SUB STATION AUTOMATION SYSTEM

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Engineering Department

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TECHNICAL SPECIFICATION FOR SUB STATION AUTOMATION SYSTEM

1.0 GENERAL

1.1. The substation automation system shall be offered from a manufacturer who must have designed, manufactured, tested, installed and commissioned substation automation system successfully in any power utility in India which must be in satisfactory operation on 132kV system or higher for at least **2 (Two)**years as on the date of bid opening.

1.2. The Substation Automation System (SAS) shall be installed to control and monitor all the sub-station equipment (with the provision for future additional bay extensions) from remote control centre **&SLDC**as well as from local control centre.

The SAS shall contain the following main functional parts:

- Bay control Intelligence Electronic Devices (IED s) for control and monitoring.
- Station Human Machine Interface (HMI)
- Redundant managed switched Ethernet Local Area Network communication infrastructure with hot standby.
- Gateway for remote control via industrial grade hardware from local control centre through IEC60870-5-101/104 protocol.
- Gateway for remote supervisory control from SLDC, the gateway should be able tocommunicate with SLDC on IEC 60870-5-101/104 protocol. It shall be the bidder'sresponsibility to integrate his offered system with existing SLDC system including creation of Database for exchange of desired data (in existing database system at SLDC). The requirement of IO point shall be worked out by the bidder as per criterion enclosed as Annexure-1 for data exchange with SLDC.
- Remote HMI.
- Peripheral equipment like printers, display units, key boards, Mouse etc.
- Control & monitoring of Sub-station ACDB/DCDB, Battery chargers system, Firefighting system, surveillance system, Standby Aux. Power supply (DG) system etc.
- **Adequate Cyber Security as per relevant existing Government norms and guidelines are to be maintained. All required hardware and software to comply the same is under the scope of bidder. A demonstration regarding the same is to be conducted. Necessary cyber security certificates are to be submitted for verification.**

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.

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

The offered SAS shall support remote control and monitoring from Remote Control centres via gateways. The system shall be designed such that personnel without any background knowledge in Microprocessor-based technology are able to operate the system. The operator interface shall be intuitive such that operating personnel shall be able to operate the system easily after having received some basic training.

The system shall incorporate the control, monitoring and protection functions specified, self-monitoring, signalling and testing facilities, measuring as well as memory functions, event recording and evaluation of disturbance records.

Maintenance, modification or extension of components may not cause a shutdown of the whole substation automation system.

Self-monitoring of components, modules and communication shall be incorporated to increase the availability and the reliability of the equipment and minimize maintenance.

Bidder shall offer the Bay level unit (a bay comprises of one circuit breaker and associated disconnector, earth switches and instrument transformer), bay mimic along with relay and protection panels and PLCC/FO panels housed in air-conditioned Panel Room suitably located and Station HMI in Control Room building for overall optimisation in respect of cabling and control room building.

2.2 System architecture

The SAS shall be based on a decentralized architecture and on a concept of bay-oriented, distributed intelligence. Functions shall be decentralized, object-oriented and located as close as possible to the process.

The main process information of the station shall be stored in distributed databases. The typical SAS architecture shall be structured in two levels, i.e. in a station and a bay level.

Bay Level

At bay level, the IEDs shall provide all bay level functions regarding control, monitoring and protection, inputs for status indication and outputs for commands. The IEDs should be directly connected to the switchgear without any need for additional interposition or transducers.

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

The data exchange between the electronic devices on bay and station level shall take place via the communication infrastructure. This shall be realized using fibre-optic cables, thereby

guaranteeing disturbance free communication. The fibre optic cables shall be run in GI conduit pipes.

Data exchange is to be realised using IEC 61850 protocol with a redundant managed switched Ethernet communication infrastructure The communication shall be made in fault tolerant ring in redundant mode, excluding the links between individual bay IEDs to switch wherein the redundant connections are not envisaged, such that failure of one set of fiber shall not affect the normal operation of the SAS. However failure of fiber shall be alarmed in SAS. Each fiber optic cable shall have four (4) spare fibers

Station Level

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. SLDC, station HMI, bay level or apparatus level.

The priority shall always be on the lowest enabled control level. The station level contains the station-oriented functions, which cannot be realised at bay level, e.g. alarm list or event list related to the entire substation, gateway for the communication with remote control centres. The GPS time synchronising signal (as specified in the section relay & protection) for the synchronization of the entire system shall be provided. The SAS shall contain the functional parts as described in para 1.2 above.

2.3 FUNCTIONAL REQUIREMENTS

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

- Remote control centres
- Station HMI.
- Local Bay controller IED (in the bays)

Operation shall be possible by only one operator at a time.

The operation shall depend on the conditions of other functions, such as interlocking, synchrocheck, etc. (see description in ”Bay level control functions”).

(a) 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.

(b) 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.

(c) 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.

(d) Self-supervision Continuous

self-supervision function with self-diagnostic feature shall be included.

(e) User configuration

The monitoring, controlling and configuration of all input and output logical signals and binary inputs and relay outputs for all built-in functions and signals shall be possible both locally and remotely. It shall also be possible to interconnect and derive input and output signals, logic functions, using built-In functions, complex voltage and currents, additional logics (AND-gates, OR gates and timers). (Multi-activation of these additional functions should be possible).

The Functional requirement shall be divided into following levels:

a. Bay (a bay comprises of one circuit breaker and associated disconnector, earth switches and instrument transformer) Level Functions

b. System Level Functions

3.1. Bay level functions

In a decentralized architecture the functionality shall be as close to the process as possible. **Separate IEDs shall be provided for bay control function and bay protection function.**

In this respect, the following functions can be allocated at bay level:

3.1.1 Bay control functions

(a) Overview Functions

- Control mode selection
- Select-before-execute principle
- Command supervision:
  (a) Interlocking and blocking
  (b) Double command
- Synchrocheck, voltage selection
- Run Time Command cancellation
- Tlransformer tap changer control (Raise and lower of tap) (for power transformer bays)
- Operation counters for circuit breakers and pumps
- Hydraulic pump/ Air compressor runtime supervision
- Operating pressure supervision through digital contacts only
- Breaker position indication per phase
- Alarm annunciation
- Measurement display
- Local HMI (local guided, emergency mode)
- Interface to the station HMI.
- Data storage for at least 200 events *f*
- Extension possibilities with additional I/O's inside the unit or via fibre optic communication and process bus
- Controlling of all switching devices of the bay with annunciation.
- Monitoring of all monitoring devices of the bay with annunciation.

(b) Control mode selection

Bay level Operation: As soon as the operator receives the operation access at bay level the operation is normally performed via bay control IED. During normal operation bay control unit allows the safe operation of all switching devices via the bay control IED.

EMERGENCY Operation

It shall be possible to close or open the selected Circuit Breaker with ON or OFF push buttons even during the outage of bay IED.

REMOTE mode

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

(c)Synchronism and energizing check

The synchronism and energizing check functions shall be bay-oriented and distributed to the bay control and/or protection devices.

These features are:

- Settable voltage, phase angle, and frequency difference.

- Energizing for dead line - live bus, live line - dead bus or dead line – dead bus with no synchro-check function.
- Synchronising between live line and live bus with synchro-check function

Voltage selection

The voltages relevant for the Synchro check functions are dependent on the station topology, i.e. on the positions of the circuit breakers and/or the isolators. The correct voltage for synchronizing and energizing is derived from the auxiliary switches of the circuit breakers, the isolator, and earthing switch and shall be selected automatically by the bay control and protection IEDs.

(d)Transformer tap changer control

Raise and lower operation of OLTC taps of transformer shall be facilitated through Bay controller IED.

3.1.2.Bay protection functions

(a)General

The protection functions are independent of bay control function. The protection shall be provided by separate protection IEDs (numerical relays) and other protection devices as per section Relay & Protection. IEDs, shall be connected to the communication infrastructure for data sharing and meet the real-time communication requirements for automatic functions. The data presentation and the configuration of the various IEDs shall be compatible with the overall system communication and data exchange requirements.

Event and disturbance recording function

Each IED should contain an event recorder capable of storing at least 200 time-tagged events. The disturbance recorder function shall be as per detailed in section C&R

(b)Bay Monitoring Function:

Analogue inputs for voltage and current measurements shall be connected directly to the voltage transformers (VT) and the current transformers (CT) without intermediate transducers. The values of active power (W), reactive power (VAR), frequency (Hz), and the rms values for voltage (U) and current (I) shall be calculated in the Bay control/protection unit.

3.2.System level functions

3.2.1. Status supervision

The position of each switchgear, e.g. circuit breaker, isolator, earthing switch, transformer tap changer etc., shall be supervised continuously. Every detected change of position shall be immediately displayed in the single-line diagram on the station HMI screen, recorded in the event list, and a hard copy printout shall be produced. Alarms shall be initiated in the case of spontaneous position changes. The switchgear positions shall be indicated by two auxiliary switches, normally closed (NC) and normally open (NO), which shall give ambivalent

signals. An alarm shall be initiated if these position indications are inconsistent or if the time required for operating mechanism to change position exceeds a predefined limit.

The SAS shall also monitor the status of sub-station auxiliaries. The status and control of auxiliaries shall be done through separate one or more IED and all alarm and analogue values shall be monitored and recoded through this IED.

3.2.2. Measurements

The analogue values acquired/calculated in bay control/protection unit shall be displayed locally on the station HMI and in the control centre. The abnormal values must be discarded. The analogue values shall be updated every 2 seconds. Threshold limit values shall be selectable for alarm indications.

3.2.3. Event and alarm handling

Events and alarms are generated either by the switchgear, by the control IEDs, or by the station level unit. They shall be recorded in an event list in the station HMI. Alarms shall be recorded in a separate alarm list and appear on the screen. All, or a freely selectable group of events and alarms shall also be printed out on an event printer. The alarms and events shall be time-tagged with a time resolution of 1 ms. The tentative list for various feeders and systems are enclosed as Annexure-I

3.2.4. Station HMI

(a)Substation HMI Operation:

On the HMI the object has to be selected first. In case of a blocking or interlocking conditions are not met, the selection shall not be possible and an appropriate alarm annunciation shall occur. If a selection is valid the position indication will show the possible direction, and the appropriate control execution button shall be pressed in order to close or open the corresponding object. Control operation from other places (e.g. REMOTE) shall not be possible in this operating mode.

(b) Presentation and dialogues

General

The operator station HMI shall be a redundant with hot standby and shall provide basic functions for supervision and control of the substation. The operator shall give commands to the switchgear on the screen via mouse clicks. The HMI shall give the operator access to alarms and events displayed on the screen. Aside from these lists on the screen, there shall be a printout of alarms or events in an event log.

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

The following standard pictures shall be available from the HMI:

- Single-line diagram showing the switchgear status and measured values

- Control dialogues with interlocking or blocking information details. This control dialogue shall tell the operator whether the device operation is permitted or blocked.
- Measurement dialogues
- Alarm list, station / bay-oriented
- Event list, station / bay-oriented
- System status

(c) 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

(d) 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.

(e) 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.

(f) 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. 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

(g) Alarm list

Faults and errors occurring in the substation shall be listed in an alarm list and shall be immediately transmitted to the control centre. The alarm list shall substitute a conventional alarm tableau, and shall constitute an evaluation of all station alarms. It shall contain unacknowledged alarms and persisting faults. The date and time of occurrence shall be indicated. The alarm list shall consist of a summary display of the present alarm situation. Each alarm shall be reported on one line that contains:

- The date and time of the alarm
- The name of the alarming object
- A descriptive text
- The acknowledgement state.

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

Unacknowledged and cleared, Acknowledged and persistent). Filters for selection of a certain type or group of alarms shall be available as for events.

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

- Type of blocking
- Authority
- Local / remote control
- RSCC / SAS control
- Errors
- etc.,

shall be displayed.

(i) Control dialogues

The operator shall give commands to the system by means of mouse click located on the single-line diagram. Data entry is performed with the keyboard. Dedicated control dialogues for controlling at least the following devices shall be available:

- Breaker and disconnector
- Transformer tap-changer

3.2.5. User-authority levels

It shall be possible to restrict activation of the process pictures of each object (bays, apparatus...) within a certain user authorisation group. Each user shall then be given access rights to each group of objects, e.g.:

- Display only
- Normal operation (e.g. open/close of switchgear)
- Restricted operation (e.g. by-passed interlocking)
- System administrator

For maintenance and engineering purposes of the station HMI, the following authorisation levels shall be available:

- No engineering allowed
- Engineering/configuration allowed
- Entire system management allowed

The access rights shall be defined by passwords assigned during the log-in procedure. Only the system administrator shall be able to add/remove users and change access rights.

3.2.6. Reports

The reports shall provide time-related follow-ups of measured and calculated values. The data displayed shall comprise:

- Trend reports:
    - Day (mean, peak)
    - Month (mean, peak)
    - Semi-annual (mean, peak)
    - Year (mean, peak)
- Historical reports of selected analogue Values:
    - Day (at 15 minutes interval)
    - Week
    - Month
    - Year

It shall be possible to select displayed values from the database in the process display on-line. Scrolling between e.g. days shall be possible. Unsure values shall be indicated. It shall be possible to select the time period for which the specific data are kept in the memory. Following printouts shall be available from the printer and shall be printed on demand:

i. Daily voltage and frequency curves depicting time on X-axis and the appropriate parameters on the Y-axis. The time duration of the curve is 24 hours.
ii. Weekly trend curves for real and derived analogue values.
iii. Printouts of the maximum and minimum values and frequency of occurrence and duration of maximum and minimum values for each analogue parameter for each circuit in 24 hr period.
iv. Provision shall be made for logging information about breaker status like umber 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.

3.2.7. Trend display (historical data)

It shall be possible to illustrate all types of process data as trends - input and output data, binary and analogue data. The trends shall be displayed in graphical form as column or curve diagrams with a maximum of 10 trends per screen. Adjustable time span and scaling ranges must be provided.

It shall be possible to change the type of value logging (direct, mean, sum, or difference) on-line in the window. It shall also be possible to change the update intervals on-line in the picture as well as the selection of threshold values for alarming purposes.

3.2.8. Automatic disturbance file transfer

All recorded data from the IEDs with integrated disturbance recorder as well as dedicated disturbance recording systems shall **be automatically uploaded (event triggered or once per day) to a dedicated computer and be stored on the hard disc**.

3.2.9. Disturbance analysis

The PC-based work station shall have necessary software to evaluate all the required information for proper fault analysis.

3.2.10. IED parameter setting

It shall be possible to access all protection and control IEDs for reading the parameters (settings) from the station HMI or from a dedicated monitoring computer. The setting of parameters or the activation of parameter sets shall only be allowed after entering a password.

3.2.11. Automatic sequences

The available automatic sequences in the system should be listed and described, (e.g. sequences related to the bus transfer). It must be possible to initiate pre-defined automatic sequences by the operator and also define new automatic sequences.

3.3.Gateway

3.3.1Communication Interface

The Substation Automation System shall have the capability to support simultaneous communications with minimum four independent remote master stations,

The Substation Automation System shall have minimum Four ports for Remote Control Centres

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 (RCC). The substation automation system shall support the use of a different communication data exchange rate (bits per second), scanning cycle, and/or communication protocol to each remote control centres. Also, each control centre's data scan and control commands may be different for different data points within the substation automation system's database.

3.3.2 Remote Control Centre Communication Interface

The communication channels between the Substation Automation System and the remote control centre will consist either of power line carrier, microwave, optical fibre, VSAT or leased line , the details of which shall be provided during detailed Engineering .

3.3.3 Interface equipment:

The Contractor shall provide interface equipment for communicating between Substation Automation system and Remote control centre.

The modems can be used communicating to remote master station. The Contractor shall supply two (2) number modems one at Remote Control Centre/Stand alone and other at Substation end.The modem shall be, complete in all respects including power supply unit &rack. The 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 60870-5-101, 60870-5-104 and IEC 61850 for all levels of communication for sub-station automation such as Bay to station HMI, gateway to remote station etc.

4.0 System hardware:

4.1 Redundant Station HMI, Remote HMI and Disturbance Recorder Work station:

The contractor shall provide redundant station HMI in hot standby mode. The servers used in these work stations shall be of industrial grade.

It shall be capable to perform all functions for entire substation including future requirements as indicated in the SLD. It shall use industrial grade components. Processor and RAM shall be selected in such a manner that during normal operation not more than 30% capacity of processing and memory are used. Supplier shall demonstrate these features. The capacity of hard disk shall be selected such that the following requirement should occupy less than 50% of disk space:

1. Storage of all analogue data (at 15 Minutes interval)and digital data including alarm , event and trend data for thirty(30) days,

2. Storage of all necessary software,

3. 20GB space for OWNER'S use.

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

4.1.1 HMI (Human Machine Interface)

The VDU shall show overview diagrams (Single Line Diagrams) and complete details of the switchgear with a colour display. All event and alarm annunciation shall be selectable in the form of lists. Operation shall be by a user friendly function keyboard and a cursor positioning device. The user interface shall be based on WINDOWS concepts with graphics & facility for panning, scrolling, zooming, decluttering etc.

4.1.2 Visual Display Units/TFT's (Thin Film Technology)

The display units shall have high resolution and reflection protected picture screen. High stability of the picture geometry shall be ensured. The screen shall be at least 21" diagonally in size and capable of colour graphic displays. The display shall accommodate resolution of 1280 X 1024 pixels.

4.1.3 Printer

It shall be robust & suitable for operation with a minimum of 132 characters per line. The printing operation shall be quiet with a noise level of less than 45 dB suitable for location in the control room. Printer shall accept and print all ASCII characters via master control computer unit interface. The printer shall have in built testing facility. Failure of the printer shall be indicated in the Station HMI. The printer shall have an off line mode selector switch to enable safe maintenance. The maintenance should be simple with provisions for ease of change of print head, ribbon changing, paper insertion etc.

All reports and graphics prints shall be printed on laser printer. One dot matrix printer shall have to be supplied for exclusively used for hourly log printing. All printers shall be continuously online.

4.1.4 Mass Storage Unit

The mass storage unit shall be built-in to the Station HMI. All operational measured values, and indications shall be stored in a mass-storage unit in form of DVD RW The unit should support at least Read (48X), Write(24X), and Re-Write (10X) operations, with Multi-Session capability. It should support ISO9660, Rockridge and Joliet Filesystems. It should support formatting and use under the operating system provided for Station HMI. The monthly back up of data shall be taken on disc. The facility of back up of data shall be inherent in the software.

4.1.5 Ethernet network topology

SAS shall comply with IEC62439-3 clause 4 PRP (Parallel Redundant Protocol) principle, based on the duplication of the Ethernet network infrastructure. Preferably, main system component (bay controllers, protection devices, HMI and gateway PC's) shall embed redundant interface to be doubly attached on a PRP network. **Bidder shall submit necessary compliance certificate for PRP from statutory authority/certifying agencies like KEEMA, UCA, CPRI etc.**

The Software to be supplied shall also be PRP compliant.

Each network infrastructure can on its own be compliant with any other Ethernet redundancy principle.

4.1.6 Switched Ethernet Communication Infrastructure:

The bidder shall provide the redundant switched optical Ethernet communication infrastructure for SAS. The number of bay per set of switch shall be guided by attached scheme drawing and as follows –

(a) One (1) pair of Ethernet switch for one (1) number 400KV bay.

(b) One (1) pair of Ethernet switch for two (2) number 220KV bay

(c) One (1) pair of Ethernet switch for two (2) number 132KV bay

(d) One (1) pair of Ethernet switch for six (6) number 33KV bay

(e) One (1) pair of Ethernet switch for six (6) number 11KV bay

4.2 Bay level unit

The bay unit shall use industrial grade components. The bay level unit, based on microprocessor technology, shall use numerical techniques for the calculation and evaluation of externally input analogue signals. They shall incorporate select-before-operate control principles as safety measures for operation via the HMI. They shall perform all bay related functions, such as control commands, bay interlocking, data acquisition, data storage, event recording and shall provide inputs for status indication and outputs for commands. They shall be directly connected to the switchgear. The bay unit shall acquire and process all data for the bay (Equipment status, fault indications, measured values, alarms etc.) and transmit these to the other devices in sub-station automation system. In addition, this shall receive the operation commands from station HMI and control centre. The bay unit shall have the capability to store all the data for at least 24 hours.

One no. Bay level unit shall be provided for supervision and control of each 220KV,132KV and 33 kV bay (a bay comprises of one circuit breaker and associated disconnector, earth switches and instrument transformer). The Bay level unit shall be equipped with analogue and binary inputs/outputs for handling the control, status monitoring and analogue measurement functions. All bay level interlocks are to be incorporated in the Bay level unit so as to permit control from the Bay level unit/ local bay mimic panel, with all bay interlocks in place, during maintenance and commissioning or in case of contingencies when the Station HMI is out of service.

The bay control unit to be provided for the bays shall be preferably installed in the CB relay panel/feeder protection panel for respective bay. 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) shall be installed in a separate panel.

The Bay level unit shall meet the requirements for withstanding electromagnetic interference according to relevant parts of IEC 61850. Failure of any single component within the equipment shall neither cause unwanted operation nor lead to a complete system breakdown.

Input/Output (I/O) modules

The I/O modules shall form a part of the bay level unit and shall provide coupling to the

substation equipment. The I/O modules shall acquire all switchgear information (i.e. data coming directly from the switchgear or from switchgear interlocking devices) and transmit commands for operation of the switchgear. The measured values of voltage and current shall be from the secondaries of instrument transformers. The digital inputs shall be acquired by exception with 1 ms resolution. Contact bouncing in digital inputs shall not be assumed as change of state.

4.3 Switchyard(GIS) Panel Room:

The switchyard(GIS) panel room shall be constructed to house Bay level units, bay mimic, relay and protection panels, PLCC/FO panels etc. for onebay in 220KV&132KV and two bays in 33 kV Level. In case of incomplete diameter the switchyard panel room shall have necessary space for accommodating the future bay IEDs. The layout of equipment/panel shall be subject to Owner's approval. The switchyard panel room shall be provided with necessray illuminations, fire alarm system with at least two detectors with necessary power supply if required and it shall be wired to SAS. The detailed constructional requirement of switchyard(GIS) panel room is detailed in section civil of technical specification and air conditioning requirement of switchyard (GIS)panel room shall be as detailed in section Air conditioning system of technical specification. The air conditioner provided in switchyard (GIS) panel room shall be monitored from substation automation system.

4.4 Extendibility in future

Offered substation automation system shall be suitable for extension in future for additional bays. During such requirement, all the drawings and configurations, alarm/event list etc. displayed shall be designed in such a manner that its extension shall be easily performed by the employer.

During such event, normal operation of the existing substation shall be unaffected and system shall not require a shutdown. The contractor shall provide all necessary software tools along with source codes to perform addition of bays in future and complete integration with SAS by the user. These software tools shall be able to configure IED, add additional analogue variable, alarm list, event list, modify interlocking logics etc. for additional bays/equipment which shall be added in future.

5.0Software 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.

The Software to be supplied shall be PRP compliant.

The contractor shall provide in two copies of all software in CD to load into the system in case of any problem related with Hardware/Communication etc.

5.1.1 Station level software

Human-machine interface (HMI) The base HMI software package for the operator station shall include the main SAS functions and it shall be independent of project specific hardware version and operating system. It shall further include tools for picture editing, engineering and system configuration. The system shall be easy to use, to maintain, and to adapt according to specific user requirements. Systems shall contain a library with standard functions and applications.

5.1.2 Bay level software

(A)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.

(B) 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.

(C) Network Management System:

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

a. Configuration Management

b. Fault Management

c. Performance Monitoring

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

(a) Maintain performance, resource usage, and error statistics for all managed links and devices and present this information via displays, periodic reports and on demand reports.

(b) Maintain a graphical display of SAS connectivity and device status.

(c) Issue alarms when error conditions occurs

(d) Provide facility to add and delete addresses and links

6.0 TESTS

The substation automation system offered by the bidder shall be subjected to following tests to establish compliance with IEC 61850 for EHV sub-station equipment installed in sheltered area in the outdoor switchyard and specified ambient conditions:

6.1 T**ype Tests**:

Control IEDs and Communication Equipment:

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

6.2 Factory Acceptance Tests:

The supplier shall submit a test specification for factory acceptance test (FAT) and commissioning tests of the station automation system for approval. For the individual bay level IED's applicable type test certificates shall be submitted.

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

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

6.2.1 Hardware Integration Tests:

The hardware integration test shall be performed on the specified systems to be used for Factory tests when the hardware has been installed in the factory. The operation of each item shall be verified as an integral part of system. Applicable hardware diagnostics shall be used to verify that each hardware component is completely operational and assembled into a configuration capable of supporting software integration and factory testing of the system.

The equipment expansion capability shall also be verified during the hardware integration tests. The vendor specifically demonstrates how to add a device in future in SAS during FAT. The device shall be from a different manufacturer than the SAS supplier.

6.2.2 Integrated System Tests:

Integrated system tests shall verify the stability of the hardware and the software. During the tests all functions shall run concurrently and all equipment shall operate a continuous 100 Hours period. The integrated system test shall ensure the SAS is free of improper interactions between software and hardware while the system is operating as a whole.

6.3 Site Acceptance Tests:

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

7.0 SYSTEM OPERATION

Operation of the system by the operator from the remote SLDC or at the substation shall take place via industry standard HMI(Human Machine interface) subsystem consisting of graphic colour VDU, a standard keyboard and a cursor positioning device (mouse). The coloured screen shall be divided into 3 fields:

i) Message field with display of present time and date
ii) Display field for single line diagrams
iii) Navigation bar with alarm/condition indication

For display of alarm annunciation, lists of events etc a separate HMI View node shall be provided.

All operations shall be performed with mouse and/or a minimum number of function keys and cursor keys. The function keys shall have different meanings depending on the operation. The operator shall see the relevant meanings as function tests displayed in the command field (i.e. operator prompting). For control actions, the switchgear (i.e. circuit breaker etc.) requested shall be selectable on the display by means of the cursor keys. The switching element selected shall then appear on the background that shall be flashing in a different color. The operator prompting shall distinguish between:-

- Prompting of indications e.g. fault indications in the switchgear, and
- prompting of operational sequences e.g. execution of switching operations

The summary information displayed in the message field shall give a rapid display of alarm/message of the system in which a fault has occurred and alarm annunciation lists in which the fault is described more fully.

Each operational sequence shall be divided into single operation steps which are initiated by means of the function keys/WINDOW command by mouse. Operator prompting shall be designed in such a manner that only the permissible keys are available in the command field

related to the specific operation step. Only those switching elements shall be accessed for which control actions are possible. If the operation step is rejected by the system, the operator prompting shall be supported by additional comments in the message field. The operation status shall be reset to the corresponding preceding step in the operation sequence by pressing one of the function keys. All operations shall be verified. Incorrect operations shall be indicated by comments in the message field and must not be executed.

The offer shall include a comprehensive description of the system. The above operation shall also be possible via WINDOWS based system by mouse.

8.0 POWER SUPPLY

Power for the substation automation system shall be derived from substation 220V DC system. Inverter of suitable capacity shall be provided.

9.0 DOCUMENTATION

The following documents shall be submitted for employer's approval during detailed engineering:

(a) System Architecture Drawing

(b) Hardware Specification

(c) Functional Design Document

(d) Clear procedure describing how to add an IED/bay/diameter in future covering all major supplier

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

- List of Drawings
- Substation automation system architecture
- Block Diagram
- Guaranteed technical parameters, Functional Design Specification and Guaranteed availability and reliability
- Calculation for power supply dimensioning
- I/O Signal lists
- Schematic diagrams
- List of Apparatus
- List of Labels

- Logic Diagram (hardware &software)
- Switchyard Panel Room layout drawing
- Control Room Lay-out
- Test Specification for Factory Acceptance Test (FAT)
- Product Manuals
- Assembly Drawing
- Operator's Manual
- Complete documentation of implemented protocols between various elements
- Listing of software and loadable in CD ROM
- Other documents as may be required during detailed engineering

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

In addition to the above, all the relevant .icd& .scd configuration files are to be handed over to WBSETCL.

10.0 TRAINING, SUPPORT SERVICES, MAINTENANCE AND SPARES

10.1 Training

Contractor personnel who are experienced instructors and who speak understandable English shall conduct training. The contractor shall arrange on its own cost all hardware training platform required for successful training and understanding in 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.

The Contractor shall quote training prices as indicated in BPS. The schedule, location, and detailed contents of each course will be finalized during Employer and Contractor discussions.

10.2 Computer System Hardware Course

A computer system hardware course shall be offered, but at the system level only. The training course shall be designed to give Employer hardware personnel sufficient knowledge of the overall design and operation of the system so that they can correct obvious problems, configure the hardware, perform preventive maintenance, run diagnostic programs, and communicate with contract maintenance personnel. The following subjects shall be covered:

(a) **System Hardware Overview:** Configuration of the system hardware.

(b) **Equipment Maintenance**: Basic theory of operation, maintenance techniques and diagnostic procedures for each element of the computer system, e.g., processors, auxiliary memories, LANs, routers and printers. Configuration of all the hardware equipments.

(c) **System Expansion:** Techniques and procedures to expand and add equipment such as loggers, monitors, and communication channels.

(d) **System Maintenance**: Theory of operation and maintenance of the redundant hardware configuration, failover hardware, configuration control panels, and failover switches. Maintenance of protective devices and power supplies.

(e) Subsystem Maintenance: Theory of design and operation, maintenance techniques and practices, diagnostic procedures, and (where applicable) expansion techniques and procedures. Classes shall include hands-on training for the specific subsystems that are part of Employer's equipment or part of similarly designed and configured subsystems. All interfaces to the computing equipment shall be taught in detail.

(f) **Operational Training**: Practical training on preventive and corrective maintenance of all equipment, including use of special tools and instruments. This training shall be provided on Employer equipment, or on similarly configured systems.

10.3 Computer System Software Course

The Contractor shall provide a computer system software course that covers the following subjects:

(a) **System Programming**: Including all applicable programming languages and all stand-alone service and utility packages provided with the system. An introduction to software architecture, Effect of tuning parameters (OS software, Network software, database software etc.) on the performance of the system.

(b) **Operating System**: Including the user aspects of the operating system, such as program loading and integrating procedures; scheduling, management, service, and utility functions; and system expansion techniques and procedures

(c) **System Initialization and Failover**: Including design, theory of operation, and practice

(d) **Diagnostics:** Including the execution of diagnostic procedures and the interpretation of diagnostic outputs,

(e) **Software Documentation**: Orientation in the organization and use of system software documentation.

(f) **Hands-on Training**: One week, with allocated computer time for trainee performance of unstructured exercises and with the course instructor available for assistance as necessary.

10.4 Application Software Course

The Contractor shall provide a comprehensive application software courses covering all applications including the database and display building course. The training shall include:

(a) **Overview:** Block diagrams of the application software and data flows. Programming standards and program interface conventions.

(b) **Application Functions**: Functional capabilities, design, and major algorithms. Associated maintenance and expansion techniques.

(c) **Software Development**: Techniques and conventions to be used for the preparation and integration of new software functions.

(d) **Software Generation**: Generation of application software from source code and associated software configuration control procedures.

(e) **Software Documentation**: Orientation in the organization and use of functional and detailed design documentation and of programmer and user manuals.

(f) **Hands-on Training**: One week, with allocated computer time for trainee performance of unstructured exercises and with the course instructor available for assistance as necessary.

10.5 Requirement of training:

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

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

11.0 Maintenance

During Guaranteed Availability Period, the Contractor shall take continual actions to ensure the guaranteed availability and shall make available all the necessary resources such as specialist personnel, spare parts, tools, test devices etc. for replacement or repair of all defective parts and shall have prime responsibility for keeping the system operational. During guarantee period as specified in tender document, contractor shall arrange bi-monthly visit of their representative to site to review the performance of system and in case any defect/shortcoming etc. is observed during the period, the same shall be set right by the contractor within 15 days.

12.0 RELIABILITY AND AVAILABILITY

The SAS shall be designed so that the failure of any single component, processor, or device shall not render the system unavailable. The SAS shall be designed to satisfy the very high demands for reliability and availability concerning:

- Mechanical and electrical design
- Security against 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 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.

   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.
2) **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).
3) **Actual Outage hours (AOH)**
   The sum of actual outage duration within the reporting period

   $AOH = \sum AOD$

4) **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.

Guarantees Required

The availability for the complete SAS shall be guaranteed by the Contractor. Bidder shall include in their offer the detailed calculation for the availability. The contractor shall demonstrate their availability guaranteed by conducting the availability test on the total sub-station automation system as a whole after commissioning of total Sub-station Automation system. The test shall verify the reliability and integrity of all sub-systems. Under these conditions the test shall establish an overall availability of 99.98%. After the lapse of 1000 Hours of cumulative test time, test records shall be examined to determine the conformance with availability criterion. In case of any outage during the availability test, the contractor shall rectify the problem and after rectification, the 1000 Hours period start after such rectification. If test object has not been met the test shall continue until the specified availability is achieved.

The contractor has to establish the availability in a maximum period of three months from the date of commencement of the availability test. After the satisfactory conclusion of test both contractor and employer shall mutually agree to the test results and if these results satisfy the availability criterion, the test is considered to be completed successfully. After that the system shall be taken over by the employer and then the guarantee period shall start.

13.0Spares

13.1Consumables:

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

13.2 Availability Spares:

In addition to mandatory spares as mentioned below for SAS, the bidder is required to list the spares, which may be required for ensuring the guaranteed availability during the guaranteed availability period. The final list of spares shall form part of scope of supply and accordingly the price thereof shall be quoted by the bidder and shall be considered in the evaluation of the bids. During the guaranteed availability period, the spare parts supplied by the Contractor shall be made available to the Contractor for usage subject to replenishment at the earliest. Thus, at the end of availability period the inventory of spares with the Employer shall be fully replenished by the Contractor. However, any additional spares required to meet the availability of the system (which are not a part of the above spares supplied by the Contractor) would have to be supplied immediately by the Contractor free of cost to the Employer.

14.0 LIST OF EQUIPMENTS

Quantity of equipments shall be decided by bidder in order to achieve guaranteed reliability and availability as declared by bidder.

i) Main & Standby Server

ii) Station and remote HMI
iii) Gateways (main & standby)
iv) GPS
v) Bay level units along with bay mimic.
vi) Bay Level Unit for Auxiliary system (as per requirement)
vii) Disturbance Recorder Work Station(Maintenance HMI)
viii) Colour Laser Printer. (For Reports & Disturbance records)
ix) Dot matrix printers - (for Alarms and log sheets)
x) All interface equipment for gateway to SLDC
xi) Communication infrastructure between Bay level units, Station HMI, Printers, gateways, redundant LAN etc. as required
xii) Ethernet switch
xiii) Modems as per requirement.
xiv) Inverter, Red Box,Router cum firewall, LIU and other equipment as necessary.

TYPICAL ARCHITECTURAL DRAWING OF SUBSTATION AUTOMATION SYSTEM

Note:

1. The redundant managed bus shall be realized by high speed optical bus using industrial grade components and shall be as per IEC 61850.

2. Inside the sub-station, all connections shall be realized as per IEC 61850 protocol.

3. For gateway, it shall communicate with Remote Supervisory Control Centre (RSCC)i.e.SLDC on IEC 60870-5-101/104 protocol.

4. The printer as required shall be connected to station bus directly and can be managed either from station HMI, HMI view node or disturbance recorder work station.

5. The above layout is typical. However if any contractor offers slightly modified architecture based on their standard practice without compromising the working, the same shall be subject to approval during detailed engineering.

GPS

GPS receiver for synchronization for communicating over IEC-60870-5-101/104 shall be supplied with a GPS clock.

INTER-OPERABILITYPROFILE OF IEC60870-5-101/104 PROTOCOL

Interoperability Profile shall be provided to the successful bidder. However, it is the responsibility of the bidder to make it compatible with existing Net Work Management System(NMS) and/or new NMS of Remote Control Centre(SLDC)

DATA POLLING METHOD

1. The Gateway shall respond to the Master stations request for the at least the following commands as per the protocol:

- Status of Link
- Reset of Link
- Delay acquisition command
- Clock synchronization command
- General interrogation command
- Interrogation of Scan group 1 command (all status data)
- Interrogation of Scan group 2 command (all analog data)
- Class 1/2 data polling
- File transfer in Monitor direction (SOE file)

For supervisory control commands SBO procedure is to be used.

2. Gateway shall send all Analog and status data in response to the General interrogation command.

3. All digital inputs are to be assigned to Scan group-1.

4. Analogs are defined as periodic data and are sent to SLDC on Class 2 request. The periodicity varies from 10 seconds to 15 seconds depending upon the quantity of data and available bandwidth.

5. Digital input state changes are to be reported spontaneously by Gateway as Class 1 data. The Digital input data have higher priority than Analog values. An integrity scan is performed for all the digital inputs using Scan group-1 at every 10 minutes interval.

6. The SOE (Sequence of Events) information is stored in a file in the Gateway. The format of SOE data is enclosed in a separate file (please see the details in SOE_erldc_nerldc_nrldc.pdf document). This file is transferred using the file transfer feature of IEC 60870-5-101/104 protocol.

Annexure-1

Basic Monitoring and/or control requirements are:

Inputs:-

i) Healthiness of all IED
ii) Healthiness of all Trip relay
iii) Healthiness of all Trip coil
iv) Healthiness of all supervised dc/ac circuits
v) Trip of all MCB
vi) Low pressure condition (stage-1,2 etc.) of all gas chamber
vii) High pressure condition (stage-1,2 etc.) of all gas chamber
viii) Position of all switches (L/R, Normal/Bypass, PT selection, E/T selection, U/F selection, AIR selection, carrier selection, etc.)
ix) Status of all switchgear (CB, isolator, Earth switch, etc.)
x) Healthiness of CB (spring charge, SF6 pr., runtime error, etc.)
xi) All protection start (phase wise)
xii) All protection operation (phase wise)
xiii) All parameter required for AR operation
xiv) Any other parameter required for SOE
xv) Status of all fans and pumps (running/trip etc.)
xvi) All alarms related to ACDB, DCDB, Battery charger, BHMS, Fire alarm, Air-Conditioning etc.

Analog (MV) input:-

i) Bus voltage (for all bus, phase wise)
ii) Bus frequency (for all bus)
iii) Voltage (3ph), Current (3ph), pf, MW, MVAR for all feeder
iv) Fault location (impedance, km) for all line feeder
v) Fault current(for all feeder)

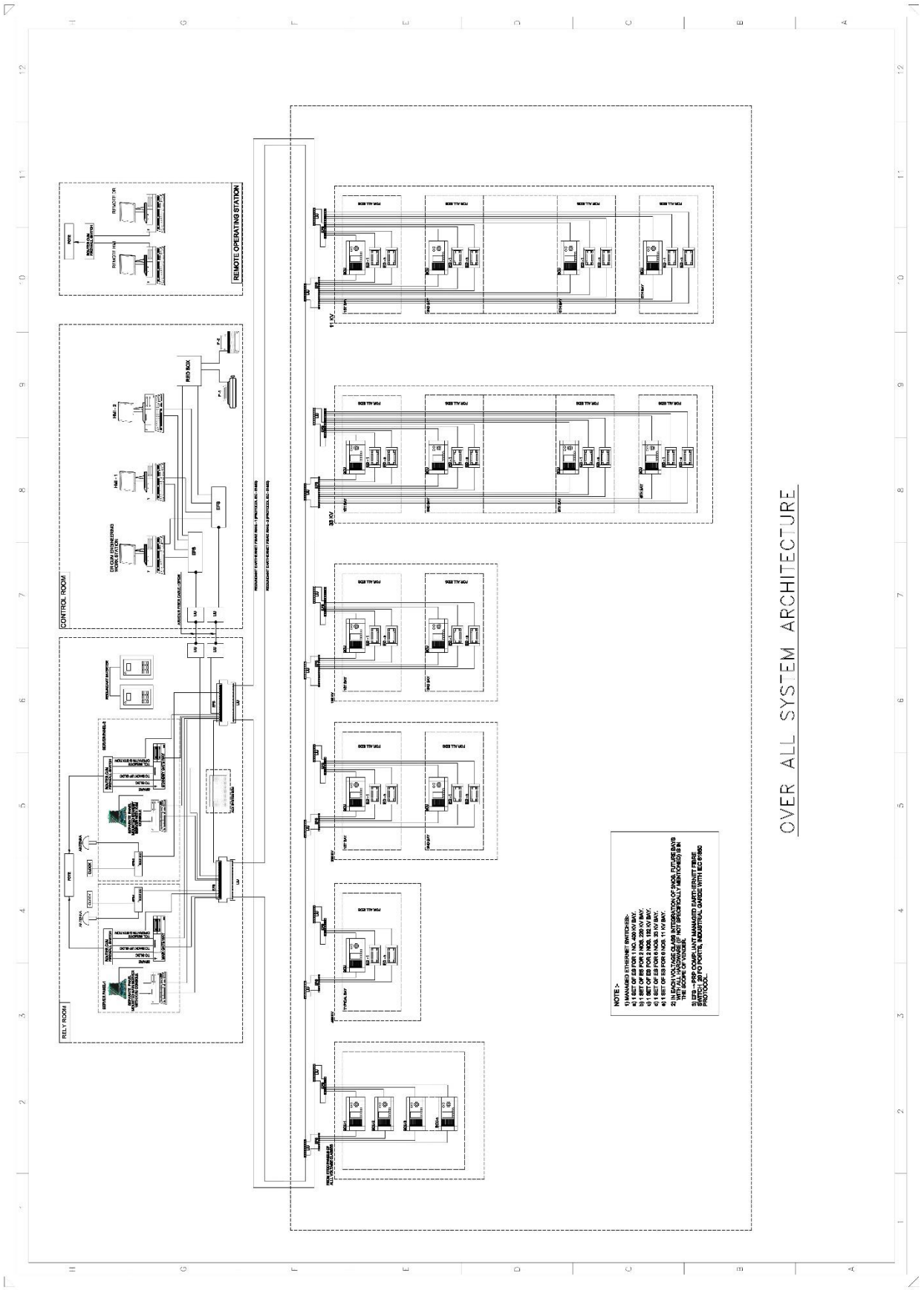
Analog(4 – 20 mA) input:-

i) Tap position of all transformer
ii) HV, LV, IV, oil temp. of all transformer
iii) Current, Voltage & Power of all auxiliary system

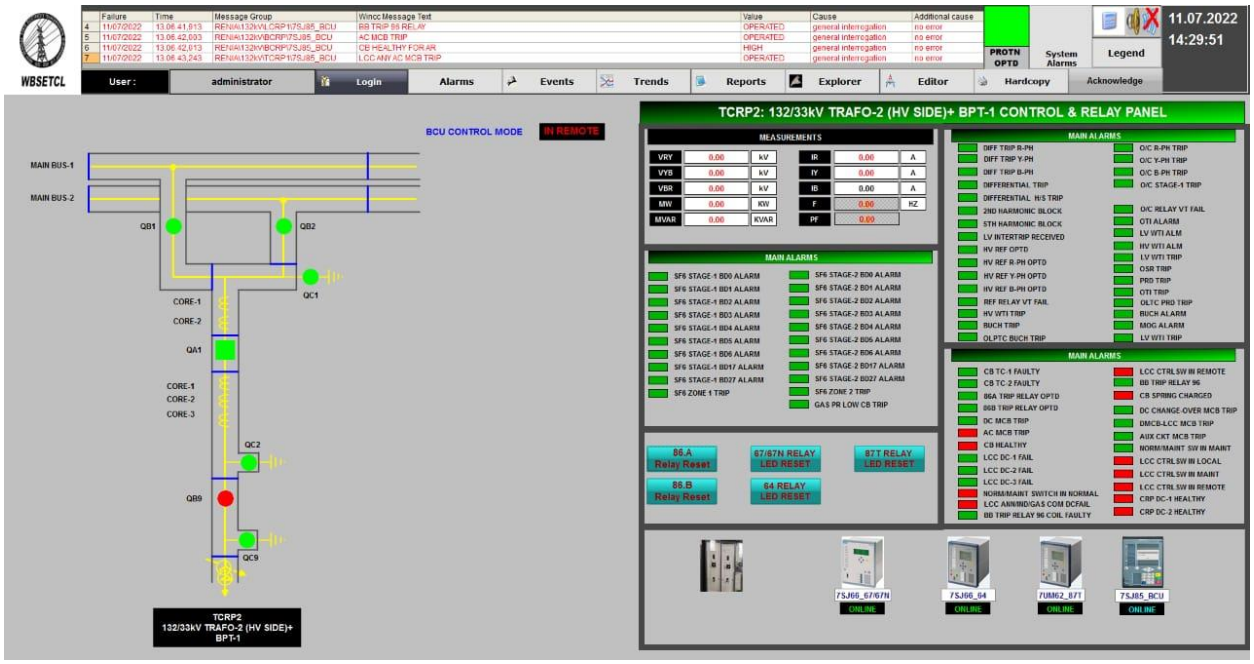
Command:-

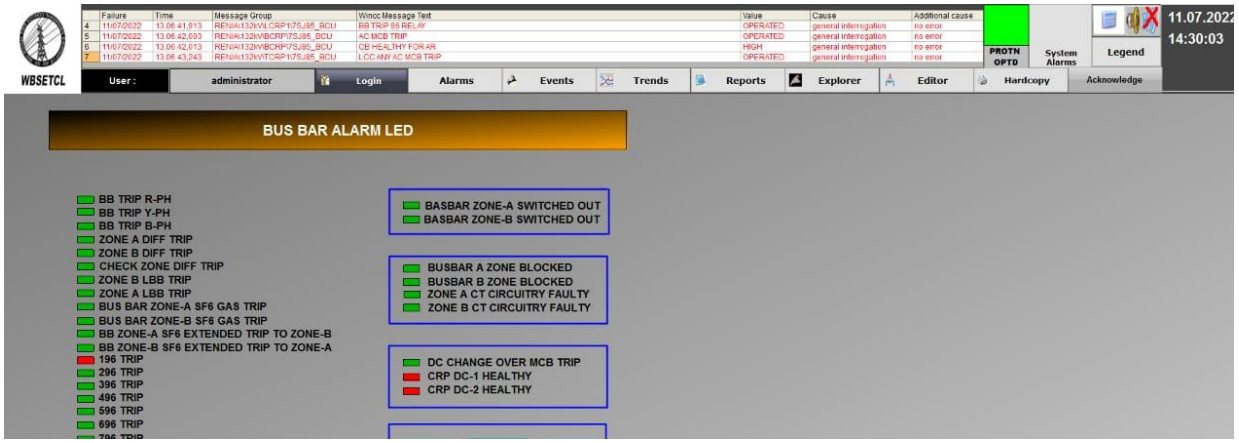
i) Open/close command for all switchgear (CB, isolator, Earth switch, ACB of ACDB/DCDB etc.)
ii) Reset of all trip relays
iii) Reset of all LED
iv) Reset of any latch required in GIS
v) Reset of any latch required in AUX system

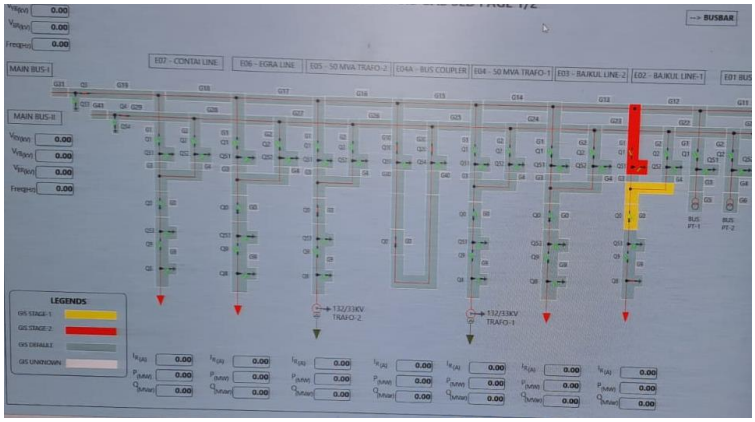
The exact number and description of inputs / outputs shall be as per system requirement considering 3 numbers future bays at each voltage class. Apart from the above-mentioned inputs and outputs, minimum of 20% spare shall be considered.
-Software license (with lifetime validity) shall be taken considering above requirement.


OVER ALL SYSTEM ARCHITECTURE
REMOTE OPERATING STATION
CONTROL ROOM
RELY ROOM
NOTE :-

Sample screenshot of user interface –







Tentative Signal List of one Line Feeder

DC FAIL/ MCB TRIP	EQPT HEALTH
DC SOURCE-1 FAIL	LIFE CONTACT OF ANNUNCIATOR
DC SOURCE-2 FAIL	BCU FAULTY
3RD DC FAIL	BB/LBB RELAY FAULTY
PT SOURCE MCB OFF	TC-1 R PHASE FAULTY
CB MOTOR MCB TRIP	TC-1 Y PHASE FAULTY
AC DISTRIBUTION MCB OPERATED	TC-1 B PHASE FAULTY
DC DISTRIBUTION MCB OPERATED	TC-2 R PHASE FAULTY
ALARM SIGNALLING VOLTAGE MCB OPERATED	TC-2 Y PHASE FAULTY
DISCONNECTOR ESW DRIVE VOLTAGE SUPERVISION	TC-2 B PHASE FAULTY
HIGH SPEED ESW DRIVE VOLTAGE SUPERVISION	86B RELAY FAULTY
CB CLOSE/TRIP RELAY MCB OFF	86A RELAY FAULTY
CARRIER SUPPLY FAIL	CARRIER CH-1 FAIL
CB AUX RELAY MCB FAIL	CARRIER CH-2 FAIL
80LCC DC-1 FAIL	96 RELAY FAULTY
80LCC DC-2 FAIL	21M1 FAULTY
PT SELECT&UV RELAY MCB FAIL	21M2 FAULTY
DC CHANGE OVER MCB TRIP	LBB RELAY FAULTY
SWITCHGEAR STATUS	**CB MONITORING**
Q0 OPEN	CB MOTOR RUNNING TIME SUPERVISION
Q0 CLOSE	CB POLE DISCREPANCY
Q1 BUS ISOL OPEN	CB SPRING CHARGE FAIL
Q1 BUS ISOL CLOSE	
Q2 BUS ISOL OPEN	
Q2 BUS ISOL CLOSE	**RELAY OPERATION STATUS**
Q9 LINE ISOL OPEN	86A OPTD
Q9 LINE ISOL CLOSE	86B OPTD
Q51 ESW OPEN	96 OPTD
Q51 ESW CLOSE	21M1 LED STATUS
Q52 ESW OPEN	21M2 LED STATUS
Q52 ESW CLOSE	LBB LED STATUS
Q8 ESW OPEN	BCU LED STATUS
Q8 ESW CLOSE	
PROT RELAY SIGNAL (LATCHED)	**PROTECTIVE RELAY SIGNAL (SOE)**
M1 LED-1 (AS PER LED LEBEL)	21M1 R PH START
M1 LED-2	21M1 Y PH START
M1 LED-3	21M1 B PH START
M1 LED-4	21M1 ZONE-1 START
M1 LED-5	21M1 ZONE-2 START

M1 LED-6	21M1 ZONE-3 START
M1 LED-7	21M1 ZONE-4 START
M1 LED-8	21M1 R PH TRIP
M1 LED-9	21M1 Y PH TRIP
M1 LED-10	21M1 B PH TRIP
M1 LED-11	21M1 ZONE-1 TRIP
M1 LED-12	21M1 ZONE-2 TRIP
	21M1 ZONE-3 TRIP
M2 LED-1	21M1 ZONE-4 TRIP
M2 LED-2	21M1 R PH AR INITIATION
M2 LED-3	21M1 Y PH AR INITIATION
M2 LED-4	21M1 B PH AR INITIATION
M2 LED-5	21M1 AR OPTD
M2 LED-6	21M1 AR LOCKOUT
M2 LED-7	21M1 SOTF
M2 LED-8	21M1 PSB
M2 LED-9	21M1 BROKEN COND
M2 LED-10	21M1 CARR SEND CH-1
M2 LED-11	21M1 CARR SEND CH-2
M2 LED-12	21M CARR RECV CH-1
	21M CARR RECV CH-2
BCU LED1	21M1 DT SEND
BCU LED2	21M1 DT RECV
BCU LED3	21M1 DEF START
BCU LED4	21M1 DEF TRIP
BCU LED5	21M1 OVER CURRENT START
BCU LED6	21M1 OVER CURRENT TRIP
BCU LED7	
BCU LED8	21M2 R PH START
BCU LED9	21M2 Y PH START
BCU LED10	21M2 B PH START
BCU LED11	21M2 ZONE-1 START
BCU LED12	21M2 ZONE-2 START
	21M2 ZONE-3 START
MEASURED VALUE	21M2 ZONE-4 START
	21M2 R PH TRIP
ACTIVE POWER	21M2 Y PH TRIP
REACTIVE POWER	21M2 B PH TRIP
APPARENT POWER	21M2 ZONE-1 TRIP
POWER FACTOR	21M2 ZONE-2 TRIP
FREQ	21M2 ZONE-3 TRIP
RY PH-PH VOLTAGE	21M2 ZONE-4 TRIP
YB PH-PH VOLTAGE	21M2 R PH AR INITIATION
BR PH-PH VOLTAGE	21M2 Y PH AR INITIATION
R PH-PH VOLTAGE	21M2 B PH AR INITIATION

Y PH-PH VOLTAGE	21M2 AR OPTD
B PH-PH VOLTAGE	21M2 AR LOCKOUT
R PH CURRENT	21M2 SOTF
Y PH CURRENT	21M2 PSB
B PH CURRENT	21M2 BROKEN COND
21M1 FAULT IMP	21M2 CARR SEND CH-1
21M2 FAULT IMP	21M2 CARR SEND CH-2
	21M2 CARR RECV CH-1
GAS MONITORING	21M2 CARR RECV CH-2
	21M2 DT SEND
GAS COMP 1 (Q1) MIN SF6 DENSITY	21M2 DT RECV
GAS COMP 2 (Q2) MIN SF6 DENSITY	21M2 DEF START
GAS COMP 3 (IC) MIN SF6 DENSITY	21M2 DEF TRIP
GAS COMP 4 (Q9) MIN SF6 DENSITY	21M2 OVER CURRENT START
GAS COMP 5 (BB1) MIN SF6 DENSITY	21M2 OVER CURRENT TRIP
GAS COMP 6 (BB2) MIN SF6 DENSITY	
GAS COMP1 LOSS OF SF6	LBB RETRIP
GAS COMP2 LOSS OF SF6	LBB BACKTRIP
GAS COMP3 LOSS OF SF6	
GAS COMP4 LOSS OF SF6	
GAS COMP5 LOSS OF SF6	SWITCH POSITION
GAS COMP6 LOSS OF SF6	SWITCH IN LOCAL POSITION
CB GEN LOCKOUT SF6	SWITCH IN REMOTE POSITION
CB GAS COMP ZONE TRIP	PTS IN BUS PT
CB LOSS OF SF6	PTSS IN INTER 1&2
	PTS IN LINE CVT
	BUS-1 NOT SELECTED
SWGR CONTROL COMMAND	BUS-2 NOT SELECTED
Q1 OPEN CMD	AR IN OFF
Q1 CLOSE CMD	
Q2 OPEN CMD	
Q2 CLOSE CMD	RESET COMMAND
Q9 OPEN CMD	86A RESET COMMAND
Q9 CLOSE CMD	86B RESET COMMAND
Q0 OPEN CMD	96 RESET COMMAND
Q0 CLOSE CMD	21M1 LED RESET COMMAND
Q51 OPEN CMD	21M2 LED RESET COMMAND
Q51 CLOSE CMD	LBB LED RESET COMMAND
Q52 OPEN CMD	MOTOR RUN TIME RESET COMMAND
Q52 CLOSE CMD	ANNUCIATION ACCEPT COMMAND
Q8 OPEN CMD	ANNUCIATION RESET COMMAND
Q8 CLOSE CMD	BCU LED RESET COMMAND

Sample AUX SIGNAL LIST		
DI (Digital Input) Signal		
ACDB, MLDB & Sub DB		
1	Main ACDB Incomer-1 CB ON	
2	Main ACDB Incomer-1 CB OFF	
3	Main ACDB Incomer-1 Over Current Earth Fault Trip/Optd.	
4	Main ACDB Incomer-2 CB ON	
5	Main ACDB Incomer-2 CB OFF	
6	Main ACDB Incomer-2 Over Current Earth Fault Trip/Optd.	
7	Main ACDB Bus Coupler ON	
8	Main ACDB Bus Coupler OFF	
9	Main ACDB DG ON	If applicable
10	Main ACDB DG OFF	If applicable
11	Main ACDB DG Over Current / REF / Trip operated	If applicable
12	RoofTop Solar Plant Incomer ON	If applicable
13	RoofTop Solar Plant Incomer OFF	If applicable
14	Oil Filtration & Welding Supply -1 ON/OFF	
15	Oil Filtration & Welding Supply -2 ON/OFF	
16	Fire Fighting Pumps & Panels Supply -1 ON/OFF	
17	Fire Fighting Pumps & Panels Supply -2 ON/OFF	
18	EOT Crane ON/OFF	
19	415V ACDB BUS -1 U/V OPTD	
20	415V ACDB BUS -2 U/V OPTD	
21	Main ACDB Section-1 any O/G FDR MCB OFF	All Section -1 feeders are grouped together
22	Main ACDB Section-2 any O/G FDR MCB OFF	All Section -2 feeders are grouped together
23	Sub DB Incomer-1 CB ON/OFF	
24	Sub DB Incomer-2 CB ON/OFF	
25	Sub DB B/C CB ON/OFF	
26	Sub DB Section-1 any O/G FDR MCB OFF	All Section -1 feeders are grouped together
27	Sub DB Section-2 any O/G FDR MCB OFF	All Section -2 feeders are grouped together
28	MLDB Incomer-1 CB ON/OFF	
29	MLDB Incomer-2 CB ON/OFF	
30	MLDB B/C CB ON/OFF	
31	MLDB Section-1 any O/G FDR MCB OFF	All MLDB Section -1 feeders are grouped together
32	MLDB Section-2 any O/G FDR MCB OFF	All MLDB Section -2 feeders are grouped together
33	SCADA / Networking Panel Supply-1 ON/OFF	
34	SCADA / Networking Panel Supply-2 ON/OFF	
35	CCTV Supply-1 ON/OFF	

36	CCTV Supply-2 ON/OFF	
37	Inverter Supply-1 ON/OFF	
38	Inverter Supply-2 ON/OFF	
39	220V Battery Charger-1 I/C OFF	
40	220V Battery Charger-2 I/C OFF	
41	48V Battery Charger I/C OFF	
42	Power Transformer MK Supply-1 OFF	
43	Power Transformer MK Supply-2 OFF	
44	Switchyard Lighting Supply OFF	
45	Colony Lighting Supply OFF	
46	GIS/Control Room Lighting Supply-1 OFF	
47	GIS/Control Room Lighting Supply-2 OFF	
48	Street Lighting Supply OFF	
220V & 48V DCDB		
49	220V DCDB Incomer-1 ON/OFF	
50	220V DCDB Incomer-2 ON/OFF	
51	220V DCDB Bus Coupler ON/OFF	
52	Control Room DC Lighting Supply OFF	
53	NWP Supply OFF	
54	220V DCDB Sec-1 U/V or O/V Optd	
55	220V DCDB Sec-2 U/V or O/V Optd	
56	220V DCDB Section-1 any O/G FDR MCB OFF	All 220V DCDB Section -1 feeders are grouped together
57	220V DCDB Section-2 any O/G FDR MCB OFF	All 220V DCDB Section -2 feeders are grouped together
58	48V DCDB Incomer-1 ON/OFF	
59	48V DCDB Incomer-2 ON/OFF	
60	48V DCDB Bus Coupler ON/OFF	
61	Communication Panel (FOTE) Supply OFF	
62	DPC Supply OFF	
63	48V DCDB Sec-1 U/V or O/V Optd	
64	48V DCDB Sec-2 U/V or O/V Optd	
65	48V DCDB Section-1 any O/G FDR MCB OFF	All 48V DCDB Section -1 feeders are grouped together
66	48V DCDB Section-2 any O/G FDR MCB OFF	All 48V DCDB Section -2 feeders are grouped together
220V & 48V Battery And Chargers		
67	220V CHARGER-1 FAIL	
68	220V CHARGER-1 BATTERY LOW	
69	220V CHARGER-1 OVER CURRENT OPTD.	
70	220V CHARGER-1 RECTIFIER FUSE FAIL / BLOCKING DIODE FAIL	
71	220V CHARGER-1 IN BOOST MODE	
72	220V CHARGER-1 IN FLOAT MODE	
73	220V CHARGER-1 DC OVER VOLT	
74	220V CHARGER-2 FAIL	
75	220V CHARGER-2 BATTERY LOW	

76	220V CHARGER-2 OVER CURRENT OPTD.	
77	220V CHARGER-2 RECTIFIER FUSE FAIL / BLOCKING DIODE FAIL	
78	220V CHARGER-2 IN BOOST MODE	
79	220V CHARGER-2 IN FLOAT MODE	
80	220V CHARGER-2 DC OVER VOLT	
81	48V CHARGER-1 FAIL	
82	48V CHARGER-1 BATTERY LOW	
83	48V CHARGER-1 OVER CURRENT OPTD.	
84	48V CHARGER-1 RECTIFIER FUSE FAIL / BLOCKING DIODE FAIL	
85	48V CHARGER-1 IN BOOST MODE	
86	48V CHARGER-1 IN FLOAT MODE	
87	48V CHARGER-1 DC OVER VOLT	
88	48V CHARGER-2 FAIL	If Applicable
89	48V CHARGER-2 BATTERY LOW	If Applicable
90	48V CHARGER-2 OVER CURRENT OPTD.	If Applicable
91	48V CHARGER-2 RECTIFIER FUSE FAIL / BLOCKING DIODE FAIL	If Applicable
92	48V CHARGER-2 IN BOOST MODE	If Applicable
93	48V CHARGER-2 IN FLOAT MODE	If Applicable
94	48V CHARGER-2 DC OVER VOLT	If Applicable
95	220V Battery Bank-1 Health Monitoring - Alarm	
96	220V Battery Bank-2 Health Monitoring - Alarm	
97	48V Battery Bank-1 Health Monitoring - Alarm	
98	48V Battery Bank-2 Health Monitoring - Alarm	If Applicable
Others		
99	LT TRFO-1 WTI Trip	
100	LT TRFO-1 WTI Alarm	
101	LT TRFO-1 OTI Trip	
102	LT TRFO-1 OTI Alarm	
103	LT TRFO-1 BUCH Trip	
104	LT TRFO-1 BUCH Alarm	
105	LT TRFO-2 WTI Trip	
106	LT TRFO-2 WTI Alarm	
107	LT TRFO-2 OTI Trip	
108	LT TRFO-2 OTI Alarm	
109	LT TRFO-2 BUCH Trip	
110	LT TRFO-2 BUCH Alarm	
111	Earthing TRFO-1 OTI Trip	
112	Earthing TRFO-1 OTI Alarm	
113	Earthing TRFO-1 BUCH Trip	
114	Earthing TRFO-1 BUCH Alarm	

115	Earthing TRFO-2 OTI Trip	
116	Earthing TRFO-2 OTI Alarm	
117	Earthing TRFO-2 BUCH Trip	
118	Earthing TRFO-2 BUCH Alarm	
119	Time Sync. Signal Absent	
120	Fire in Transformer-1 (NIFPS / HVWS operated)	If applicable
121	Fire in Transformer-2 (NIFPS / HVWS operated)	If applicable
122	Fire in Transformer-3 (NIFPS / HVWS operated)	If applicable
123	Fire detection Alarm Zone-1	
124	Fire detection Alarm Zone-2	
125	Fire detection Alarm Zone-3	
126	Fire detection Alarm in GIS Hall	
127	AirCondition in Relay Room Running	
128	AirCondition in SCADA / Control Room Running	
129	Jockey Pump-1 Operated	
130	Jockey Pump-2 Operated	
131	Main Pump (Elect)Operated	
132	Main Pump (DG)Operated	
133	Fire Fighting Pump House Annunciator - Alarm	
NB: If separate BCU is not provided at RTCC panels, then the required DI signals from all the RTCCs (OTI, WTI, Bucholtz - Alarm & Trip, RTCC panel incoming AC/DC supply ON/OFF status, OLTc Upper / Lower limit reach etc.) are to be consider		
DO (Digital Output) Signal		
1	ACDB Incomer-1 ON command	
2	ACDB Incomer-2 ON command	
3	DG Set Incomer ON command	If Applicable
4	RoofTop Solar Plant Incomer ON command	If Applicable
5	ACDB Bus Coupler ON command	
6	ACDB Incomer-1 OFF command	
7	ACDB Incomer-2 OFF command	
8	DG Set Incomer OFF command	If Applicable
9	RoofTop Solar Plant Incomer OFF command	If Applicable
10	ACDB Bus Coupler OFF command	
11	220V DCDB I/C-1 ON	
12	220V DCDB I/C-2 ON	
13	220V DCDB B/C ON	
14	48V DCDB I/C-1 ON	
15	48V DCDB I/C-2 ON	
16	48V DCDB B/C ON	

NB: If separate BCU is not provided at RTCC panel, then the required DO signals for OLTC Tap Raise and OLTC Tap Lower for all the Transformers are to be consider		
AI (Analog Input) Signal		
1	ACDB Incomer-1 R-PH Voltage	
2	ACDB Incomer-1 Y-PH Voltage	
3	ACDB Incomer-1 B-PH Voltage	
4	ACDB Incomer-2 R-PH Voltage	
5	ACDB Incomer-2 Y-PH Voltage	
6	ACDB Incomer-2 B-PH Voltage	
7	ACDB Incomer-1 R-PH Current	
8	ACDB Incomer-1 Y-PH Current	
9	ACDB Incomer-1 B-PH Current	
10	ACDB Incomer-2 R-PH Current	
11	ACDB Incomer-2 Y-PH Current	
12	ACDB Incomer-2 B-PH Current	
13	ACDB Section-1 Voltage R-Y	
14	ACDB Section-1 Voltage Y-B	
15	ACDB Section-1 Voltage B-R	
16	ACDB Section-2 Voltage R-Y	
17	ACDB Section-2 Voltage Y-B	
18	ACDB Section-2 Voltage B-R	
19	220V DCDB Section-1 Voltage	
20	220V DCDB Section-2 Voltage	
21	220V DCDB incomer-1 Current	
22	220V DCDB incomer-2 Current	
23	48V DCDB Section-1 Voltage	
24	48V DCDB Section-2 Voltage	
25	48V DCDB incomer-1 Current	
26	48V DCDB incomer-2 Current	
27	220V Battery Charger-1 Current	
28	220V Battery Charger-2 Current	
29	48V Battery Charger-1 Current	
30	48V Battery Charger-2 Current	
31	220V Charger-1 Float Current	
32	220V Charger-1 Boost Current	
33	220V Charger-2 Float Current	
34	220V Charger-2 Boost Current	
35	48V Charger-1 Float Current	
36	48V Charger-1 Boost Current	
37	48V Charger-2 Float Current	
38	48V Charger-2 Boost Current	
NB: If separate BCU is not provided at RTCC panel, then the required AI signals from all the RTCCs for Tap position indication, Transformer temperatures etc. are to be consider		