

	DESCRIPTION	UNIT		DATA to be Filled
3.7 i. ii.	**Breaker Fail Lockout Relay, 86K** DC VVoltage Rating, V Nos. of Electrically separate NO & NC Contacts	 V	 110	
3.8 i. ii.	**Breaker Failure Lockout Relay, 86BF & LBB Protection** DC Voltage Rating, V Nos of Electrically separate NO & NC Contacts	 V	 110	
v.	Technical literature submitted	Yes/No	Yes	
3.9	**BREAKER FAILURE PROTECTION RELAYS**			
i.	Manufacturer and Country of Origin			
ii.	Manufacturer's type designation			
iii.	Applicable standard	IEC	IEC	
iv.	Triple pole or single pole		Triple Pole	
v.	Current setting range	% of rated current	20-200%	
vi.	Time setting range	sec		
vii.	Reset time	mS		
viii.	Insulating test according to IEC	Yes/No		
ix.	Indication -Hand reset flags provided -Light emitting diode provided	 Yes/No Yes/No		
x.	Auxiliary DC Supply	V_{dc}	110	
xi.	Is manufacturer ISO 9001 holder?	Yes/No	Yes	
xii.	ISO certificate submitted	Yes/No	Yes	
xiii.	Technical literature submitted	Yes/No	Yes	
4	**CONSTRUCTION OF CONTROL & RELAY PANEL**			
i.	Type(Simplex/Duplex)		Duplex	
ii.	Manufacturer's type designation			
iii.	Applicable standard	IEC	IEC	
iv.	Control panels furnished as per specifications	Yes/No	Yes	
v.	Enclosure protection class	IP	IP 4X	
vi.	Thickness of sheet metal used -Front and rear portion -Side, top and bottom covers -Doors	 mm mm mm	 >=3 >=2 >=3	
vii.	All instruments, meters, relays and control switches flush or semi-flush type		Flush	
viii.	Ground bus -Material -Size	 mm x mm	 Copper 25 X 6	
ix.	Internal Wiring - Type of Insulation - Voltage Grade of Wires - Cross Section of wire Current circuit Voltage & auxiliary Circuit	 V Sq.mm	 600	
x.	Overall dimension of control boards (LxWxH)	mm		

TECHNICAL DATA SHEET
(To Be Completed By the Tenderer)

ITEM No.1: CONTROL AND RELAY PANEL FOR TRANSFORMER **Sheet 6 of 6**

	DESCRIPTION	UNIT		DATA to be Filled
xi.	Shipping data -Size of large package -Weight of the heaviest package	 mm Kg		
xii.	Delivery of equipment in months following award of contract (Allowing time for approval of drawing)	month		
xiii.	Is manufacturer is ISO 9001 holder?	Yes/No	Yes	
xiv.	ISO 9001 certificate submitted?	Yes/No	Yes	
xv.	Has manufacturer exported units?	Yes/No	Yes	
xvi.	User's certificate submitted?	Yes/No	Yes	
xvii.	Technical literature/drawings submitted?	Yes/No	Yes	

Deviations from technical requirements:

Signed……………………………………………. As representative for…………………………

Address……………………………………………. Date…………………………………………

TECHNICAL DATA SHEET
(To Be Completed By the Tenderer)

ITEM No.2: CONTROL AND RELAY PANEL FOR LINE **Sheet 1 of 4**

	DESCRIPTION	UNIT		DATA to be Filled
1	**CONTROL AND RELAY PANEL TYPE**	**Duplex / Simplex**		
1.1	Manufacturer and Country of Origin			
1.2	Year of manufacturing experience	Years	5	
1.3	Manufacturing's Designation as per submitted catalogue			
2	**CONTROL DISCREPANCY SWITCHES**			
2.1	Manufacturer and Country of Origin			
2.2	Type		Discrepancy	
2.3	Current Rating	A		
3	**PUSH BUTTON**			
3.1	Manufacturer and Country of Origin			
3.2	Type			
3.3	Contact Rating, continuous Making Current Breaking Current	Amp Amp Amp		
4	**INDICATING LAMPS**			
4.1	Manufacturer			
4.2	Voltage Rating	V		
4.3	Wattage	W		
5	**INDICATING INSTRUMENTS**			
5.1	**Ammeter**			
i.	Manufacturer and Country of Origin			
ii.	Type		Digital	
iv.	Accuracy class		0.5	
v.	**Scale**			
	-Range of indication (………./1 Amp CT operated)	A	As Required	
	-Overload range	%	1.5	
vi.	VA Burden			
vi.	Transducer operated	Yes/No	Yes	
5.2	**Apparent Power Meter (VA)**			
i.	Manufacturer and Country of Origin			
ii	Type		Digital	
iii	Rated voltage	kV	132/√3 : 0.11/√3	
iv	Rated current	A	………/1	
vi	Accuracy class		0.5	
vii	Scale		Centre zero	
	-Range of indication	MVA	As Required	
viii.	VA Burden Current Coil Voltage Coil			
x	Transducer operated	Yes/No	Yes	

TECHNICAL DATA SHEET
(To Be Completed By the Tenderer)

ITEM No.2: CONTROL AND RELAY PANEL FOR LINE **Sheet 2 of 4**

	DESCRIPTION	UNIT		DATA to be Filled
5.3	**KWh Meter**			
i.	Manufacturer and Country of Origin			
ii.	Type		Digital, 3-phase, 4 wire	
iii.	Applicable standard	IEC	IEC	
iv.	Accuracy class		0.2	
v.	Import and Export meter provided	Yes/No	Yes	
vi.	Rated voltage	kV	132/√3 : 0.11/√3	
vii.	Rated current	A	……../1	
viii.	Operating current range	A	1-10A	
ix.	Operating Voltage range	A	0-480V	
x.	VA Burden Current Coil Voltage Coil	VA		
xi.	Impulse contact provided	Yes/No	Yes	
xii.	Programmable at Site		Yes	
xiii.	Software and optical probe provided as per Price schedule & BOQ		Yes	
5.4	**Power Factor meter, PF**			
i.	Manufacturer and Country of Origin			
ii.	Type		Digital	
iii.	Accuracy class		0.5	
iii	Rated voltage	kV	132/√3 : 0.11/√3	
iv	Rated current	A	………/1	
5.5	**Voltmeter meter, V**			
i.	Manufacturer and Country of Origin			
ii.	Type		Digital	
iii.	Accuracy class		0.5	
iii	Rated voltage	kV	132/√3 : 0.11/√3	
iv.	-Range of indication	V	0-150	
5.6	**Frequency Meter**			
i.	Manufacturer and Country of Origin			
ii.	Type		Digital	
iii.	Accuracy class		0.5	
iii	Rated voltage	kV	132/√3 : 0.11/√3	
5.7	**Annunciators**			
I	Manufacturer and Country of Origin			
ii.	Type			
iii.	Manufacturer's type designation			
iv.	Catalogue furnished	Yes/No	Yes	
vi.	Number of active points	No.	Min 18	

TECHNICAL DATA SHEET
(To Be Completed By the Tenderer)

ITEM No.2: CONTROL AND RELAY PANEL FOR LINE **Sheet 3 of 4**

	DESCRIPTION	UNIT		DATA to be Filled
6	**PROTECTIVE RELAYS**			
6.1	**PHASE OVERCURRENT RELAYS**			
i.	Manufacturer and Country of Origin			
ii.	Type		Numerical Directional	
iii.	Manufacturer's type designation			
iv.	Applicable standard	IEC	IEC	
v.	Triple pole or single pole		Triple	
vi.	Current setting range	% of rated current	20-200%	
vii.	Characteristics Characteristic Angle		IDMT(standard inverse), 45°	
viii.	Instantaneous unit provided -Current setting range -Operating range	Yes/No % of rated current, mS	Yes 500-2000%	
ix.	Auxiliary DC Supply	Vdc	220	
6.2	**Directional Earthfault Relay**			
i.	Manufacturer and Country of Origin			
ii.	Type		Numerical Directional	
iii.	Manufacturer's type designation			
v.	Triple pole or single pole		Triple	
vi.	Current setting range	% of rated current	10-80%	
vii.	Characteristics Characteristic Angle		IDMT(standard inverse), 45°	
x.	Instantaneous unit provided -Current setting range -Operating range	Yes/No % of rated current mS	Yes 500-2000%	
6.3	**Distance Protection**			
i.	Manufacturer / Country of Origin			
ii.	Standard Reference	IEC	IEC	
iii.	Type of Construction			
iv.	Type		Numerical Non switched	
v.	Voltage Rating	V	220	
vi.	Type of Mounting		Flush	
vii.	Stepped Characteristic	mS	<30	
viii.	Number of Zone		3 Fw / 1 Rev	
ix.	Tripping		1 P / 3P	
x.	Weak infeed feature		Yes	
xi.	permissive under reach/ over reach/ blocking communication mode		Yes	
xii.	number of potential free contacts for Carrier aided Tripping, Auto reclosing, CB failure, Disturbance recorder & Data acquisition system		Yes	
xiii.	power swing blocking protection		Yes	

TECHNICAL DATA SHEET
(To Be Completed By the Tenderer)

ITEM No.2: CONTROL AND RELAY PANEL FOR LINE **Sheet 4 of 4**

	DESCRIPTION	UNIT		DATA to be Filled
xiv.	Fault Recorder / Disturbance Recorder		Yes	
xv.	Distance Fault Locator		Yes	
xvi	Other features as per specification		Yes	
6.4	**Auto reclosing Relay**			
i.	Manufacturer and Country of Origin			
ii.	Type			
6.5 i. ii.	**Breaker Failure Lockout Relay, 86BF & LBB Protection** DC Voltage Rating, V Nos of Electrically separate NO & NC Contacts	V	110	
6.6	**AUXILIARY TRIPPING & LOCKOUT RELAYS**			
i.	Manufacturer and Country of Origin			
ii.	Type			
iii.	Manufacturer's type designation			
v.	Operating time	mS	<15	
viii.	Insulating test according to IEC	Yes/No		
ix.	Indication -Hand reset flags provided -Light emitting diode provided	 Yes/No Yes/No		
x.	Auxiliary DC Supply	V_{dc}	220	
xi.	Technical literature submitted	Yes/No	Yes	
7	**CONSTRUCTION OF CONTROL & RELAY PANEL**			
i.	Type(Simplex/Duplex)		Duplex	
ii.	Manufacturer's type designation			
iii.	Applicable standard	IEC	IEC	
iv.	Control panels furnished as per specifications	Yes/No	Yes	
v.	Enclosure protection class	IP	IP 4X	
vi.	Thickness of sheet metal used -Front and rear portion -Side, top and bottom covers -Doors	 mm mm mm	 >=3 >=2 >=3	
viii.	Ground bus -Material -Size	 mm x mm	 Copper 25 X 6	
x.	Overall dimension of control boards (LxWxH)	mm		
xii.	Delivery of equipment in months following award of contract (Allowing time for approval of drawing)	month		
xvii.	Technical literature/drawings submitted?	Yes/No	Yes	

Deviations from technical requirements:

Signed……………………………………………. As representative for…………………………

Address……………………………………………. Date…………………………………………

TECHNICAL DATA SHEET
(To Be Completed By the Tenderer)

ITEM No.3: CONTROL AND RELAY PANEL FOR BUS COUPLER **Sheet 1 of 3**

	DESCRIPTION	**UNIT**		**DATA to be Filled**
1	**CONTROL AND RELAY PANEL TYPE**	**Duplex / Simplex**		
1.1	Manufacturer and Country of Origin			
1.2	Year of manufacturing experience	Years	5	
1.3	Manufacturing's Designation as per submitted catalogue			
2	**CONTROL DISCREPANCY SWITCHES**			
2.1	Manufacturer and Country of Origin			
2.2	Type		Discrepancy	
2.3	Current Rating	A		
2.3	Catalogue furnished	Yes/No	Yes	
3	**PUSH BUTTON**			
3.1	Manufacturer and Country of Origin			
3.2	Type			
3.3	Contact Rating, continuous Making Current Breaking Current	Amp Amp Amp		
4	**INDICATING LAMPS**			
4.1	Manufacturer			
4.2	Voltage Rating	V		
4.3	Wattage	W		
5	**INDICATING INSTRUMENTS**			
5.1	**Ammeter**			
i.	Manufacturer and Country of Origin			
ii.	Type		Digital	
iv.	Accuracy class		0.5	
v.	**Scale**			
	-Type of scale		Center zero	
	-Range of indication (………./1 Amp CT operated)	A	As Required	
	-Overload range	%	1.5	
vi.	Transducer operated	Yes/No	Yes	
5.2	**Annunciators**			
I	Manufacturer and Country of Origin			
ii.	Type			
iii.	Manufacturer's type designation			
iv.	Catalogue furnished	Yes/No	Yes	
vi.	Number of active points	No.	Min 18	

TECHNICAL DATA SHEET
(To Be Completed By the Tenderer)

ITEM No.3: CONTROL AND RELAY PANEL FOR BUS COUPLER **Sheet 2 of 3**

	DESCRIPTION	UNIT		DATA to be Filled
6	**PROTECTIVE RELAYS**			
6.1	**PHASE OVERCURRENT RELAYS**			
i.	Manufacturer and Country of Origin			
ii.	Type		Numerical Non Directional	
iii.	Manufacturer's type designation			
iv.	Applicable standard	IEC	IEC	
v.	Triple pole or single pole		Triple Pole	
vi.	Current setting range	% of rated current	20-200%	
vii.	Characteristics		IDMT(standard inverse)	
viii.	Instantaneous unit provided -Current setting range -Operating range -NO Contacts	Yes/No % of rated current	Yes 500-2000%	
x.	Auxiliary DC Supply	V_{dc}	220	
x.	Technical literature submitted	Yes/No	Yes	
6.2	EARTH FAULT RELAYS			
i.	Manufacturer and Country of Origin			
ii.	Type		Numerical, Non-Directional	
iii.	Manufacturer's type designation			
iv.	Applicable standard	IEC	IEC	
vi.	Continuous overload capacity	x In		
vii.	Current setting range	% of rated current	10-80%	
ix.	Characteristics		IDMT(standard inverse)	
x.	Instantaneous unit provided -Current setting range -Operating range -NO Contacts, Nos	Yes/No % of rated current mS	Yes 500-2000%	
xi.	Auxiliary DC Supply	V_{dc}	220	
xii.	Technical literature submitted	Yes/No	Yes	
6.3	**AUXILIARY TRIPPING & LOCKOUT RELAYS**			
i.	Manufacturer and Country of Origin			
ii.	Type			
iii.	Manufacturer's type designation			
iv.	Applicable standard	IEC	IEC	
v.	Operating time	mS	<15	

TECHNICAL DATA SHEET
(To Be Completed By the Tenderer)

ITEM No.3: CONTROL AND RELAY PANEL FOR BUS COUPLER **Sheet 3 of 3**

	DESCRIPTION	UNIT		DATA to be Filled
6.4	**BREAKER FAILURE PROTECTION RELAYS**			
i.	Manufacturer and Country of Origin			
ii.	Manufacturer's type designation			
iii.	Applicable standard	IEC	IEC	
iv.	Triple pole or single pole		Triple Pole	
v.	Current setting range	% of rated current	20-200%	
7	**CONSTRUCTION OF CONTROL & RELAY PANEL**			
i.	Type(Simplex/Duplex)		Duplex	
ii.	Manufacturer's type designation			
iii.	Applicable standard	IEC	IEC	
iv.	Control panels furnished as per specifications	Yes/No	Yes	
v.	Enclosure protection class	IP	IP 4X	
vi.	Thickness of sheet metal used -Front and rear portion -Side, top and bottom covers -Doors	 mm mm mm	 >=3 >=2 >=3	
vii.	All instruments, meters, relays and control switches flush or semi-flush type		Flush	
viii.	Ground bus -Material -Size	 mm x mm	 Copper 25 X 6	
x.	Overall dimension of control boards (LxWxH)	mm		
xii.	Delivery of equipment in months following award of contract (Allowing time for approval of drawing)	month		
xiii.	Technical literature/drawings submitted?	Yes/No	Yes	

Deviations from technical requirements:

Signed……………………………………………. As representative for…………………………

Address……………………………………………. Date…………………………………………

This schedule contains GTP for all the possible parameters of SACDA Equipments BCU generally have. Instead of simply confirming, the Bidder shall fill in the particulars against appropriate items in respect of each rating and type of equipment offered in the broad categories listed below along with supporting authentic technical documents.

(In the absence of GTP in the below mentioned format, the purchaser has every right to evaluate the product accordingly and bidder cannot raise any objection against any point of the technical scrutiny.)

TECHNICAL DATA SHEET

(To Be Completed By the Tenderer)

ITEM No.15: SUBSTATION AUTOMATION SYSTEM **Sheet 1 of 6**

Sr. No.	Parameters	To be filled by bidder
A	**BCU**	
1	Make and Type	
2	Numerical Technology	
3	Modular design	
4	Nos of Analogue Input	
5	Nos of Digital Input	
6	Nos of Output	
7	Data Storage	
8	Self- monitoring	
9	Power supply	
10	IEC 61850 Protocol Compatibility	
11	Binary Input processing & Nos	
12	Analogue Input processing & Nos	
13	Measured value acquisition	
14	Derived values	
15	Digital Outputs	
16	Sub-station/bay inter-locking	
17	Trip Circuit Supervision	
18	Event Logging Nos	
19	Disturbance files & record of wave forms , storage capacity	
20	Gateway support	
21	Local control, Operation and Display	
22	Contact bouncing in digital inputs shall not be assumed as change of state	
23	I/O processing capacities	

	TECHNICAL DATA SHEET **(To Be Completed By the Tenderer)**	
ITEM No.15: SUBSTATION AUTOMATION SYSTEM		**Sheet 2 of 6**
24	Internal Ethernet switches	
	Nos of port –	
26	Environmental conditions	
27	Mounting & design	
28	Warranty	
	Bay control functions	
	Control mode selection	
	Command supervision	
	Commands for	
32	Local communication facility through HMI	
	Local communication facility provided on front side for	
34	Compatibility with owner's SCADA for remote control	
35	Extension possibilities with additional I/O's inside the unit or via fiber-optic communication and process bus.	
B	Gateway	
1	Power supply	
2	Processor Type	
3	Chipset	
4	Memory Type	
5	Standard memory	
6	Memory slots	
	Internal hard disk drive	
	Hard disk drive speed	
	Optical drives	
	Video adapter, bus	
	Expansion slots	
	Network Interface	
	External I/O ports	
	Operating system installed.	
	Make	
	Antivirus s/w	

TECHNICAL DATA SHEET
(To Be Completed By the Tenderer)

ITEM No.15: SUBSTATION AUTOMATION SYSTEM **Sheet 3 of 6**

D	**HMI SERVER**	
1	Power supply	
2	Processor Type	
3	Chipset	
4	Memory Type	
5	Standard memory	
6	Memory slots	
7	Memory upgrade	
8	Internal hard disk drive	
9	Hard disk drive speed	
10	Optical drives	
11	Flexible disk drives	
12	Chassis type	
13	Video adapter, bus	
14	Expansion slots	
15	Audio	
16	Modem	
17	Network Interface	
18	External I/O ports	
19	Monitor	
20	Keyboard	
21	Pointing Device	
22	Operating system installed.	
23	Other	
24	Warranty	
25	UPS	
26	Make	
27	Antivirus s/w	

TECHNICAL DATA SHEET
(To Be Completed By the Tenderer)

ITEM No.15: SUBSTATION AUTOMATION SYSTEM **Sheet 4 of 6**

E	**DR WORK STATION**	
1	Power supply	
2	Processor Type	
3	Chipset	
4	Memory Type	
5	Standard memory	
6	Memory slots	
7	Memory upgrade	
8	Internal hard disk drive	
9	Hard disk drive speed	
10	Optical drives	
11	Flexible disk drives	
12	Chassis type	
13	Video adapter, bus	
14	Expansion slots	
15	Audio	
16	Modem	
17	Network Interface	
18	External I/O ports	
19	Monitor	
20	Keyboard	
21	Pointing Device	
22	Operating system installed.	
23	Other	
24	Warranty	
25	UPS	
26	Make	
27	Antivirus s/w	

TECHNICAL DATA SHEET
(To Be Completed By the Tenderer)

ITEM No.15: SUBSTATION AUTOMATION SYSTEM **Sheet 5 of 6**

F	**LINE INTERFACE UNIT**	
1	Area Network Type	
2	Power Supply	
3	Protocol/ Network	
4	Module	
5	No. of Ports	
6	Ports/Interfaces	
7	Features	
8	Make	
9	Manufacturer Warranty	
10	Suitability for Nos of F.O. Inlet/Outlet	
11	IEC 61850 Compatibility	
G	**COLOUR LASER JET PRINTER**	
1	Model	
2	Power Supply	
3	Black Print Speed	
4	Black Print Resolution	
5	Print Memory	
5	Processor	
6	Supported paper sizes	
7	Print technology	
8	Pages quantity	
9	Paper handling	
10	Connectivity	
11	Manufacturer Warranty	
12	Networking:	
13	Supporting OS	
14	Make	
15	Suitability to print all types of drafts and graphics	

TECHNICAL DATA SHEET
(To Be Completed By the Tenderer)

ITEM No.15: SUBSTATION AUTOMATION SYSTEM **Sheet 6 of 6**

H	**LASER JET PRINTER**	
1	Model	
2	Power Supply	
3	Black Print Speed	
4	Black Print Resolution	
5	Print Memory	
6	Processor	
7	Supported paper sizes	
8	Print technology	
9	Pages quantity	
10	Paper handling	
11	Connectivity	
12	Manufacturer Warranty	
13	Networking:	
14	Supporting OS	
15	Make	
16	Suitability to print all types of drafts and graphics	

Deviations from technical requirements and reasons for such deviations:

Signed……………………………………………. As representative for…………………………

Address……………………………………………. Date…………………………………………