

TECHNICAL **SPECIFICATIONS**

CHAPTER 15- SUBSTATION AUTOMATION SYSTEM

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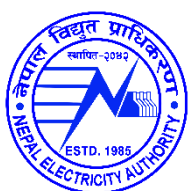
PACKAGE KC-6

of

KOSHI CORRIDOR 220kV TRANSMISSION LINE PROJECT

IFB No.: KOSHI/NEA/KC-6

**Procurement of Design, Supply, Installation, Testing
and Commissioning of 220kV(GIS)/132kV
Substation Expansion at Dhungesanghu Substation**



नेपाल विद्युत प्राधिकरण
(नेपाल सरकारको स्वामित्व)
Nepal Electricity Authority
(A Government of Nepal Undertaking)

CHAPTER 15: SUBSTATION AUTOMATION SYSTEM

1. GENERAL

- 1.1. The Substation Automation System (SAS) shall be installed to control and monitor all the sub-station equipment from Master/Remote Control Centers (MCC/RCC) & Load Dispatch Center Nepal (LDC), as well as from local control center.
- 1.2. The SAS shall contain the following main functional parts:
 - Bay Control Unit (BCU) Intelligence Electronic Devices (IEDs) for control and monitoring.
 - Bay Level Unit for Auxiliary system (as per requirement)
 - Redundant Station Human Machine Interface (HMI) 1 & 2 with industrial grade rack mounted servers and monitors
 - Redundant managed switched Ethernet Local Area Network communication infrastructure with hot standby.
 - Disturbance Recorder Work Station (Maintenance HMI) with monitor
 - Redundant rack mounted Main Servers 1 and 2
 - Redundant Gateway 1 & 2 for remote monitoring and control via industrial grade servers (to MCC/RCC, LDC etc.), the gateway should be able to communicate on IEC 60870-5-104 protocol.
 - Disturbance Recorder/Maintenance/Engineering PCs with monitor as specified.
 - 1 Set of Firewall with 2 nos. of Router & Modems as per requirement
 - One (1) GPS Master Clock System with interface to secondary system
 - Large Screen Display System with Controller
 - Peripheral equipment like Color Laser A4 printer (For Reports, Disturbance records, Alarms and log sheets), display units, key boards, Mouse etc.
 - Communication infrastructure between Bay level units, Station HMI, Printers, gateways, redundant LAN etc. as required.
 - 2 Nos. of Pure Sinewave Inverter and Associated Accessories. The size of the Inverter shall be decided by contractor as per load calculation; however, the minimum size shall be 3.5 kVA.
 - One set of furniture for local control center.
 - Configuration of gateway to communicate with Employer existing LDC system for exchange of desired data. The details of Data acquisition principles (types of analogue /digital data) for control, monitoring of substation is as per Annexure-I.
 - Merging Units & Switchgear Controller IEDs (applicable for Process Bus based SAS only) only if Digital Substation specified in Chapter-PSR.
 - Remote disturbance recorder workstation and Remote HMI work station along with necessary printers & furniture only if specified in Chapter-PSR.
 - It shall be the bidder's responsibility to configure gateway and integrations with Employer Master Control Center (MCC) for remote operation of substation from the MCC only if specified in Chapter-PSR.
- 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.
- 1.4. It shall include communication gateway, intelligent electronic devices (IED) for bay control and inter IED communication infrastructure. An architecture drawing for SAS is enclosed.
- 1.5. The communication gateway shall facilitate the information flow with remote control centres. The bay level intelligent electronic devices (IED) for protection and control



shall provide the direct connection to the switchgear without the need of interposing components and perform control, protection, and monitoring functions. However, in case of Process Bus based SAS, Switchgear Controllers (SGCs) shall be used as digital interfaces between switchgear and bay level IEDs.

- 1.6. The Sub-station Automation system being offered shall generally conform to provision of IEC 62351, IEEE1686 and NERC CIP (applicable part such as CIP 003, CIP-005, and CIP-007) for cyber security.
- 1.7. Process bus-based SAS shall be applicable only if specifically Digital Substation envisaged in Chapter-PSR.

2. System design

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-PSR.

The systems shall be of the state-of-the art suitable for operation under electrical environment present in Extra high voltage substations, follow the latest engineering practice, ensure long-term compatibility requirements and continuity of equipment supply and the safety of the operating staff.

The offered SAS shall support remote control and monitoring from MCC/RCC 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. It shall also have provisions for inhibiting control on any or all devices for purpose of maintenance. The devices under maintenance shall be provided with tags which shall include provision for entering text (256 characters).

Maintenance, modification or extension of components may not cause a shutdown of the whole substation automation system. Self-monitoring of components, modules and communication shall be incorporated to increase the availability and the reliability of the equipment and minimize maintenance.

IP addressing of the system shall be as per the IP plan provided by the owner.

The system shall be remotely accessed for collection of disturbance records and hence shall be provided with a firewall/router to comply at least with the requirements of CIP-005, CIP-007 (Critical infrastructure protection) standard as per NERC (North American Electric Reliability Council).

Bidder shall house the Bay level unit (a bay comprises of one circuit breaker and associated disconnecter, earth switches and instrument transformer), bay mimic along with relay and protection panels and PLCC panels (described in other sections of technical specifications) in air-conditioned Switchyard Panel Room suitably located in switchyard (GIS hall relay room in case of GIS s/s) and Station HMI in Control Room building for overall optimization in respect of cabling and control room building.

In case of Process bus-based SAS, both bay level unit and station bus level components can also be placed at a centralized location like control room.

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 three levels, i.e. process level, bay level and station level. Process Level will be applicable only in Process Bus based SAS.

At Process Level (applicable, only in IEC 61850 Process Bus based SAS) is at the switchyard level where instrument transformers, switchgear, transformers/reactor are located, and employs IEC 61850 part 9-2 for communicating Sampled Measured Values (SMV) to the Bay Level IEDs and GOOSE messaging for binary values exchange.

At Bay Level, the IEDs shall provide all bay level functions regarding control, monitoring and protection, inputs for status indication and outputs for commands. The bay level intelligent electronic devices (IED) for protection and control shall provide the direct connection to the switchgear without the need of interposing components and perform control, protection, and monitoring functions. However, in case of Process Bus based SAS, Switchgear Controllers (SGCs) shall be used as digital interfaces between switchgear and bay level IEDs.

Each bay control IED shall be independent from each other and its functioning shall not be affected by any fault occurring in any of the other bay control units of the station.

The data exchange between the electronic devices on bay and station level shall take place via the communication infrastructure. This shall be realized using fibre-optic cables, thereby guaranteeing disturbance free communication. The fibre optic cables shall be run in G. I. conduit pipes. Data exchange is to be realised using the protocols defined and standardized in the latest edition of IEC 61850 with a redundant managed switched Ethernet communication infrastructure. The modelling of various aspects of Substation Automation System, like, Data Objects, Data Attributes, Logical Nodes, etc. shall be according to the latest edition of IEC 61850.

The communication shall be made in fault tolerant ring, excluding the links between individual bay IEDs to switch wherein the redundant connections are not envisaged, such that failure of one set of fiber shall not affect the normal operation of the SAS. However, failure of fiber shall be alarmed in SAS. Each fiber optic cable shall have four (4) spare fibers.

The typical architecture for SAS is enclosed as Annexure.

At Station Level, the entire station shall be controlled and supervised from the station HMI. It shall also be possible to control and monitor the bay from the bay level equipment at all times.

Clear control priorities shall prevent operation of a single switch at the same time from more than one of the various control levels, i.e. MCC/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 Chapter 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.

2.3 FUNCTIONAL REQUIREMENTS



The high-voltage apparatus within the station shall be operated from different places:

- Master/Remote control centers/LDC
- Station HMI
- Local Bay controller IED (in the bays)

Operation shall be possible by only one operator at a time with the priority to the lowest enabled control level.

The operation shall depend on the conditions of other functions, such as interlocking, synchro-check, control-inhibit tags etc. (see description in ``Bay level control function’’).

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 and an alarm shall be generated to indicate the failure of command.

2.3.4 Self-supervision

Continuous self-supervision function with self-diagnostic feature shall be included. The redundant components such as servers, gateway shall monitor each other for availability and the active device shall takeover all the functions of the failed device. This failover shall happen within 30 seconds. The events occurring when a server is in failed state shall be synchronised from the active server.

3 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).

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 unless allowed in the chapter Control Relay & Protection Panels.

3.1.1. Bay control functions

3.1.1.1. Overview of Functions

- Control mode selection
- Select-before-execute principle
- Command supervision:
 - Interlocking and blocking
 - Double command
- Synchrocheck, voltage selection
- Run Time Command cancellation
- Transformer tap changer control (Raise and lower of tap) (for power transformer bays)
- Transformer Master/follower selection
- Operation counters for circuit breakers and pumps
- Hydraulic pump/ Air compressor 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
- Auto-reclose mode selection (non-auto/1-phase etc.)
- Protection transfers switch control (for Transfer Bus scheme arrangement)
- Monitoring of Gas Tight Chambers in GIS
- Monitoring of temperature of Transformer and Reactor
- Monitoring of multi-gas output of Transformer and Reactor
- Any other requirement specified elsewhere in the specification.

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. All the interlocks shall be get bypassed under such circumstances.

REMOTE mode

Control authority in this mode is given to a higher level (Master/Remote Control Centre/Station HMI) and the installation can be controlled only remotely. Control operation from lower levels shall not be possible in this operating mode.

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

3.1.1.4. 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.

3.1.1.5. Transformer tap changer control

Digital RTCCs shall be integrated with the SAS to provide Tap Changer Control functions. Raise and lower operation of OLTC taps of transformer facilitated through Bay controller IED should only be allowed if approved by the employer.

3.1.1.6. Auto-reclose mode selection

Auto-reclose mode selection for each of the Circuit breaker shall be facilitated through bay controller IED.

3.1.1.7. Protection transfer switch control (As applicable)

Based on selection of isolator for double main with transfer switching scheme or single main with transfer switching scheme for the switchyard, the protection shall be transferred automatically with an alarm indication that protection is successfully transferred.

3.1.1.8. Monitoring of Gas Chambers in GIS Sub-stations:

In case of a GIS sub-stations, all the gas tight chambers are required to be monitored individually phase wise for their SF6 gas density status by the bay control unit in a bay. Sufficient numbers of inputs are required to be provided in the BCU. In case there is any limitation of number of inputs in the BCU, additional BCUs are required to be provided without any cost implication to Employer. These inputs shall be used for necessary monitoring, control and protection purpose.

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 Chapter ~~Relay & Protection~~ Control Relay & Protection Panels.

IEDs, shall be connected to the communication infrastructure for data sharing and meet the real-time communication requirements for automatic functions. The data presentation and the configuration of the various IEDs shall be compatible with the overall system communication and data exchange requirements.

Event and disturbance recording function

Each IED should contain an event recorder capable of storing at least 200 time-tagged events. The disturbance recorder (DR) function shall be as per detailed in Chapter CRP. The DR(s) shall be integrated with the SAS.

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 or through merging units. The values of active power (W), reactive power (VAR), frequency (Hz), and the rms values for voltage (U) and current (I) shall be calculated in the Bay control/protection unit.

3.2. Station Level Functions

3.2.1. Status supervision

The position of each switchgear, e.g. circuit breaker, isolator, earthing switch, transformer tap changer, Transformer/Reactor Temperature, Transformer/Reactor Multi-gas conditions, Temperature of Switchyard Panel Room, Ambient Temperature etc., as applicable 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 center. The abnormal values must be discarded. The analogue values shall be updated based on the dead band settings and the same shall be demonstrated during FAT of the system.

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/notification shall occur. If a selection is valid the position indication will show the possible direction, and the appropriate control execution button shall be pressed in order to close or open the corresponding object.

Control operation from other places (e.g. MCC/RCC/LDC) shall not be possible in this operating mode.

3.2.4.2. Presentation and dialogues

The operator station HMI shall be a redundant with hot standby and shall provide basic functions for supervision and control of the substation. The operator shall give commands to the switchgear on the screen via mouse clicks.

The HMI shall give the operator access to alarms and events displayed on the screen. Aside from these lists on the screen, there shall be a printout of alarms or events in an event log.

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

The following standard pictures shall be available from the HMI:

- > Dynamic Single-line diagram showing the switchgear status and measured values
- > Control dialogues with interlocking or blocking information details. This control dialogue shall tell the operator whether the device operation is permitted or blocked and also show the Interlocking logic with status.
- > Measurement dialogues
- > Alarm list, station / bay-oriented
- > Event list, station / bay-oriented
- > System status

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
- > Energised or deenergised state (based on substation topology)

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 (with 1 ms resolution) of its occurrence has to be displayed for each event.

The operator shall be able to call up the chronological event list on the monitor at any time for the whole substation or sections of it.

A printout of each display shall be possible on the hard copy printer.

The events shall be registered in a chronological event list in which the type of event and its time of occurrence are specified. It shall be possible to store all events in the computer for at least one month. The information shall be obtainable also from a printed event log.

The chronological event list shall contain:

- Position changes of circuit breakers, isolators and earthing devices
- Indication of protective relay operations
- Fault signals from the switchgear
- Indication when analogue measured values exceed upper and lower limits. Suitable provision shall be made in the system to define two level of alarm on either side of the value or which shall be user defined for each measurands.



- Loss of communication.
- User actions (control/Tag placement/manual update) with USER identity
- System messages (Operator logging info, System supervision and device monitoring, failure of supervisory control etc.)

Filters for selection of a certain type or group of events shall be available. The filters shall be designed to enable viewing of events grouped per:

- Date and time
- Bay
- Device
- Function e.g. trips, protection operations etc.
- Alarm class

3.2.4.7. Alarm list

Faults and errors occurring in the substation shall be listed in an alarm list and must be displayed in a flashing state along with an audible alarm. After acknowledgement of the alarm, it should appear in a steady (i.e. not flashing) state and the audible alarm shall stop. The alarm should disappear only if the alarm condition has physically cleared and the operator has reset the alarm with a reset command. The state of the alarms shall be shown in the alarm list (Unacknowledged and persistent, Unacknowledged and cleared, Acknowledged and persistent).

Filters for selection of a certain type or group of alarms shall be available as for events.

In addition to the regular alarms, following alarms shall also be displayed and logged:

- Alarms shall be displayed on the HMI, for each device of SAS when they lose time synchronization.
- 'GOOSE Fail Alarm' shall be configured which shall be generated when any of the subscriber IEDs fails to receive any of the GOOSE messages. These alarms shall be mapped IED-wise in the station HMI.

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/Control inhibit Tag
- Authority
- Local / remote control mode
- RCC / 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
- Mode selection (L/R, Non-Auto/1-ph, Auto/Manual etc.)



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.

In case of non-activity for a pre-determined period (say 30 minutes), the system will automatically logged out the user and user has to log in again for doing any operation. Further each operation must be logged in in the event/alarm list along with the user name.

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 stored values from the database in the process display on-line. Scrolling between e.g. days shall be possible. Unsure values shall be indicated. It shall be possible to select the time period for which the specific data are stored in the memory.

Following printouts shall be available from the printer and shall be printed on demand:

- i. Daily voltage and frequency curves depicting time on X-axis and the appropriate parameters on the Y-axis. The time duration of the curve is 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 vale 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.
- ix. It shall be possible to generate user made reports based on measured/recorded values of various combination of parameters particularly for transformer and reactors for healthiness of equipment depending upon defined criterion. These generation of reports must be user friendly and shall be easy to define.

All the utilities/tools used for building a report shall be provided with the system so that the owner is able to build new reports. The tools shall be user friendly with 'drag & drop' or 'menu based selection' features and shall not require any knowledge of programming.

The reports utility shall be configured such that reports requiring long duration data (yearly) shall not take more than 2 minutes and does not impact the other applications running in the system.

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 and once per day in case no event during the day) to a dedicated computer and be stored on the hard disc in specified folders.

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 in a GIS). It must be possible to initiate pre-defined automatic sequences by the operator and also define new automatic sequences. The automatic sequencing is required to be developed at SCADA level.

3.3. Gateway

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 on each gateway (two gateways per station) as follows:

- (a) Three ports for Remote/Master Control Centers on Secure IEC 60870-5-104 protocol.
- (b) One port on IEC 60870-5-104 for LDC

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/RCC& LDC). 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/master control centre. Also, each control centre's data scan and control commands may be different for different data points within the substation automation system's database.

The Gateway shall collect the IEC 61850 data directly from the IEDs through Ethernet switches, without using any other intermediate interface or network device, and should be implemented in a separate hardware, so that the failure of the local SCADA Server would not impact the remote communication through the Gateway.

The Gateway shall identify the actions performed by the each of the remote masters individually and log it in its database. The logs for last 120 days shall be stored and accessible at the Station HMI.

3.3.2 Remote/Master Control Centre Communication Interface

Employer will supply communication channels between the Substation Automation System and the remote/Master control center. The communication channels provided by Employer will consist either of power line carrier, optical fibre, or leased line, the details of which shall be provided during detailed Engineering.

3.3.3 Interface equipment

The Contractor shall provide interface equipment for communicating between Substation Automation system and MCC/RCC and between Substation Automation system and LDC. However, the communication channels available for this purpose are specified in Chapter-PSR.

The communication interface with the MCC/RCCs is an Ethernet interface. In case of PLCC communication (if any) any modem supplied shall not require manual



equalization and shall include self-test features such as manual mark/space keying, analogue loop-back, and digital loop-back. The modems shall provide for convenient adjustment of output level and receive sensitivity. The modem should be stand alone complete in all respects including power supply to interface the SAS with communication channel. The configuration of tones and speed shall be programmable and maintained in non-volatile memory in the modem. All necessary hardware and software shall also be in the scope of bidder except the communication link along with communication equipment between substation control room and Remote Control Centre.

3.3.4 Communication Protocol

The communication protocol for gateway to control centre must be open protocol and shall support IEC 60870-5-104 and IEC 61850 for all levels of communication for sub-station automation such as Bay to station HMI, bay to bay etc. based on requirement specified. The protocol shall support the features such as Report by exception; Periodic reporting so that the data update times at the MCC/RCC & LDC can be optimised.

4.0 System hardware:

4.1. Redundant Station HMI, Remote HMI (Remote HMI only if mentioned in Chapter-PSR) 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 for two years and trend data for thirty (30) days,
2. Storage of all necessary software,
3. 1TB space for OWNER'S use.

Supplier shall demonstrate that the capacity of hard disk is sufficient to meet the above requirement.

4.1.1. Operator/Workstations with Relational Database

Two operator stations, each fitted with one monitor of 32" diagonally and laser printers shall be provided for the complete operation and supervisory functions.

The man machine interface shall incorporate the following functions:

- Monitoring and operation of the entire power scheme;
- Event handling and event list;
- Alarm functions and alarm list;
- Trend data logs and trend display;
- Report functions;
- Status list;



- Display printout;
- Communication with controllers;
- Display design and integration.

Minimum Specification of each Branded Operator/Workstation shall be as follows:

- (a) Type: Industrial Grade
- (b) 512GB SSD, 1 TB of HDD & DVD RW
- (c) 8 GB of DDR5 RAM or better
- (d) Genuine Windows 11 Pro Operating System
- (e) i7-13 generation 16 core H Series processor or better
- (f) Redundant Ethernet Ports

4.1.2. Disturbance Recorder Work Station/Engineering Station

The engineering and configuration station shall be equipped with one monitor of 32" diagonally and laser printer. At the station the following functions shall be possible, but not limited to:

- Database creation and modification;
- Mimic views creation and modification;
- System operation and maintenance.

Minimum Specification of Branded Engineering Station shall be as follows:

- (a) Type: Industrial Grade Rack Mounted
- (b) 512GB SSD and 1 TB of HDD
- (c) 16 GB of DDR5 RAM or better
- (d) Genuine Windows 11 Pro Operating System
- (e) i7-13 generation 16 core H Series processor or better
- (f) Redundant Ethernet Ports
- (g) Antivirus Software for 1 year

4.1.3. Redundant Main Servers 1 and 2

Redundant industrial rack type data servers in hot standby shall be used to perform the station control functions and monitor the substation equipment.

The data servers shall carry out the following function, but not being limited to:

- Signalling and measuring data acquisition from local control level;
- Data transfer to the different sub-systems;
- Electrical measurements and calculations;
- Remote control of the substation from the MCC/RCC/LDC;
- Metering and signalling.

The primary function of the SAS in the Central Control Room shall include, but not be limited to the following features and requirements:

- Switching (on / off) of circuit breakers, isolators, earthing switches;
- Operation of switchgears;
- Operation of main AC/DC station service main circuit-breakers.



Minimum Specification of each Branded Redundant Main Servers 1 and 2 shall be as follows:

- ❖ Type: Industrial Grade Rack Mounted
- ❖ 512 GB SSD and 1 TB of HDD Storage or better
- ❖ 16 GB DDR5 , RAM or better
- ❖ Genuine Operating System
- ❖ i7-13, 3.1 GHz generation 16 core processor or better
- ❖ 4 Numbers of Gigabit Ethernet Ports
- ❖ 2 Numbers of Power Supply Units (minimum)

4.1.4. GPS Master Clock System

The SAS requires exact time information at various stations to apply signalling time stamps accurately or to schedule time-dependent procedures.

The scope shall comprise a complete functional clock system, including but not be limited to the following equipment:

- Clock system mounted in a free-standing cubicle;
- Cable distribution system with junction terminals using and extending, if necessary, the communication tray and junction system;
- Differential frequency / time indicator with automatic and manual adjuster in the control panel;
- Antenna, receiver and system interface module for receiving the international time signal (GPS) to adjust the clocks automatically;
- Output signal for secondary clock system (minute- and second-pulses).

The digital clock system shall have provision for time stamping of events with a resolution of 2 ms or better. The clock shall be synchronised by the GPS system to give an absolute accuracy of time stamps of better than 1 ms. The antenna shall be mounted in an adequate position.

All digital control and protection systems shall be synchronised with the master clock system. The clock system shall be designed and installed as a master-slave system with independent timing and adjustment possibilities.

The master clock shall be controlled by a temperature stabilised quartz oscillator with an accuracy of 0.01 s/ day producing all reference data necessary to control and supervise electronic and electromechanical time-controlled equipment.

A digital frequency differential indicator shall be installed in the control panel showing the network frequency, the quartz frequency and the difference in seconds. A manual adjuster shall be installed; an automatic adjustment shall take place every 24 hours.

The system shall work on seconds, minutes and hourly impulses. For day and month indication a memory shall be installed.

The system shall be supplied by the UPS system.

4.1.5. Redundant Gateway Servers 1 & 2 to the MCC/RCC and LDC

The pertaining national specifications for power system / dispatch system interface shall be observed. Detailed data exchange requirements shall be determined during the detailed design. The gateway protocol shall be in accordance with the national protocol standards.

Minimum Specification of each Branded Gateway Servers 1 and 2 shall be as follows:

- ❖ Type: Industrial Grade Rack Mounted



- ❖ 512 GB SSD and 1 TB of HDD Storage or better
- ❖ 16 GB RDIMM, 3200MT/s RAM or better
- ❖ Genuine Operating System
- ❖ i7-13 generation 16 core processor or better
- ❖ 4 Numbers of Gigabit Ethernet Ports
- ❖ 2 Numbers of Power Supply Units (minimum)

4.1.6. **Portable Service Station**

One industrial standard notebook computer shall be provided. The notebook shall be suitable of connection to each unit via a local sub-bus system to the unit controller; or directly to the main station bus and equipped with all relevant interface and protocol software.

Minimum Specifications of the Branded Portable Engineering Workstation shall be as follows:

- ❖ 16GB DDR5 RAM
- ❖ 1TB PCIe/ NVMe SSD for storage
- ❖ 15.6 Inch at least (1920 x 1080p) Display
- ❖ i7-13 generation 16 core processor or better
- ❖ Genuine Windows 11 Pro

4.1.7. **Large Screen with Controller**

A high-resolution large screen (65" Diagonally, 4K, UHD) shall be installed in the Local Control Room. The relevant displays shall be selectable from the large screen controller.

The large screen shall include the interfaces to the SAS and shall include all related supports and equipment, coupling units, software etc. to provide a functional system.

The large display system (dashboard) shall have minimum display size of 84" diagonally with resolution of 3840*2160 (4K). The large video screen should have inbuilt Wi-Fi, HDMI and USB connectivity. The contractor should provide all the necessary accessories/peripheral for the independent operation of the video screen.

The large screen shall be operable in parallel to the monitors.

4.1.8. **Interface to Office LAN and Web Client with Remote Access**

This interface with firewall shall enable communication to an office Ethernet LAN and to a web client providing a remote access function for unit and system diagnosis.

The remote access interface to the process control system shall be used to provide specialist assistance, maintenance support or for diagnosis of the SAS.

4.1.9. **Metering Station**

The metering system shall be of digital type with accuracy classes suitable for revenue purposes.

The pertaining national specifications for power system / dispatch system interface shall be observed. The gateway protocol shall be in accordance with the national protocol standards.

The metering station shall be capable of receiving energy pulses from the active and reactive energy transducers or the contact signals and capable of counting and saving them, transmitting them periodically or according to the scanning requirement. The pulse counting rate shall be not higher than 10 pulses/s and the register capacity shall be equal or greater than 16 digits of binary code. The accumulated pulses shall be converted with a conversion factor and displayed with the actual kWh and kVarh.



Note: Energy Meters Data shall be integrated to SCADA system for reading and data analysis purposes.

4.1.10. Inverter System

The main characteristics of the inverter system shall be the following:

- (a) Rated Input Voltage : 220/110V DC (existing)
- (b) Output Voltage VAC : 230V AC
- (c) Rated Output: : 3.5 kVA (min)
- (d) Permissible Variation of the Input Voltage: 0.8 to 1.15
- (e) AC Voltage Stability (Steady State) : $\pm 1\%$
- (f) AC output voltage waveform : Pure Sinusoidal
- (g) Harmonic Voltage Distortion (Linear Load): $\leq 5\%$
- (h) Voltage Recovery Time : ≤ 4 ms
- (i) Frequency : 50 Hz
- (j) Maximum Frequency Variation : $\pm 1\%$
- (k) Minimum Power Factor Range : 0.8 to 1
- (l) Noise Level: dB (A) : 60
- (m) Permissible Overload Minimum for 1 min/10 min: 150% / 125%
- (n) Protection Class : IP41
- (o) Safety & protections: Short Circuit, Over Temp, Battery Low/High, Mains MCB Trip etc. With

4.1.11. 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.

4.1.12. 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 32" diagonally in size and capable of colour graphic displays.

The display shall accommodate resolution of 1920 X 1080 pixels.

4.1.13. Printer

The printers shall be of laser type and should have a minimum print resolution of 600*600 dpi and able to print, photocopy and scan the documents. The printers shall have USB, LAN and Wi-Fi Connectivity provisions. The printers shall accept and print all necessary documents 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 offline 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 printers.

4.1.14. 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.

4.1.15. Switched Ethernet Communication Infrastructure:

The bidder shall provide the redundant switched optical Ethernet communication infrastructure for SAS. One switch shall be provided to connect all IEDs in one diameter of 400kV yard, for two bays of 220kV yard, for 4 bays of 132/66 kV and adequate number of switches shall be provided for 33kV & 11kV to communication infrastructure. Each switch shall have at least two spare ports for connecting bay level IEDs and one spare port for connecting station bus.

The Ethernet Fast Switches shall be compliant to IEC 61850. These Switches shall be suitable for the substation environment and shall conform to type tests as per IEC 61850-3.

4.1.16. Firewall and Router

There shall be two sets of Firewall and Routers which shall be connected to a LAN. This LAN shall be different than the IEC 61850 LAN. The substation firewall and router shall be suitable for the substation environment and shall comply with the requirements for IEC 61850-3.

The substation firewall shall have the following features:

- IP firewall features such as Address/port inspection and filtering
- Shall be stateful firewall
- Shall support upto 4 Ethernet switches 10/100 Mbps
- Shall support IPv4 and IPv6
- Shall have IP sec/VPN with 3DES/AES encryption
- Shall have NAT
- Shall have syslog capability
- Shall be NERC compliant
- Shall have hot- standby operation with similar router

The substation routers shall have the following features:

- Routing protocols such as OSPF and support for IPv4 and IPv6
- 4 Ethernet interfaces of 10/100 Mbps
- 2 E1 interfaces
- Hot standby operation with a similar router
- Support IEEE 802.3u, 802.1p, 802.1Q, 802.1d, 802.1w,
- Traffic prioritization for routed IP flows/ports

The substation firewall and router can be a single device.

4.2. Bay level unit or Bay control unit (BCU)

4.2.1 General

- Bay Control Unit (BCU) shall be provided for each Bays (a bay comprises of one circuit breaker and associated disconnector, earth switches and instrument transformer, Number of bays shall be as per Chapter-PSR) for control and monitoring of the bay equipment. Separate BCU (as per Chapter-PSR) shall be provided for the monitoring of substation auxiliaries.
- The BCUs shall have adequate capacity for the estimated hardwired Inputs & Outputs plus a minimum of two Inputs and a minimum of two outputs as spare capacity per BCU. Requirement for external IO modules shall be avoided as far as possible.



- BCUs shall have redundant DC Power Supply or with automatic changeover scheme, to be fed from the two station DC power supplies. Each power supply shall be supervised separately and alarmed.
- Each BCU shall be equipped with Local HMI (display) facilities, enabling control of each particular bay from BCU whenever required. The Local HMI facilities shall be accomplished by means of Graphical LCD display embedded into the front panel of the BCU. Display will show the color dynamic SLD (with device identification number) showing status of bay switching equipment (such as circuit breaker, isolators, earth switches) and enabling issuance of switching controls. Other display type will be multiple displays of analog values readings / reports, displays for controls other than switching, Alarm panel displays, Diagnostic/ on- line configuration displays etc.
- In the event of switchgear apparatus controls, the software-interlocking scheme should be applied based on hardwired analog/digital inputs or Process Bus signals. In the event of closing control for circuit breakers requiring checking of synchronization conditions, software synchro- check scheme should be applied as well. Auto-reclose functions mentioned elsewhere in the specification, if required, can also be applied.

4.2.2 Design

- The bay unit shall use industrial grade components. The bay level unit, based on microprocessor technology, shall use numerical techniques for the calculation and evaluation of externally input analogue signals. They shall incorporate select-before-operate control principles as safety measures for operation via the HMI. Following power interruption and/or communications failure, the BCU shall be capable to restart automatically. Time synchronisation of BCUs with UTC time shall be done over the IEC 61850 field LAN for Substation with SAS. For conventional substation, Time synchronisation of BCU shall be done by other suitable Time synch input like IRIG-B, RS232 etc.
- They shall perform all bay related functions, such as control commands, bay interlocking, data acquisition, data storage, event recording and shall provide inputs for status indication and outputs for commands. They shall be directly connected to the switchgear. However, in case of Process Bus based SAS, Switchgear Controllers (SGCs)/Merging Units (MUs) shall be used as digital interfaces between switchgear/instrument transformers and bay level IEDs. The bay unit shall acquire and process all data for the bay (Equipment status, fault indications, measured values, alarms etc.) and transmit these to the other devices in sub- station automation system. In addition, this shall receive the operation commands from station HMI and control centre.
- One no. Bay Control unit shall be provided for supervision and control of each 400, 220, 132, 66 kV bay (a bay comprises of one circuit breaker and associated disconnector, earth switches and instrument transformer) & 33 & 11 kV as per specifications. 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. Further in case of one



and half breaker schemes, the BCU for Tie CB shall be provided in Tie CB relay panel. The tie CB relay panel shall also house the Ethernet switch(es) to be provided for the diameter. The bay control unit for future bay (if required as per Chapter-PSR) 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.

4.2.3 Input/ Output (I/O) modules (applicable for non-Process Bus SAS)

- The I/O modules shall form a part of the bay level unit / Bay control unit and shall provide coupling to the substation equipment. The I/O modules shall acquire all switchgear information (i.e. data coming directly from the switchgear or from switchgear interlocking devices) and transmit commands for operation of the switchgear.
- It shall be suitable for analog inputs from secondary of instrument transformers.
- The BCU/IED shall be able to integrate at least 10 analog input channels as a minimum and digital input / output channel to meet the control & monitoring scheme requirement.
- Plant alarms and indications will be derived as digital input. Plant contacts shall change state to register the specified status change or alarm, and each input shall be configurable to register a positive input from either a closed or open contact, i.e. input signals may be either a normally open or a normally closed contact. Alarm contacts may be either fleeting or sustained inputs. Digital filtering to suppress plant contact bounce shall be provided for each input. Time tagging to a resolution of 1 ms shall be provided.
- The pulse counting inputs shall be provided as per scheme requirement. These inputs shall acquire and count impulses produced by potential free contacts, which can be either, normally open or normally closed. Pulse counting inputs shall be provided as either a separate input module or using digital inputs. These inputs shall meet the same requirements specified for digital inputs; additionally they shall be able to cater for pulse rates up to 10 per second.
- Where DC analogue measurement inputs are provided as per the scheme requirement, they shall be capable of accepting unipolar and bipolar current of range 0-10/4-20mA and -10 to +10 mA (range as applicable for the project), with over/under range detection.
- The command outputs shall be designed to provide select and execute outputs. The period of the command pulse shall be configurable between 0.1 second and 15 seconds on point basis. The command pulses shall reset immediately after the command is executed. Controls transmitted between the operator workstation of SAS / SCADA and the BCU shall comprise a select, check back & execute sequence (or other means of providing high message security).

4.2.4 The BCU supplied for substation automation system shall further meet the requirements mentioned elsewhere in the specification

4.3. Extensibility in future

Offered substation automation system shall be suitable for extension in future for additional bays. During such requirement, all the drawings and configurations, alarm/event list etc. displayed shall be designed in such a manner that its extension shall be easily performed by the employer. During such event, normal operation of the existing substation shall be unaffected and system shall not require a complete shutdown. The contractor shall provide all necessary software tools along with details



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. Following is to be ensured during initial supply of system:

- All the licenses for various components such as SCADA, servers, configuration tools for various IEDs, Gateways etc. shall be for complete system i.e. system as per single line diagram including both present and future scope plus 30% spare. The contractor shall submit the list of equipment and Inputs/Outputs covered under the licenses provided.
- All the servers shall be capable of handling total system (present and future).

In case of extension packages, the interoperability between devices compliant to IEC 61850 Edition 2 (or latest) and existing devices compliant to IEC 61850 Edition 1 should be ensured.

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 Station level software

5.1.1 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.

5.2 Bay level software

5.2.1 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.

5.2.2 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 form part of a library.

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

5.3 Network Management System:



The contractor shall provide network management system software for following management functions:

- a. Configuration Management
- b. Fault Management
- c. Performance Monitoring

This system shall be used for management of communication devices and other IEDs in the system. This NMS can be loaded in DR work-station and shall be easy to use, user friendly and menu based. The NMS shall monitor all the devices in the SAS and report if there is any communication fault/problem in the monitored devices. The NMS shall

- (a) Maintain performance, resource usage, and error statistics for all managed links and devices and present this information via displays, periodic reports and on demand reports.
- (b) Maintain a graphical display of SAS connectivity and device status.
- (c) Issue alarms when error conditions occur
- (d) Provide facility to add and delete addresses and links

5.4 Operating System

The Operating system of the Servers, HMIs and Gateways shall be hardened in line with the following suggested guidelines to reduce its vulnerability to cyber-attacks.

5.4.1 Secure Build Strategy

Packages unnecessary for system operation are not to be installed during the initial build of the servers and workstations, reducing the amount of post-build hardening required. Any package that must be installed but is not required to be actively running have to be disabled.

The software to be removed and/or disabled includes, but is not limited to:

- Games
- Messaging services
- Servers or clients for unused Internet services
- Software compilers (except where required, i.e. development platform)
- Unused networking and communication protocols
- Unused operating system features
- free utilities delivered with OS

5.4.2 Generic and Default Accounts

Disable or remove all unnecessary generic and default user accounts from the operating system and third party applications. Application accounts (such as daemon) that exist strictly for identification and ownership are disabled from all interactive, network, or other access to prevent unauthorized access. Required accounts and their functions have to be documented.

5.4.3 Insecure Protocol

Insecure protocols such as telnet, FTP, RSH, and RCP have to be disabled from operation.

5.4.4 Malicious Software Prevention

Implementation of anti-virus and other malicious software prevention tools to detect, prevent, deter, and mitigate the introduction, exposure, and propagation of malware. Supplier shall verify that commercially available anti- malware products do not cause harm to the product.

Provide procedures on how to update the signature database of the anti- malware software, if provided.



5.4.5 System Whitelisting

System whitelisting is to be done i.e. the software takes an inventory of the host in a known good state, and any applications not present at that time (such as viruses, malware, games, portable applications, etc.) are prevented from executing.

5.4.6 Ports and Services

The system shall be configured by the supplier to only use those ports and services required for normal and emergency operations. The ports and services required for operation are documented and supplied to the customer as part of the deliverable system documentation.

5.4.7 Host-Based Firewalls

The host-based firewalls shall be configured with a standardized set of rules as an additional layer of security if the network firewall to fail. The host-based firewalls are configured with a default deny rule that logs any traffic not explicitly allowed.

In the case where a service cannot be disabled but does not require communication with hosts external to itself, this host-based firewall also serves to prevent any communication to the port(s) used by that service.

5.4.8 Removable Media

Removable media (CD and DVD, USB Drives, etc.) is not required for the operation of the SAS and may be inhibited from operation except in case of data back up on CD/DVD as per specification.

- 5.5 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.

6.0 General Guidelines for IEC 61850 SAS Engineering:

- i. Data exchange is to be realised using the protocols defined and standardized in the latest edition of IEC 61850 with a redundant managed switched Ethernet communication infrastructure. The modelling of various aspects of Substation Automation System, like, Data Objects, Data Attributes, Logical Nodes, etc. shall be according to the latest edition of IEC 61850.
- ii. During the GOOSE communication engineering, it shall be ensured that the publishing IEDs shall have the quality attribute included invariably for each GOOSE message in the GOOSE dataset. Further, the subscriber IEDs shall not use any GOOSE message which it receives without the quality attribute.
- iii. The GOOSE subscribing IEDs shall have the feature of detecting duplicate GOOSE message and intrusion using State Number (StNum), Sequence Number (SqNum) fields of a GOOSE message. Once duplicate GOOSE messages or intrusion is detected, the subscribing device shall discard the GOOSE messages from that particular publishing device and shall generate an alarm.
- iv. If the association between the publisher and subscriber is lost (please refer Sec. 6.2 of IEC 61850 part 7-3), the 'validity' field of the quality will be set to questionable, and the detailQual 'oldData' will be set. The rest of quality fields will not be changed.
- v. Separate VLANs shall be created for multicast communication between IEDs belonging to different voltage levels. Also, a 'Cross-VLAN' shall be created which will include the IEDs of different voltage levels together as per the requirement of the cross communication for control/protection schemes.
- vi. A guideline over usage of logical nodes for Report Control/ GOOSE control engineering shall be issued during the detailed engineering.



- vii. In the control and protection schemes, wherever GOOSE messages are used, the schematic documents submitted by the vendor should indicate the communication between LNs used in the indicating the source and destination LNs.

7.0 Additional Requirements for IEC 61850 based Process Bus Projects (Applicable only if Process Bus SAS is specified in Chapter-PSR):

(i) Switchgear Controllers (SGC) IED

- SGCs shall function as digital interface between switchgear and control and protection IEDs (bay level IEDs) and shall be installed near the switchgear in the switchyard.
- SGCs shall be able to withstand the electrical and environmental conditions of the switchyard, like, temperature (preferably in the range of -25°C to 70°C temperature), humidity, electromagnetic interference (EMI/EMC) conditions, radio interference etc. SGCs shall be installed in panels designed with IP55 protection (or better) for outdoor use. The SGCs shall be suitable for the hostile substation environment and shall comply with the requirements for IEC 61850-3.
- Modelling of SGCs shall adhere to the IEC 61850 standard. Logical nodes, such as, XCBB and XSWI shall be used as the interfaces to Circuit Breaker and Isolator respectively. Engineering of the device shall comply with IEC 61850 Part 6 (Substation Configuration Language). Further, to accommodate supervision inputs and other 4-20mA inputs, Logical Nodes, as defined in the standard (the latest edition of IEC 61850) shall be used.
- The devices shall use Parallel Redundancy Protocol (PRP), and be High- availability Seamless Redundancy (HSR) capable. SGC devices should be time synchronized via SNTP or IEEE 1588v2 (Precision Time Protocol – PTP). No separate cable shall be used for time synchronization purpose. Ethernet based Data Network which will be used for GOOSE communication shall also be used for time synchronization purpose.
- The user shall be able to configure/access the device from the Engineering PC in the Control Room.
- The number of binary inputs and binary outputs along with 4-20mA inputs shall be as per the requirement of the project. These mA inputs can either be provided in SGCs or can be provided in separate IEDs mounted near the equipment.
- Each bay shall have at least one SGC.
- SGCs should be powered by redundant Station DC power supplies and if the same is not available, then external changeover circuit shall be used.

(ii) Merging Units (MU) for Conventional CT and VT

- Merging Units (MU) shall digitize the conventional CT and VT values as per IEC 61850 Sampled Measured Values (SMV).
- MUs shall be able to withstand the electrical and environmental conditions of the switchyard, like, temperature (preferably in the range of -25°C to 70°C temperature), humidity, electromagnetic interference (EMI/EMC) conditions, radio interference etc. MUs shall be installed in panels designed with IP55 protection (or better) for outdoor use. The SGCs shall be suitable for the hostile substation environment and shall comply with the requirements for IEC 61850-3.
- Modelling of MUs shall adhere to IEC 61850 standard. Logical nodes, such as, TCTR and TVTR shall be used as the interfaces to Current Transformer and Voltage Transformer respectively. Engineering of the device shall comply with IEC 61850 Part 6 (Substation Configuration Language).
- The devices shall use Parallel Redundancy Protocol (PRP), or/and High- availability Seamless Redundancy (HSR) capable as applicable to meet the SAS architecture requirement. Also, these devices should have the capability to be time synchronized via IEEE 1588v2 (Precision Time Protocol – PTP). No separate cable is envisaged for



time synchronization purpose. Ethernet based Data Network which will be used for SMV transmission shall also be used for time synchronization purpose.

- The user shall be able to configure/access the device from a separate Engineering PC in the Control Room.
- Each bay shall have 2 nos. MUs, each having CT and CVT inputs from different cores. For Bus CVTs, separate MUs shall be provided.
- MUs should be powered from Station DC power supplies, one from source-1 & other from source-2.

(iii) Specific Requirement for Control & Protection IEDs to be used in Process Bus SAS:

- The control and protection IEDs shall have 4 optical ports (2 each for connection with Process Bus LAN and Station Bus LAN). In case of insufficient availability of number of ports natively in the IED, then Redundancy Boxes (RedBox) shall be used. However, atleast 2 ports shall compulsorily be available natively on the IED (with one port having the capability to get connected with Process Bus LAN and other to get connected with Station Bus LAN).
- The IEDs, wherever required, shall have the capability to internally summate the Sampled Values (SV) streams from two or more instrument transformers.

(iv) For Transformers and Reactors, sufficient (redundant)SGCs/MUs shall be provided in the Transformer/Reactor MB (or in a separate panel near the Transformer/Reactor MB as per the site specific conditions) for interfacing bushing CTs, Online DGA, PPM Monitor, Optical Temperature Sensor and other annunciation/data of Transformer/Reactor with the process bus / station bus of SAS.

(v) Following alarms shall be generated by devices subscribing to SMV streams in the following two cases:

Firstly, when a subscribing IED stops receiving SMV streams from the Merging Unit(s), alarms shall be generated.

Secondly, there shall be a mechanism in the IEDs to detect using the SMV streams, the loss of time synchronization of Merging Units.

In case, the IEDs are not receiving the Sampled Values or are receiving improper Sampled Values from the Merging Unit, the IEDs shall not process their functions which utilize those Sampled Values.

(vi) In addition to the requirements specified at Section 4.1.5 for Switched Ethernet Communication Infrastructure, the Ethernet Fast Switches shall be PRP (IEC 62439 - 3), HSR (IEC 62439 - 3) and PTP (IEEE 1588v2) capable.

(vii) A suggested architecture for Process bus based SAS is enclosed. The architecture of Process Bus based SAS shall be such that the failure of any one Ethernet switch or any one fibre section of the SAS LAN (either in Process Bus LAN or in Station Bus LAN) shall not result into any communication interruption.

(viii) All the control and protection schemes/functions shall be designed and implemented with GOOSE messages and Sampled Values, unless specifically desired by NEA to be implemented using hardwiring. For energy metering, hardwiring between CT & CVT and meters shall be done. For signal exchange between PLCC and Protection IEDs and between CT/CVT and Control Switching Devices (CSDs), hardwiring shall also be acceptable. For integration of analog and binary signals from station auxiliaries (DG, FFPH, Air Conditioning, AC and DC LT etc.), hardwiring to IEDs shall also be acceptable.

8.0

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:

8.1 Type Tests:

8.1.1 Control IEDs /BCU and Communication Equipment:

The above equipment shall conform to following type tests as per IEC 61850-3 (latest Revision)

- a. Power Input:
 - i. Auxiliary Voltage
 - ii. Current Circuits
 - iii. Voltage Circuits
 - iv. Indications
- b. Accuracy Tests:
 - i. Operational Measured Values
 - ii. Currents
 - iii. Voltages
 - iv. Time resolution
- c. Insulation Tests:
 - i. Dielectric Tests
 - ii. Impulse Voltage withstand Test
- d. Influencing Quantities
 - i. Limits of operation
 - ii. Permissible ripples
 - iii. Interruption of input voltage
- e. Electromagnetic Compatibility Test:
 - i. 1 MHZ. burst disturbance test
 - ii. Electrostatic Discharge Test
 - iii. Radiated Electromagnetic Field Disturbance Test
 - iv. Electrical Fast transient Disturbance Test
 - v. Conducted Disturbances Tests induced by Radio Frequency Field
 - vi. Magnetic Field Test
 - vii. Emission (Radio interference level) Test.
 - viii. Conducted Interference Test
- f. Function Tests:
 - i. Indication
 - ii. Commands
 - iii. Measured 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

8.1.2 All the IEDs, other communication equipment including Ethernet switches and SCADA/SAS software shall be compliant with the latest edition of IEC 61850 and should conform to conformance tests as per IEC 61850-10.

8.2 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 of the Employer.



For the individual bay level IED's applicable type test certificates shall be submitted.

The manufacturing and configuration phase of the SAS shall be concluded by the factory acceptance test (FAT). The purpose is to ensure that the Contractor has interpreted the specified requirements correctly and that the FAT includes checking to the degree required by the user. The general philosophy shall be to deliver a system to site only after it has been thoroughly tested and its specified performance has been verified, as far as site conditions can be simulated in a test lab. During FAT the entire Sub-station Automation System including complete control and protection system to be supplied under present scope shall be tested for complete functionality and configuration in factory itself. The extensive testing shall be carried out during FAT. The purpose of Factory Acceptance Testing is to ensure trouble free installation at site. No major configuration setting of system is envisaged at site.

The bidder shall provide the SCD file after FAT to site so that any intermittent issues with FAT configuration and changed site configuration (if any) can be analyzed.

If the complete system consists of parts from various suppliers or some parts are already installed on site, the FAT shall be limited to sub-system tests. In such a case, the complete system test shall be performed on site together as part of site acceptance test (SAT).

In case of an extension of sub-station, Factory Acceptance Test shall be carried out with the help of a demo system owned by supplier. However, the complete system is to be tested along with SCADA at site by the supplier after complete integration of the system as part of SAT.

8.2.1 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.

8.2.2 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.

8.3 Site Acceptance Tests:

The site acceptance tests (SAT) shall completely verify all the features of SAS hardware and software. The contractor shall submit the detailed SAT procedure and SAT procedure shall be read in conjunction with the specification.

9.0 **SYSTEM OPERATION**

9.1 Substation Operation



9.1.1 NORMAL OPERATION

Operation of the system by the operator from the remote RCC/MCC 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.

10.0 POWER SUPPLY

Power for the substation automation system shall be derived from station DC power supplies.

Inverter of suitable capacity shall be provided for station HMI disturbance recorder evaluation unit and its peripheral devices e.g. printer etc. In the event of Power failure, necessary safeguard software shall be built for proper shutdown. Separate Inverters powered from separate station DC supplies shall be provided for Main & hot standby SAS system. Separate Inverter shall also be supplied for Remote HMI & Workstation only if applicable.

2 Nos. of Inverter 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 220/110V 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.

11.0 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
- (e) VLAN architecture drawing

The following documentation to be provided for the system in the course of the project shall be consistent, CAD supported, and of similar look/feel. All CAD drawings to be provide in "dxf" format.

- 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)
- Test Specification for Site Acceptance Test (SAT)
- The SCD files of the station's project shall be submitted by the vendor during the FAT and after successful commissioning of SAS.
- A GOOSE matrix sheet with publisher and subscriber IEDs.
- Product Manuals (Installation, Configuration, maintenance, Troubleshooting, detailed diagnostics etc.)
- Assembly Drawing
- Operator's Manual
- Complete documentation of implemented protocols between various elements
- Listing of software and loadable in CD ROM
- Other documents as may be required during detailed engineering

Two sets of hard copy and Four sets of CD ROM/USB drive containing all the as built documents/drawings shall be provided.

12.0 **TRAINING, SUPPORT SERVICES, MAINTENANCE AND SPARES**

12.1 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 India. The Contractor shall provide all necessary training material. Each trainee shall receive individual copies of all technical manuals and all other documents used for training. These materials shall be sent to Employer at least two months before the scheduled commencement of the particular training course. Class materials, including the documents sent before the training courses as well as class handouts, shall become the property of Employer. Employer reserves the right to copy such materials, but for in-house training and use only. Hands-on training shall utilize equipment identical to that being supplied to Employer.

For all training courses, the travel (e.g., airfare) and per-diem expenses will be borne by the participants.

The Contractor shall quote training prices as indicated in BPS.

The schedule, location, and detailed contents of each course will be finalized during Employer and Contractor discussions.

12.2 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 equipment.
- (c) System Expansion: Techniques and procedures to expand and add equipment such as loggers, monitors, and communication channels.
- (d) System Maintenance: Theory of operation and maintenance of the redundant hardware configuration, failover hardware, configuration control panels, and failover switches. Maintenance of protective devices and power supplies.
- (e) Subsystem Maintenance: Theory of design and operation, maintenance techniques and practices, diagnostic procedures, and (where applicable) expansion techniques and procedures. Classes shall include hands-on training for the specific subsystems that are part of Employer's equipment or part of similarly designed and configured subsystems. All interfaces to the computing equipment shall be taught in detail.
- (f) Operational Training: Practical training on preventive and corrective maintenance of all equipment, including use of special tools and instruments. This training shall be provided on Employer equipment, or on similarly configured systems.

12.3 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.

12.4 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 Documentation: Orientation in the organization and use of functional and detailed design documentation and of programmer and user manuals.
- e) Hands-on Training: One week, with allocated computer time for trainee performance of unstructured exercises and with the course instructor available for assistance as necessary.

12.5 Requirement of training:

The contractor shall provide training for Employer personnel comprehensively covering following courses.

S. No.	Name of Course
1	Computer System Hardware
2	Computer System Software
3	Application Software

13.0 Maintenance

13.1 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 visit of SAS manufacturer's representative to site as per requirement to review the performance of system and in case any defect/shortcoming etc. is observed during the period, the same shall be set right by the contractor within 15 days.

14.0 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 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 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 9.1.1 due to an event directly related to the SAS or unit of SAS. In the event, the owner has taken any equipment/system other than Sub-station Automation System for schedule/forced maintenance, the consequent outage to SAS shall not be considered as outage for the purpose of availability.
 - 2) Actual outage duration (AOD)
The time elapsed in hours between the start and the end of an outage. The 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.

14.1 Guarantees Required

The availability for the complete SAS shall be guaranteed by the Contractor. The contractor shall demonstrate their availability guaranteed by conducting the availability test on the total sub-station automation system as a whole after commissioning of total Sub-station Automation system. The test shall verify the reliability and integrity of all sub-



systems. Under these conditions the test shall establish an overall availability of 99.98%. After the lapse of 1000 Hours of cumulative test time, test records shall be examined to determine the conformance with availability criterion. In case of any outage during the availability test, the contractor shall rectify the problem and after rectification, the 1000 Hours period start after such rectification. If test object has not been met the test shall continue until the specified availability is achieved.

The contractor has to establish the availability in a maximum period of three months from the date of commencement of the availability test.

After the satisfactory conclusion of test both contractor and employer shall mutually agree to the test results and if these results satisfy the availability criterion, the test is considered to be completed successfully. After that the system shall be taken over by the employer and then the guarantee period shall start.

15.0 Spares

15.1 Consumables:

All consumables such as paper, cartridges shall be supplied by the contractor till the SAS is taken over by the owner.

15.2 Availability Spares:

In addition to mandatory spares as listed in BPS, the bidder is required to list the spares, which may be required for ensuring the guaranteed availability during the guaranteed availability period.

During the guaranteed availability period, the spare parts supplied by the Contractor shall be made available to the Contractor for usage subject to replenishment at the earliest. Thus, at the end of availability period the inventory of mandatory spares with the Employer shall be fully replenished by the Contractor. However, any additional spares required to meet the availability of the system (which are not a part of the above spares supplied by the Contractor) would have to be supplied immediately by the Contractor free of cost to the Employer.

The price of above availability spare, as assessed by the SAS vendor, shall be deemed to be included in the complete SAS price.

15.3 **Special Tools for IEC 61850 based SAS:**

The contractor shall supply a GOOSE Inspection and Simulation Tool. The tool(s) shall have the capability to sniff and inspect the GOOSE in the data network. The tool(s) shall also have the capability to extract the GOOSE information from .cid/.scd file(s) and simulate them.

For IEC 61850 based Process Bus Projects, the bidder also shall supply a SV (IEC 61850 Sampled Values) Inspection and Simulation Tool. The tool(s) shall have the capability to sniff and inspect the SV in the data network. The tool(s) shall also have the capability to extract the SV information from .cid/.scd file(s) and simulate them.

The price of above shall be deemed to be included in the complete SAS.

16.0 **LIST OF EQUIPMENTS**

In addition to equipment required for as listed in clause 1.2 of this chapter, following equipment shall be decided by bidder in order to achieve guaranteed reliability and availability as declared by bidder.

- i) One (1) Lot of Panel(s) for Installation of Servers and other accessories;
- ii) One (1) Lot of USB KVM 8 Port Switch



- iii) One (1) Lot of Furniture for the Substation Automation System Control Room
- iv) Engineering Station for Merging Units (applicable in case of Process Bus System/Digital Substation) with monitor
- v) Merging Units (MUs) [applicable for Process Bus SAS], as per requirement.
- vi) Switchgear Controllers (SGCs) [applicable for Process Bus SAS], as per requirement.
- vii) Any other equipment as necessary.

Annexure-I

List of Analogue and Digital Inputs

Basic Monitoring requirements are:

- Switchgear status indication
- Measurements (U, I, P, Q, f)
- Event
- Alarm
- Oil & Winding temperature of transformer & reactor individual units
- ambient temperature
- Status and display of 400V LT system, 220/110V & 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 (if applicable).
- Acquisition of alarm and fault record from protection relays
- Disturbance records
- Monitoring the state of batteries by displaying DC voltage, charging current and load current etc.
- Tap-position of Power Transformer



- Data from all online monitoring systems as applicable
- Status and display of LT transformer & its associated switchgear for station auxiliary supply

List of Inputs

The list of input for typical bays is as below: -

Analogue inputs

- i) For Each line Current
 - R phase
 - Y phase
 - B phase
 - Voltage R-Y phase
 - Y-B phase
 - B-R phase
- ii) For each transformer/reactor Current
 - R phase
 - Y phase
 - B phase
 - WTI (Winding Wise)
 - OTI
 - Data from all online monitoring systems as applicable
 - Tap position
- 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) GIS Hall Temperature & Humidity
 - f) 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 220/110V DCDB-I
 - viii) Voltage of 220/110V DCDB-II
 - ix) Current from 220/110V Battery set-I
 - x) Current from 220/110V Battery set-II
 - xi) Current from 220/110V Battery charger-I
 - xii) Current from 220/110V Battery charger-II
 - 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
- g) Other inputs as required

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
 - xlvi) MAIN-I/II fault in reverse direction
 - xlvi) Back-up o/c optd
 - xlvi) Back-up e/f optd
 - xlvi) 220/110V DC-I/II source fail
 - xlvi) SPEECH CHANNEL FAIL
 - xlvi) PLCC Protection Channel-I FAIL
 - xlvi) PLCC Protection Channel-II FAIL

2. Transformer bays (HV Side)

- i) Status of each pole of CB,
- ii) Status of Isolator, Earth switch



- iii) CB trouble
 - iv) CB operation/closing lockout
 - v) Pole discrepancy optd
 - vi) Trip coil faulty
 - vii) LBB optd
 - viii) Bus bar protn trip relay optd
 - ix) REF OPTD
 - x) DIF OPTD (Phase Wise)
 - xi) OVERFLUX ALARM (MV)
 - xii) OVERFLUX TRIP (MV)
 - xiii) OVERFLUX ALARM (HV)
 - xiv) OVERFLUX TRIP (HV)
 - xv) HV BUS CVT ½ FUSE FAIL
 - xvi) MV BUS CVT ½ FUSE FAIL
 - xvii) OTI ALARM/TRIP
 - xviii) PRD OPTD (each PRD)
 - xix) OVERLOAD ALARM
 - xx) BUCHOLZ TRIP
 - xxi) BUCHOLZ ALARM
 - xxii) OLTC BUCHOLZ ALARM
 - xxiii) OLTC BUCHOLZ TRIP
 - xxiv) OIL LOW ALARM
 - xxv) back-up O/C (HV) optd
 - xxvi) back-up E/F (HV) optd
 - xxvii) 220/110V DC-I/II source fail
 - xxviii) TAP MISMATCH
 - xxix) GR-A PROTN OPTD
 - xxx) GR-B PROTN OPTD
 - xxxi) back-up O/C (MV) optd
 - xxxii) back-up E/F (MV)optd
 - xxxiii) All indication, alarms and trip signals as per chapter Transformer and Chapter CRP.
 - xxxiv) Healthiness of each Protection Relay through watchdog contact.
3. Transformer bays (MV Side)
- i) Status of each pole of CB, Isolator, Earth switch
 - ii) CB trouble
 - iii) CB operation/closing lockout
 - iv) Pole discrepancy optd
 - v) Trip coil faulty
 - vi) LBB optd
 - vii) Bus bar protn trip relay optd
 - viii) Back-up impedance relay
 - ix) 220/110V DC-I/II source fail
 - x) GR-A PROTN OPTD
 - xi) GR-B PROTN OPTD

4. Line/Bus Reactor bays (as applicable):

- i) Status of each pole of CB, Isolator, 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 (Phase wise)
- 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) 220/110V DC-I/II source fail
- xviii) GR-A PROTN OPTD
- xix) GR-B PROTN OPTD
- xx) All indication, alarms and trip signals as per chapter Reactor and Chapter CRP

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. GIS system

- i) All alarms and trip signals as per chapter GIS and Chapter CRP.
- ii) Data from all online monitoring systems as applicable.

7. 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 Chapter: 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 Chapter: Battery and Battery charger
- xvi) 220/110V DC-I earth fault
- xvii) 220/110V DC-II earth fault
- xviii) Alarm/trip signals as listed in Chapter: Fire protection system

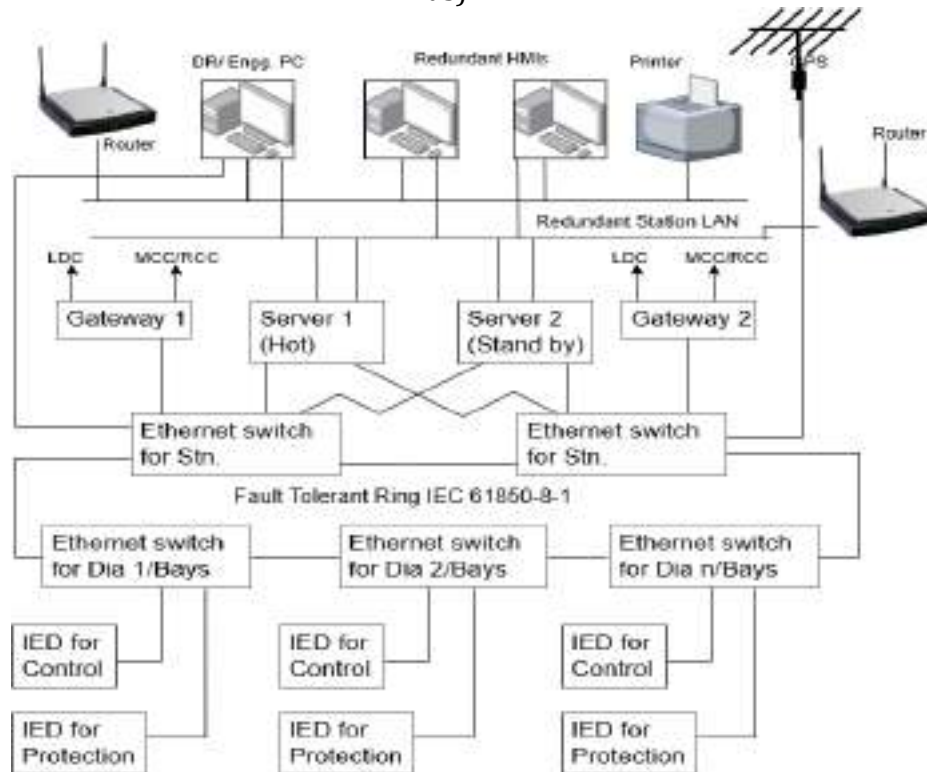
8. Switchyard Panel Room:

- 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 employer's/owner's use in future for new substations. For extension substations, minimum 04 nos. digital inputs per bay shall be kept for future use.



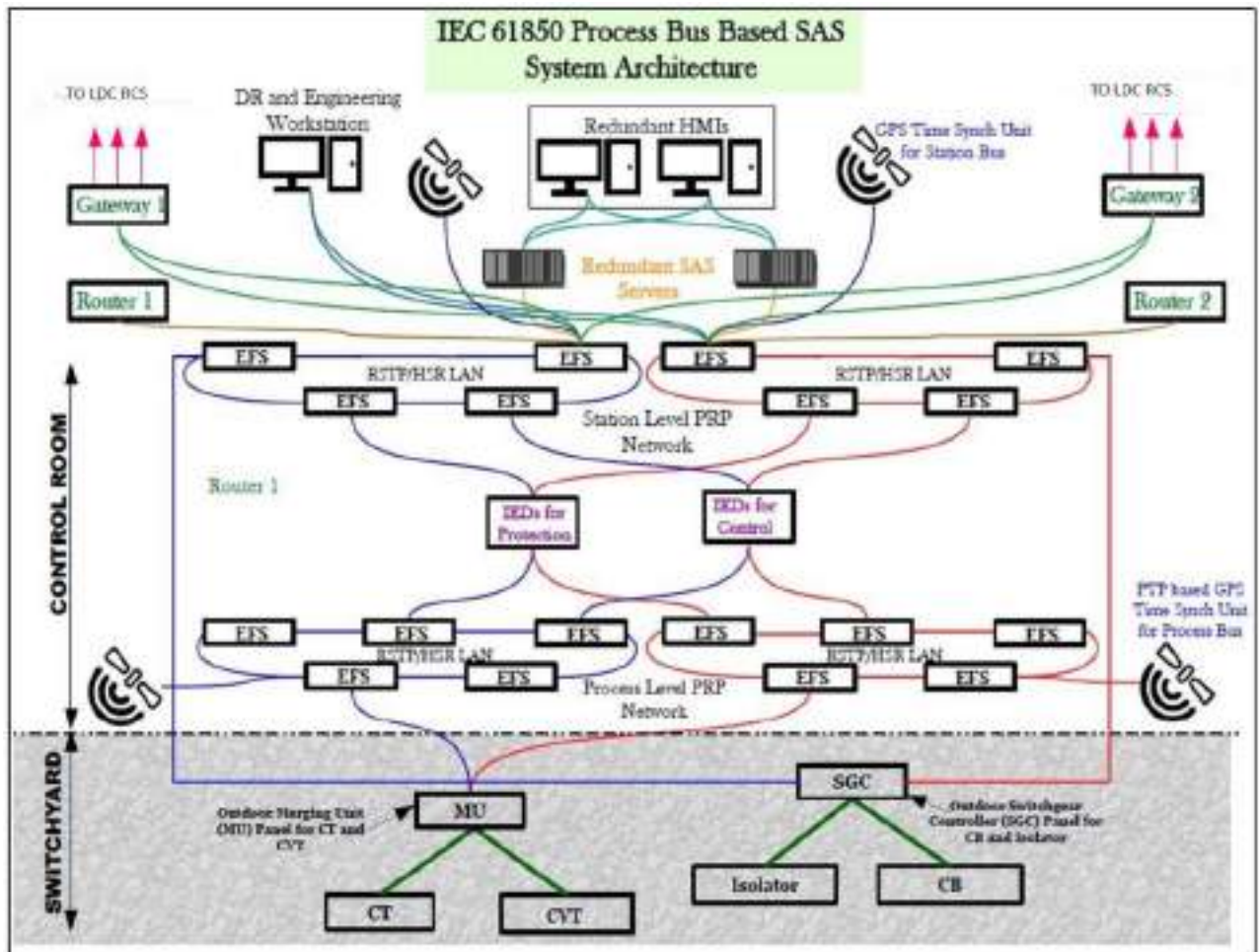
TYPICAL ARCHITECTURAL DRAWING OF SUBSTATION AUTOMATION SYSTEM (Without Process Bus)



Note:

1. The redundant managed bus (station LAN) shall be realized by high speed optical bus 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 LDC/MCC/RCC on IEC 60870-104 protocol. The number of ports required shall be as per clause no. 1.1 and 3.3 of this specification.
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.
6. Gateways, operator workstations and servers shall not be combined.
7. RCC/MCC means Remote/Master Control Stations. Similarly, LDC means Main and Backup Load Dispatch Center of Nepal.

TYPICAL ARCHITECTURAL DRAWING OF SUBSTATION AUTOMATION SYSTEM (with Process Bus)



Annexure-I

List of IO Points to be transmitted to LDC

- a) MW and MVAR for all lines, transformers, reactors and Capacitors
- b) Voltage of all buses
- c) Frequency of all 400kV buses
- d) Frequency of one 220/132 kV Bus
- e) All Breakers
- f) All isolators
- g) Tap Position for all transformers and oil and winding temperature
- h) Master protection signal for all feeders, transformers Units and Bus Bar
- i) Loss of Voltage signal for Bus bar
- j) All the points identified in point (e), (h) and (i) above as GPS Time stamped.
- k) Temperature value per substation.
- l) Any other point decided during detailed engineering

List of IO Points to be transmitted to MCC/RCC

- a) MW and MVAR for all lines, transformers, reactors and Capacitors
- b) Voltage of all buses
- c) Frequency of all 400kV buses
- d) Frequency of one 220/132 kV Bus
- e) All Breakers Control and Operations
- f) All isolators Control and Operations
- g) Tap Position for all transformers Control and Operations
- h) All transformers/Reactors oil and winding temperature
- i) Master protection signal for all feeders, transformers/reactors units and Bus Bar required for complete remote operation of the substation
- j) Loss of Voltage signal for Bus bar
- k) All the points identified in point (e), (h) and (i) above as GPS Time stamped.
- l) Temperature value per substation.
- m) All required auxiliary signals for complete remote operation of the substation
- n) Any other point decided during detailed engineering

