7.2.1 Scope of Supply

This specification covers the design, manufacture, inspection, testing at the manufacturer's works and erection and commissioning of a Substation Automation System described in the following sections, to control and operate the 33/11 kV GIS substation. The scope includes the design, manufacture, supply, installation and commissioning of Substation Automation System (SAS) for both 33KV GIS system with provision for interfacing with SCADA System for 07 Nos. New 33/11kV GIS Substation, 04 Nos. 33/11kV GIS Substation (Up-gradation) and 01 no 33 kV Bay extension.

The Substation Automation System shall have all arrangements to interface with BPDB's SCADA a system. Demonstration by simulation for functional/operational check for future interfacing with SCADA system shall be done by the contractor.

This describes the facilities required to provide the control of plant and system within a substation and outlines the facilities to be provided on site, interface requirements and performance criteria.

The Substation Automation System (SAS) shall comprise full station and bay protection, control, monitoring and communication functions. It shall enable local station control via PC by means of a human machine interface (HMI) and control software package and perform the necessary system control and data acquisition functions. It shall include communication gateway to inter-bay-bus, intelligent electronic devices (IED) for bay control and protection as shown in the enclosed general system architecture drawing.

The communication gateway shall secure control from and information flow to remote network control centres. The inter-bay bus, configured as a star connection (via star couplers) shall provide independent station-to-bay and bay-to-bay data exchange. The bay level intelligent electronic devices (IED) for protection and control shall be directy connected to the instrument transformer without any interposing equipment and perform control, protection, and monitoring functions subject to a detail proposal approved by the Engineer.

The IED's for protection and control functions shall maintain high availability and reliability together with bay independence through extensive self-supervision and state-of-the-art technology.

The system shall be capable of having its computing power increased in the future by the addition of additional computing systems.

The system design life shall be not less than 20 years. The Automation system shall be from EU/USA/UK/Canada/Japan.

The bidder shall provide (i) IEC 61850 compliance report for the offered system with IEDs and (ii) interoperability test report for the offered system with ABB, Siemens, Alstom and SEL IEDs with IEC 61850 protocol from any UCA approved system verification and validation center along with the bid document.

The capacity of the SA system shall be sufficient for the ultimate development of the substation as set out in the project requirements.

The SAS supplier shall demonstrate that the system proposed has been designed, installed and commissioned in accordance with relevant international standards and the specification shall provide evidence of satisfactory service experience during the past 5 years.
The contractor shall provide the installation software and required Licenses of the substation automation system.

Installation, testing and commissioning of substation automation system shall be done by the automation Engineer(s) of the substation automation manufacturer(s).

The software architecture and the database structure shall be finalized with the Purchaser. The facitlities shall be incorporated in order to access the database from the backend by the authorised user of the Purchaser. Object oriented technology shall be used in the software development.

The Source Codes of the software standard documentation shall be handed over to the Purchaser. The standard database like Oracle, MySQL, SQL shall be used.

Cyber Security of this system shall be built in with the system. The objective of cyber security is to protect information and physical assets from damages caused by theft , corruption or natural disasters while allowing the information and assets to remain accessible and productive to employer. All potential causes of cyber attacks need to be considered when employing a defense in depth approach.

7.2.2 Compliance with standards

For design and type testing of the protection and control equipment, the following standards shall be applicable:

General List of Specifications

IEC 255 :	Electrical Relays
IEC 60038:	IEC Standard voltages
IEC 68068:	Environmental testing
IEC 60664:	Insulation co-ordination for equipment within low-voltage systems
IEC 61850:	Standard for Substation integrated protection and control data communication

Detailed List of Specifications

IEC 255-6:	Measuring relays and protection equipment
IEC 255-7:	Test and measurement procedures for electromechanical all-or-nothing relays
IEC 68-2-3:	Test Ca: Damp heat steady state

IEC 68-2-30:	Test Db and guidance; Damp heat, cyclic
IEC 255-5:	Insulation tests for electrical relays
IEC 255-22:	Electrical disturbance tests for measuring relays and protection equipment:
IEC 255-22-1:	1 MHz burst disturbance test
IEC 255-22-2:	Electrostatic discharge test
IEC 255-22-3:	Radiated electromagnetic field disturbance test
IEC 255-22-4:	Fast transient disturbance test
IEC 255-11:	Interruptions to and alternating component (ripple) in D.C. auxiliary energising quantity to measuring relays
IEC 255-6:	Measuring relays and protection equipment
IEC 255-21:	Vibration, shock, bump and seismic tests on measuring relays and protection equipment:
IEC 255-21-1:	Vibration tests(sinusoidal)
IEC 255-21-2:	Shock and bump tests
IEC 255-21-3:	Seismic tests
IEC 255-0-20:	Contact performance of electrical relays
IEC 870-3 class 2:	Digital I/O, Analogue I/O dielectric tests
IEC 801-5/class 3 :	Digital I/O Surge withstand test
IEC 870-3/class2:	Radio interference test
IEC 801-4/4:	Transient fast burst test
IEC 801-2/4:	Static discharge
IEC 801-3/3:	Electromagnetic fields

7.2.3 Design and Operating Requirements

7.2.3.1 General

The SAS shall be suitable for operation and monitoring of the complete substation including future extensions. The offered products shall be suitable for efficient and reliable operation and maintenance support of the substations.

The SA system shall be state-of-the art design suitable for operation in high voltage substation environment, follow the latest engineering practice, ensure long term compatibility requirements and continuity of equipment supply and the safety of the operating staff.

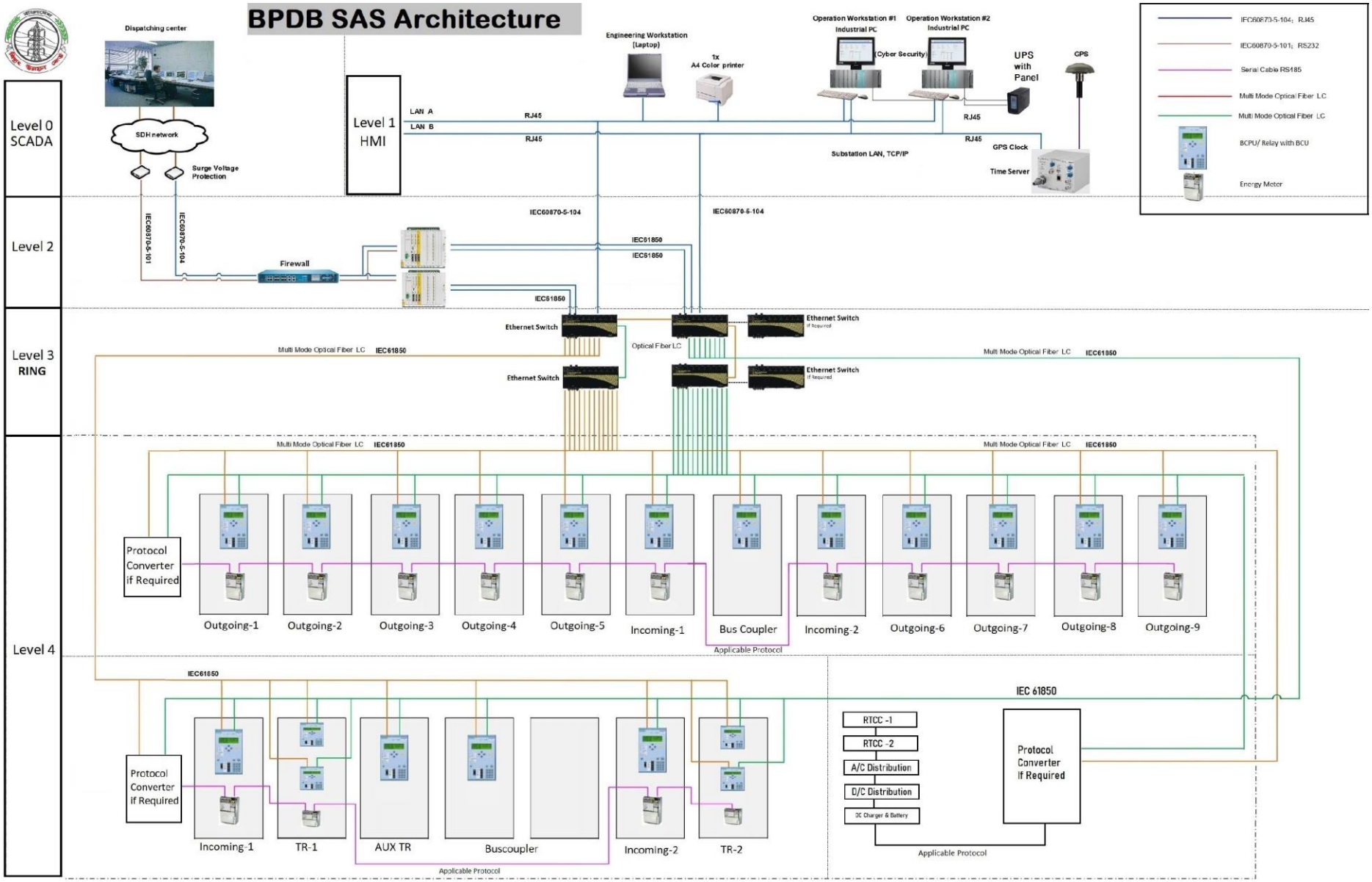
Protection is an integral part of the SA system and protective relays shall be directly connected to the interbay bus in order to provide unrestricted access to all data and information stored in the relays and for changing protection parameters from the remote control location.

Failure behaviour of the hardware and software functions shall be addressed and related diagnostic and rectification working instructions shall be provided. The system performance, if failure of communication to main and redundant computer base workstations, central functions, data model, control and protection IED's, station and bay level communication shall also be clearly addressed (shall be provided by the manufacturer).

The substation can also be controlled from Local Control Panel. The following modes of operation shall be possible

(a) Emergency operation of breaker, disconnector, earthing switch etc. from the Local Panel.

(b) Normal operation of breaker, disconnector, earthing switch etc. from the Station Automation System HMI located in the 1st floor/Ground floor.



Note: This Drawing is an indicative for Basic requirement. Detail Drawing to be submitted for approval as per scope of work & GTP

BOQ of SAS:

Substation Automation system		Unit	Qty.
ii.	Industrial Server PC for Operator workstation with SAS & Engineering Software.	Set	02
iii.	Ethernet Switch for SAS	Lot	01
iv.	GPS system	Set	01
v.	Common alarm unit with hooter/buzzer for annunciation	Set	01
vi.	One (01) set of Color Printer	Set	01
vii.	Engineering PC (Laptop) : core i7-9800X series processor, 1TB HDD, 16GB RAM, 15.6" display.	Set	01
viii.	Cable (Fiber Optic, Ethernet, Copper etc.)	Lot	01
ix.	Panel including wiring, lighting , heater & other accessories	Lot	01
x.	Gateway	Set	02
xi.	UPS with Panel (110 V DC from Substation main DC System Source will be provided)	Set	01
xii.	Other Accessories (if any)	Lot	01

7.2.3.2 Modes of Operation

The operator stations and specified remote users shall have following operational modes, each password protected.

Monitoring Ability to select graphic displays and lists for viewing only. No capability to acknowledge alarms, complete controls or select items for inclusion in program functions.

Control: Selection of graphic display and lists. Able to acknowledge station and SA alarms, complete controls, dressing etc. associate with normal real time of the control of the substation.

SA Engineering: Provides all the SA monitoring functions, together with online facilities for program/database/format modifications and checking without the possibility of executing power system controls.

System Manager: Provides access to all system functions, including assignment of passwords and system maintenance activities.

In addition a facility to provide access to the numerical Protection relays, change / modify relay settings & AVR parameters and Fault Recorder data shall be provided.

A series of passwords shall be personally assigned to operators in each of the above categories.

It shall be possible for substation operators to log on either of the substation workstation and to be allocated the appropriate mode of operation relevant to the password. SA System Engineering work and access to the protection relay and disturbance reorder information shall generally be carried out at the Engineering workstation or remote master station.

All the workstation and the system database shall function as a system. It shall not be necessary for example to acknowledge an alarm at more than one workstation.

Similarly, an operator manual entry applied at a workstation shall be immediately displayed at other workstations where this data is presented.

7.2.3.3 Project Specifications

Specific functions required and boundary conditions of the SA are detailed elsewhere in this specification. The project specific drawings are attached:

- Overall single line diagram
- General system architecture
- Location of substation buildings
- Control and operation principles
- Protection schemes

7.2.3.4 Vendor's Experience and Local Support

Only experienced and technically capable manufacturers with minimum 5 years experience in design and supply of control and protection systems for electricity transmission and distribution applications will be accepted. Preferred manufactures will be those who have experience in deliveries of the full scope of station automation systems and services. This experience has to be substantiated by means of reference installations being in service under similar environmental conditions for at least 5 years. In order to assess the vendor's experience with similar projects, the vendor is required to submit the following with his Bid:

- Technical design specifications and description of SA
- Catalogues and brochures of equipment and devices offered
- Reference list

The vendor shall assure for long-term maintenance and availability of spares. Moreover, a guarantee shall be submitted for the availability of spares during the lifetime of the SA equipment (not less than **20** years) **[as specified in GTP].**

One (01) Lot of Complete SAS including all required equipment & accessories excluding relay & protection panel for the whole Substation. SAS system shall include Server PC (Hot & standby) with SAS software and **required licenses**, Operator workstation (Main & redundant), Ethernet Switches, GPS system, Printer, Engineering PC/ **Laptop with all necessary** software **and required licenses**, panels, Cables etc. **The Master slave Licenses for SCADA and SAS communication in the gateway shall be activated.**

The Engineering PC/ **Laptop** & software of SAS shall be useable for engineering of SCADA system also. **The Master slave Licenses for SCADA and SAS communication in the gateway shall be activated.** Therefore, necessary hardware & software shall be installed here.

All required electrical signals for signalization and control shall be transmitted to the SCADA through the Industrial Gateway of the substation automation system or RTU. All breakers, motorized disconnectors, tap changer, etc. shall be controlled form SCADA through the Gateway or RTU of the substation automation system using IEC 60870-5-104 protocol. Necessary transducer, control & interposing relays, RTUs, etc. shall be used. Necessary interfacing between the Substation Automation gateway and the communication equipment is to be carried out. IED shall have dual connection to Ethernet switch (hot & standby). Ethernet switch shall have dual connection to each other.

All DC status (DC voltage status for each bus including coupling breaker on /off status, fail with alarm) excluding control & protection Panel shall be incorporated in substation automation system. The DC status of control & protection Panel shall be incorporated to SAS by individual IED.

7.2.4 General System Design

The system shall be so designed that personnel without any background in microprocessor based technology can operate the system easily after they have been provided with some basic training.

System control from the substation control room will be with the help of an Industrial Computer (PC) operated by a mouse. The following HMI (Human Machine Interface) functions shall be provided:

- Acquisition and plausibility check of switchgear status
- Control of switchgear, **Transformer Fan, OLTC**
- Remote checking of device parameters and activation of alternative parameter sets in the connected protective relays
- Display of actual measured values (U, I, P, Q, f, PF)
- Display of Energy (kWh and kVarh export and import)
- Display of events
- Display of alarms
- Display of trends
- Sequence control functions
- Disturbance records and fault location
- System self-supervision
- Hard copy printing
- **Transformer Health Monitoring**
- **AC distribution system monitoring**
- **DC charging system monitoring**
- **DC distribution system monitoring**
- **Ambient Temperature and Humidity monitoring of Transformer yard, Cable compartment and Control room**
- **Different Operational data (SAIDI, SAIFI, MOD) as a Monthly report**

Maintenance, modification or extension of components shall not require a shutdown of the whole station automation system. Self-monitoring of single components, modules and communication shall be incorporated to increase the availability of the equipment while minimising maintenance time to repair.
The data exchange between the electronic devices shall take place via an inter-bay bus using IEC 61850 protocol. The high speed bus shall permit peer-to-peer communication between the connected devices with democratic access. The entire station shall be controlled and supervised from the station level PC. It shall also be possible to control, monitor and protect each individual bay from the respective bay level equipment for maintenance purposes or if the communication to a particular bay should fail. Clear control priorities shall prevent initiation of operation of a single switch at the same time from more than one of the various control levels viz., station level, bay level or switchgear (apparatus) level. The priority shall always be with the lowest enabled control level.

Each bay control and protection unit shall be independent of each other and its functioning shall not be affected by any fault occurring in any of the other bay control and protection units of the station. Control function can be provided with O/C & E/F relay as Bay Control and Protection Unit (BCPU) in the 33 kV and 11 kV PCM panel. Separate Bay Control Unit (BCU) along with separate OC & E/F relay is also acceptable.

The SAS shall contain the following main functional parts:

- Human Machine Interface (HMI) with process database
- Gateway function for remote control via an industrial grade hardware
- Dial in facility / laptop workstation for protection relay parameterisation, disturbance analysis and SA system fault analysis.
- Data exchange between the different system components via high speed bus
- Bay level devices for control, monitoring and protection
- Bay oriented local control and protection panels with mimic inserts
- Facility for emergency operation of all the switchgear, if bay controller fails. (Key / master key system.)

The main process information of the station shall be stored in distributed databases. The system shall be based on a de-centralised concept with bay oriented distributed intelligence for safety and availability reasons. Functions shall be decentralised, object oriented and located as close as possible to the process.

The substation monitoring/protection system shall supply data for maintenance, repair and remote parameter setting of protection and control devices in the switchyard. In the event of a fault in the electrical network, the substation monitoring shall provide a quick means for collecting the relevant and critical data of the fault.

The monitoring system shall be suitable for the supervision and monitoring of all the secondary (lED) and primary devices in a substation including future extensions.

Maintenance, modification or extension of components shall not cause a shut-off of the whole station monitoring system. Self-monitoring of single components, modules and communication shall be incorporated to increase the availability and the reliability of the equipment and minimise maintenance.

It shall be possible to access all protection and control devices for reading the terminal parameters (settings). The setting of parameters or activation of parameter sets shall be restricted by password to the protection engineer.

7.2.5 Flexibility and Scalability

The offered SA system concept shall be flexible and shall permit future extensions to be realised easily. Preference will be given to those suppliers who are in a position to provide protection and control devices which can be freely adapted to the application functions required.

7.3.6 System Hardware

7.2.6.1 Operator Station

The main operator station shall be based on an industrial PC hardware and high-resolution full-graphics screen with manufacturer's standard type tested software operating under Windows latest environment. An Event printer and a Hard Copy printer shall be connected via a printer server and LAN to the operator station. The CPU shall be installed in the automation panel.

Dual station computers shall control the SA system and drive the work stations and other peripherals. One of the station computers shall operate the system in the "on line" state while the other acts as a "redundant hot standby". The standby computer shall be continuously updated and shall immediately take over the SA system duties without interruption or transfer mechanism should the on line operator workstation fail.

Disturbance Records shall be analysed using the installed Disturbance Record Analysis programmes. The Disturbance Records will be collected, over the interbay bus, from the connected IED's by the system software. All necessary facilities shall be provided to allow the system to perform spontaneous upload of Disturbance data or upload them in a pre-programmed manner. The Event printer shall print events spontaneously as they arrive in the main operator station.

Each uploaded data report file shall be reported on one line that shall contain:

- The event date and time
- The name of the event object
- A descriptive text
- The state or value of the object

The information fields above shall be structured in columns for maximum readability.

The hard copy printer shall permit printing of any picture (or part thereof) from the station level PC's using easily accessible commands from the window menus.

The main Station PC's with monitor and associated equipment of SAS shall be supplied by a UPS system connected with Substation DC battery bank.

7.2.6.2 Station Inter-bay Bus:

The LAN connecting the industrial computer based operator workstations, printers shall be Ethernet 802.3 LAN, Protocol TCP/IP **(100 M.bits/ sec or higher)** and the physical medium shall be thin Ethernet or fiber optic bus, provided this LAN is kept within the confines of the control room.

The bay control and protection units shall be connected via glass fiber optic cables to a station inter-bay bus, operating on high speed bus, via star couplers. The star coupler shall permit the data exchange between the different system components. Glass Fiber optic connections are used in order to avoid EMI in the switchgear and substation environment.

All protection and control units with serial communication facilities are connected in a star topology via glass fiber optics to the star coupler. Under no circumstances shall events from the protections be taken into the system via bay control unit hardware i.e., each protection device should have its own independent fiber optic communication channel to the star coupler. The star couplers shall be mounted in a separate communication cubicle.

7.2.6.3 Protection and Control IED's on 33 kV Level and 11kV Level:

The control IED's, 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 protection, commands, bay interlocking, data acquisition, data storage and event recording and shall provide inputs for status indication and outputs for commands. They shall be mounted in the LV compartment of the switchgear and shall be directly connected to it without any need for separate interposing equipment or transducers. All the 33kV & 11kV Circuit Breaker and TPS (DS-ES) shall be operable (ON/OFF) by the bay control unit HMI/protection relay HMI/SAS/SCADA and necessary software based closing & opening interlock shall be implemented.Required numbers of Binary Input, Binary Output, Analog Input, Programmable LED etc. of 33kV & 11kV panel's IED shall be provided to fulfill the requirements of CB,DS & ES control operation and position indication, hardware interlock, software interlock, panel equipment's status indication and all other necessary signals mentioned along with 10% as spare.

The 33 kV bay control & protection IED shall have the following features depending on the requirement:

- Minimum of 8 analogue channels
- For 33kV, not less than 42nos. BI & **32** nos. BO for Transformer Feeder and 24nos. BI & 24nos. BO for incoming& outgoing feeder, 32 nos BI and 24 nos BO for Bus coupler Feeder. For 11kV,

not less than 32 nos. BI & 32 nos. BO for incoming and 24 nos. BI & 24 nos. BO for outgoing feeder, 32 nos BI and 24 nos BO for Bus coupler Feeder.

- 8 nos. programmable LED's on the front of the unit for indication
- Instantaneous Phase Over current Protection
- Instantaneous Earth Fault Protection
- Inverse Time Phase Over current Protection
- Inverse Time Earth Fault Over current Protection
- Over voltage / under voltage Protection
- Synchrocheck function
- Built-in mimic display with controls for operating the switchgear. In the event of failure of the bay unit a backup system for emergency operation should be provided.
- Sufficient number of High speed bus serial communication port electrical and Optical communication ports for Dual channel parallel communication for multiple Ethernet switch.
- Sequence of Events Recorder with a buffer for 256 events and a resolution of 1 msec. The events that are to be recorded should be freely programmable. These could be alarm/trip signals, external signals connected to optocoupler inputs, internal signals, etc. Once events are defined, they are recorded in chronological order as they occur.
- Disturbance Recorder function which can record 9 analogue values, 16 Binary signals and 12 analogue channels for internal measurement values. It shall be possible for the Disturbance Recorder function to be triggered by any internal or external binary signal or internal protective function.
- Comprehensive self-supervision
- Battery-free memory back-up of Event and Disturbance Records
- Logic functions (AND, OR, bistable flip flop, etc.)
- Delay/Integrator function
- Fault Locator
- Disturbance Recorder

*** SAS will be provided considering GTP of GIS and BCPU/Relay should have sufficient BI/BO as per BPDB's requirement.

The numerical bay control IED's shall be mounted together with all the relevant bay protective relays in cubicles of Protection Class IP54 or better. Distributed back-up control mimics with associated switches meters and Indicating LED's shall also be provided on these cubicles. These cubicles shall be installed in an air-conditioned room in the substation.

The distributed backup mimic for Local Control shall be installed next to the bay controller IED, which can be used in case of maintenance or emergency or if bay control IED fails. Local bay control via the back-up control mimic on the Control & Protection cubicles shall incorporate the same user safety measures e.g. bay interlocking, synchrocheck, interlock override user guidance etc. as the station HMI. Local bay control shall be key-locked and the control either from GIS local control panel or station HMI or from remote shall be disabled if the local/remote selector switch on the back-up control mimic is in the 'local' position.

The electronic system has to be provided with functions for self-supervision and testing. Each circuit board shall contain circuits for automatic testing of its own function. Control function can

be provided with O/C & E/F relay as Bay Control & Protection Unit (BCPU) in the 33KV and 11KV PCM panel. Separate Bay Control Unit (BCU) along with separate O/C & E/F relay is also acceptable.

Faults in the bay control IED shall be indicated on a front HMI and a message shall be sent to the station level HMI. The time for fault tracing and replacement of a faulty unit shall be reduced to a minimum. The supervision shall also cover the power supply system, the internal system bus and the ability of the central processing module to communicate with different printed circuit boards.

Failure of any single component within the equipment shall neither cause unwanted operation nor lead to a complete system breakdown. The n-1 criteria must be maintained in worst case scenarios also. Further, a single failure must not have any affect on the primary system, which is monitored and controlled.

Only the backup protection can be incorporated in the bay control unit and not the main protections. Main protection shall be provided separately.

All IED`s shall have at least 5 years of successful proven experience in HV applications and the MTBF for the offered units shall be provided.

7.2.7 Software Structure

The software package shall be structured according to the SA architecture and strictly divided in various levels. It shall be possible to extend the station with the minimum possible effort. Maintenance, modification or 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.

Confirmation that the software programs will be supported for a minimum of 20 years is required to be submitted with the Bid.

It shall be the responsibility of the contractor to obtain any license required for the operation software. The contractor shall indemnify the client against all claims of infringement of any patent, registered design, copyright, trademark or trade name or other intellectual property right.

7.2.7.1 Station Level Software

7.2.7.1.1 Human Machine Interface (HMI)

The base HMI software package for the operator station shall include the main SA 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. The System shall contain a library with standard functions and applications.

7.2.7.1.2 Operating System

Windows operating system shall be used for the operator station as it supports several standard system features, e.g support for several Windows office applications, multitasking, security levels, data exchange mechanisms (DDE, OLE), open data base communication standards (ODBC) and a standardised, user-friendly look & feel HMI. The licensed copy of the operating system backup software shall be provided.

7.2.7.2 Bay Level Software

7.2.7.2.1 System Software

The system software shall be structured in various levels. This software shall be placed in a non-volatile memory. Its 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.

7.2.7.2.2 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 shall form part of a library.

The application software within the control/protective devices shall be programmed in a functional block language.

7.2.8 System Testing

The supplier shall submit a test specification **(Procedure and Report Format)** for factory acceptance test (FAT**) and Pre-commissioning** 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 phase of the SA shall be concluded by a Factory Acceptance Test (FAT). The purpose is to ensure that the Contractor has interpreted the specified requirements correctly. 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 with site conditions simulated to the extent possible in a test lab. If the FAT involves only a certain portion of the system for practical reasons, it has to be assured that this test configuration contains at least one unit of each and every type of equipment incorporated in the delivered system.

If the complete system consists of parts from various suppliers, the supplier shall arrange interoperability test at factory during stage inspection or FAT. The complete system test shall also be performed at site in the Site Acceptance Test (SAT).

7.2.9 System functions

7.2.9.1 Control Unit Functions

7.2.9.1.1 Control

The different high voltage apparatuses within the station shall either be operated manually by the operator or automatically by programmed switching sequences.

The control function shall comprise:
Commands from different operator places, e.g. from the station HMI, or local control panel according to the operating principle
Select-before execute commands
Operation from only one operator place at a time.
Operation depending on conditions from other functions, such as interlocking, synchrocheck, operator mode, or external status conditions.

The control function shall also include:

Prevention of double operation

- Command supervision
- Selection of operator place
- Block/deblock of operation
- Block/deblock of updating of position indications
- Manual setting of position indications
- Overriding of the interlocking function (Second key switch.)
- Switchgear run time supervision

7.3.9.1.2 Status Supervision

The position of each switchgear, e.g. circuit breaker, isolator, earthing switch, etc., shall be permanently supervised. Every detected change of position shall be immediately visible on the screen in the single-line diagram, recorded in the event list, and a hard copy printout shall be produced. Alarms shall be initiated in cases when spontaneous position changes have taken place.

Each position of an apparatus shall be indicated using two binary auxiliary normally closed (NC) and normally open (NO) contacts. An alarm shall be initiated if these position indications are inconsistent or indicate an excessive running time of the operating mechanism to change position.

7.3.9.1.3 Interlocking

The interlocking function prevents unsafe operation of apparatuses such as isolators and earthing switches within a bay or station wide. The operation of the switchgear shall only be possible when certain conditions are fulfilled. The interlocking function is required to be decentralised so that it does not depend on a central control device. Communication between the various bays for the station interlocking shall take place via bay communication system. An override function shall be provided, which can be enabled to by-pass the interlocking function via a key/password, in cases of maintenance or emergency situations.

7.2.9.1.4 Measurements:

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 correlated values of active power (W), reactive power (VAr), frequency (Hz), and the rms values for voltage (U) and current (I) shall be calculated. **Transformer area/ Switchyard area and** Control room temperature and humidity readings shall be available in SAS.

7.2.9.1.5 Event and Alarm Handling:

Events and alarms shall be generated either by the switchgear, by the control devices and 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 time tagging shall be done at the lowest level where the event occurs and the information shall be distributed with the time tagging.

7.2.9.1.6 Time Synchronisation:

The time within the SA shall be set via a GPS Clock Receiver connected directly to the Bay Level LAN. The time shall then be distributed to the control/protective devices via the high speed optic fibre bus. An accuracy of ±1 ms within the station is required.

7.2.9.1.6 Synchronism and Energising Check

The synchronism and energising check functions shall be distributed to the control and/or protective devices and shall have the following features:

- Adjustable voltage, phase angle, and frequency difference.
- Energising for dead line - live bus, or live line - dead bus.
- Settings for manual close command and auto-reclose command shall be adaptable to the operating times of the specific switchgear.

7.2.9.1.7 Voltage Selection

The voltages, which are relevant for the synchrocheck functions, depend on the station topology i.e. on the positions of the circuit breakers and/or the isolators. The correct voltage for synchronising and energising is derived from the auxiliary switches of the circuit breakers, isolator, and earthing switch and shall be selected automatically by the control and protection IED.

7.2.9.2 HMI Functions

7.2.9.2.1 General

The operator station HMI shall provide basic functions for supervision and control of the substation. The operator shall give commands to the switchgear via the station monitor with the help of mouse clicks on soft-keys.

The HMI shall provide the operator with access to alarms and events displayed on the screen. Besides these lists on the screen, there shall be a print out of hard copies of alarms or events in an event log. The Alarm List shall indicate persisting and fleeting alarms separately.

An acoustic alarm shall indicate abnormalities and all unacknowledged alarms shall be accessible from any screen selected by the operator.

Following standard pictures shall be available from the HMI:

a. Single line diagram: SLD showing Actual connection of Feeders and Transformer with bus, having different color for different voltage level, the switching status (Dynamic Color Change with status) and measured values
b. Feeder Page: Each and Every panels of the substation shall have separate window/ page in HMI for all the information related to that panel. A SLD with dynamic color coding and also showing the status in the text form (Open/ Close/ Intermediate). A portion of window shall show all the measurement data for related feeder. LV compartment Alarm signals and Protection Alarm shall also appear in different block in the HMI page.
c. Control dialogues: (Whenever a click performed on any switching device, a pop-up will appear with open and close icon having standard color. When a single command is selected a questions for pop-up for ensuring the operation with accept and deny option) Control can only be performed from feeder specific HMI page.
d. Measurement dialogues: All the feeders page on HMI shall have a portion for display of measurement (3 phase Voltage line -line, phase to phase, 3 Phase Current, MW, MVar, PF, Frequency, Last Fault Current and Voltage for all three phase with respective time, and Distance of fault for line feeder), Transformer feeder shall have additional page /window for measurement Value of HT and LT side Voltage, current, angle values and Differential and Restraining Current.
e. Blocking dialogues: Switchgear operation Interlock shall be implemented in SAS. When a switchgear operation is in interlocked condition with one or more parameter, a LOCK sign shall appear beside the switchgear symbol. After clicking the LOCK symbol/sign, a pop-up will appear showing the parameters/ variables for respective switchgear operation condition in logic diagram with dynamic color coding.
f. Alarm list, station / bay oriented: A common alarm list shall be configured for all the substation signals except manual switchgear operation by operator. Feeder panel wise (including DC Charger panel, DC Distribution panel, AC distribution Panel and SAS panel) Alarm list shall also be configured. Alarms shall be classified on Priority base (Critical, High, Medium, Low) and Status base (Active-Unacknowledged, Active-Acknowledged, Cleared- Unacknowledged, Cleared- Acknowledged) Different types of process signals shall have different color code. A legend shall be available for the color codes.
g. Event list, station / bay oriented:
h. Trends: All the Feeder specific and common real-time measurement parameter data shall be present in trend and the selection of parameter to be displayed in the HMI shall be configurable. A pop-up shall appear and follow the cursor on the trends to show the corresponding Y-Axis value for every parameter present in trend display. Trends shall have another tab for display of Real time data of different parameters in Analog Dial display.
i. Transformer Health Monitoring: Transformer Oil temperature, Winding Temperature indicator shall have a real time data trend in SAS HMI and A historical report shall be generated for OTI, WTI value for Transformer Healthiness check. Fan status shall be available in HMI with Dynamic visual presentation. Dynamic and Real time data of Oil level shall be present in the HMI. There will be a Different Page for Transformer Status. Transformer Fan status and Control shall be integrated to SAS. A report shall be generated for a selected duration having half hourly data of Transformer Phase respective Voltage, Currents, MW, Mvar, OLTC position, OTI, WTI, value, Fan Status, Transformer Yard Temperature and Humidity etc.

j. System status: This HMI screen shall have different tabs for all the SAS equipments (such as OWS, RTUs, Gateway, Firewall, Ethernet switches, BCPUs, Different controllers and others) Health monitoring and real time status
k. Checking of parameter setting
l. DC charger shall have to be interfaced with SAS system. Charger shall monitor all voltage level and physical condition of battery cells.
m. DC Distribution panels shall have a controller that can be connected to SAS and can monitor all DC distribution MCBs status.
n. AC distribution panels shall have Measurement monitor with distribution MCBs status. The monitor shall be integrated to SAS.
o. Control room AC, Access control (Finger print and Password Protection) shall be integrated to SAS. Switchyard Temperature and Humidity shall also be integrated to SAS.

7.2.9.2.2 HMI Design Principles

Consistent design principles shall be provided with the HMI concerning labels, colours, dialogues and fonts. Non-valid selections shall be dimmed out.

Object status shall be indicated using different status colours for:

- Selected object under command
- Selected on the screen
- Not updated, obsolete value, not in use or not sampled
- Alarm or faulty state
- Warning or blocked
- Update blocked or manually updated
- Control blocked
- Normal state
- Busbar colouring to show live & dead bus

7.2.9.2.3 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 are displayed in the station single line diagram.

In order to ensure a high degree of security against unwanted operation, a special "select – before - execute" command procedure shall be provided. After the "selection" of a switch, the operator shall be able to recognise the selected device on the screen and all other switchgear shall be blocked. After the “execution” of the command, the operated switch symbol shall blink until the switch has reached its final new position.

The system shall permit the operator to execute a command only if the selected object is not blocked and if no interlocking condition is going to be violated The interlocking conditions shall be checked by the interlocking scheme which is implemented on bay level.

After command execution, the operator shall receive a confirmation that the new switching position is reached or an indication that the switching procedure was unsuccessful with the indication of the reason for non-functioning.

7.2.9.2.4 System Supervision Display

The SA system shall feature comprehensive self-supervision such that faults are immediately indicated to the operator before they possibly develop into serious situations. Such faults are recorded as faulty status in a system supervision display. This display shall cover the status of the entire substation including all switchgear, IED's, communication links, and printers at the station level etc.

7.2.9.2.5 Reports

The SA shall generate reports that provide time related information on measured values and calculated values all accessed from Energy meter. The data displayed shall comprise:

Trend reports:

- Day (mean, peak)
- Month (mean, peak)
- Semi-annual (mean, peak)
- Year (mean, peak)

Historical reports:

- Day
- Week
- Month
- Year

It shall be possible to select displayed values from the database on-line in the process display. 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.
This report shall be printed automatically at pre-selected times. It shall also be possible to print this report on request.

7.2.9.2.6 Trend Display (Historical Data)

A trend is a time-related follow-up of process data. The analogue channels of all the connected bay level devices on the 33 kV level shall be illustrated as trends. The trends shall be displayed in graphical form as columns or curve diagrams with 10 trends per screen as maximum.

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.

7.2.9.2.7 Event List

The event list shall contain events, which are important for the control and monitoring of the substation. The time 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. The information shall be obtainable also from 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
- Violation of upper and lower limits of analogue measured value.
- 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
- Alarm class

7.2.9.2.8 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. Date and time of occurrence shall be indicated.
The alarm list consists of a summary display of the present alarm situation. Each alarm shall be reported on one line that contains:

- The alarm date and time

- The name of the alarming object
- A descriptive text
- The acknowledgement state

The operator shall be able to acknowledge alarms, which shall be either audible or only displayed on the monitor. Acknowledged alarms shall be marked at the list.

Faults that appear and disappear without being acknowledged shall be specially presented in a separate list for fleeting alarms. For example due to bad contacts or intermittent operation.
Filters for selection of a certain type or group of alarms shall be available as for events.

7.2.9.2.9 Object Picture

When selecting an object such as a circuit breaker or isolator in the single line diagram, first the associated bay picture shall be presented. In the selected object picture, all attributes such as-

- type of blocking,
- authority
- local / remote control
- SA control
- errors,
- etc., shall be displayed.

7.2.9.2.10 Control Dialogues

The operator shall give commands to the system by means of soft keys located on the single line diagram. It shall also be possible to use the keyboard for soft key activation. Data entry is performed with the keyboard.

7.2.9.2.11 User Authority Levels

It shall be possible to restrict the activation of the process pictures of each object (bays, apparatus, etc.) to 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 apparatus)
- Restricted operation (e.g. by-passed interlock)
- 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.

7.2.9.3 System Performance

The refresh/update times on the operator station PC under normal and calm conditions in the substation shall be according to the levels specified below:

Function	Typical values
Exchange of display (first reaction)	< 1 s
Presentation of a binary change in the process display	< 0.5 s
Presentation of an analogue change in the process display	< 1 s
From order to process output	< 0.5 s
From order to update of display	< 1.5 s

7.2.9.4 System Reliability

The SA system shall be designed to satisfy very high demands for reliability and availability concerning:

- Solid mechanical and electrical design
- Security against electrical 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, according to IEC 1131-3, of the application software
- Built-in supervision and diagnostic functions
- After sales service
- 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 to provide immunity against transient ground potential rise

7.2.9.5 Configuration Tools:

The configuration of the station HMI shall be made using the operator station working in Windows environment. The various functions shall be customised by easy to use interactive configuration tools. Configuration shall include the visual presentation of the object, adaptations needed in process database and adaptations of the communication configuration data.

A portable Personal Computer (PC) as a service unit shall be foreseen for on-site modifications of the control and protection devices. The service unit shall be used for documentation, test and commissioning.

The PC based service & support system shall be used for the following purposes:

- System configuration
- System testing
- Help functions
- Program documentation
- Down- and up-loading of programs
- System commissioning
- Data base management
- Changing peripheral parameters

The service & support system shall be able to monitor data in the running substation control system and to present changing variables on the display screen in graphic representation.

7.2.9.6 Information Required

The following documentation shall be provided for the system during the course of the project and they shall be consistent, CAD supported, and of similar look/feel:

- List of Drawings
- Control Room Lay-out
- Assembly Drawing
- Single Line Diagram
- Block Diagram
- Circuit Diagram
- List of Apparatus
- List of Labels
- Functional Design Specification (FDS)
- Test Specification for Factory Acceptance Test (FAT)
- Logic Diagram
- List of Signals
- Operator's Manual
- Troubleshooting Manual
- Product Manuals
- Calculation for uninterrupted power supply (UPS) dimensioning
- Licensed Copy of all software
- Third Party cyber security certification

7.2.9.10 Documentation required

Submission of Type Test Reports/ Certificate as stated in per relevant IEC from recongnized independentlabrotories.

7.2.9.11 Technical Orientation and Quality Test Witness (Acceptance test) of SAS :

The employer / purchaser shall have the right to inspect/test the automation system to confirm their conformity to the specification. The purchaser shall be entitled at all

reasonable time during manufacture to inspect, examine and test of automation system at the manufacturers' premises, workmanship and performance.

The following test shall be carried out as per latest version of IEC or equivalent standard unless otherwise mentioned at the manufacturer premises or other places where the test facilities are available:-

- Routine tests
- **Demo test run of SAS from SCADA System at Manufacturer's premises.**

The Supplier shall, after consulting the purchaser, give the Purchaser reasonable notice in writing of the date on and the place at which any material or equipment will be ready for testing as provided in the contract and unless the purchaser shall attend at the place so named on date, which the supplier has stated in his notice, the supplier may proceed with the tests, which shall be deemed to have been made in the purchaser's presence, and shall forth with forward to the purchaser duly certified copies of test readings.

When the purchaser intends to attend the test he shall promptly inform the supplier accordingly in writing, so that he can take action. The purchaser shall give the supplier timely notice in writing of his intention to attend the test.

Where the supplier provides for tests on the premises of the supplier or of any manufacturer of the supplier, except where otherwise specified, shall provide free of charge such assistance, labor, materials, electricity, fuel, stores, apparatus and instruments as may be requisite and as may be reasonably demanded to carry out such test efficiently. These test shall be performed as per relevant IEC Standard or equivalent and only routine tests as agreed upon, will be performed.

As and when the purchaser is satisfied that any materials/equipment shall have passes the tests referred to in this clause, purchaser shall notify the contractor in writing to that effect.

Should any inspected/tested goods fail to conform to the specification, the Purchaser shall have the right to reject any of the item or complete batch if necessary. In that case Supplier has to replace the Equipment and to make good of them without any financial involvement to the Purchaser. In case any of the Equipment found not conforming withthe specification at the time of post landing Inspection, the supplier will in no way be relieved from the responsibility of replacing them on making them good at their own cost, despite the Equipment were found good at the time of Factory Acceptance Test. Nothing in this clause shall in any way release the supplier from any warranty or other obligations under the contract.