# CHAPTER 15: SUB STATION AUTOMATION SYSTEM

## 15.1 GENERAL

The substation automation system shall be offered from a manufacturer who must have designed, manufactured, tested, installed and commissioned substation automation system which must be in satisfactory operation for at least 3 (three) years as on the date of bid opening. KEMA/ Internationally and nationally accreditted certificate for all IEDs and Ethernet switches conforming to IEC 61850 is to be furnished as qualification requirement.

## Standards

## Environment Standards

All these standards are applicable to elements like HMI, Ethernet network and elements, Gateways, IEDs.

| Type Test Name | Type Test Standard | Conditions |
|---|---|---|
| Insulation Resistance | IEC 60255-5 | 100 MΩ at 500 Vdc (CM & DM) |
| Dielectric Withstand | IEC60255-5 IEEE C37.90 | 50 Hz, 1mn, 2kV (CM), 1kV (DM) |
| | | 50 Hz, 1mn, 1kV (CM) |
| | | G 1.4 & 1.5 500V CMG 6 :1,5 kV CM |
| High Voltage Impulse Test | IEC 60255-5 | 5kV (CM), 3kV (DM) |
| | | 2kV (CM) |
| | | Groups 1 to 6 :5 kV CM & 3 kV DM(1) |
| | | Not on 1.4 & 1.5 : 5 kV CM & 3 kV DM(1) |
| Free Fall TestFree Fall Packaging Test | IEC 60068-2-31IEC 60068-2-32 | Test Ec : 2 falls from 5cm Test Ed : 2 falls from 0,5m |
| | | 2 falls of 5 cm (Computer not powered) |
| | | 25 falls of 50 cm (1) (2) (Packaging computer) |
| Vibration Response – Powered On | IEC 60255-21-1 | Class 2 :1g from 2 to 150Hz |
| | | Classe 2 :Acceleration : 1g from 10 (1) to 150Hz |
| Vibration Response – Not Powered On | IEC 60255-21-1 | Class 2 :2g from 2 to 500Hz |
| | | Classe 2 :Acceleration : 2g from 10 (1) to 500Hz |
| Vibration Endurance – Not Powered On | IEC 80068-2-6 | Class 2 :1g from 10 to 150Hz |
| | | Class 2 :Acceleration : 1g from 10 (1) to 500Hz |
| Shocks – Not Powered On | IEC 60255-21-2 | Class 1 :15g, 11 ms |
| Shocks – Powered On | IEC 60255-21-2 | Class 2 :10g, 11 ms |
| Bump Test – Not Powered On | IEC 60255-21-2 | Class 1 :10g, 16ms, 2000/axis |
| Seismic Test – Powered On | IEC 60255-21-3 | Class 1 :Axis H : 3,5mm – 2g Axis V : 3,5mm – 1g |
| | | Classe 2 : Acceleration : 2gDisplacement : 7,5mm selon axe H Acceleration : 1gDisplacement : 3,5mm selon axe V |

| Type Test Name | Type Test Standard | Conditions |
|---|---|---|
| Damp Heat Test - Operating | IEC 60068-2-3 | Test Ca :+40°C / 10 days / 93% RH |
| Cold Test - Operating | IEC 60068-2-1 | Test Ab :-10°C / 96h |
| | | Test Ab : - 25°c / 96 H |
| Cold Test - Storage | IEC60068-2-1 | Test Ad :-40°C / 96hPowered On at –25°C (for information)<br>Powered On at –40°C (for information) |
| Dry Heat Test – Operating | IEC 60068-2-2 | Test Bd : 55°C / 96h |
| | | 70°C / 2h |
| | | 70°c / 24 H |
| Dry Heat Test – Storage | IEC 60068-2-1 | Test Bd :+70°C / 96hPowered On at +70°C |
| Enclosure Protection | IEC 60529 | Front : IP=52<br>Rear : IP=30 |
| Inrush current (start-up) | | T < 1,5 ms / I < 20 A<br>T < 150 ms / I < 10 AT > 500 ms / I < 1,2 In |
| Supply variation | IEC 60255-6 | Vn +/- 20%Vn+30% & Vn-25% for information |
| Overvoltage (peak withstand) | IEC 60255-6 | 1,32 Vn max2 Vn during 10 ms (for information) |
| Supply interruption | IEC 60255-11 | From 2,5 ms to 1 s at 0,8 Vn50 ms at Vn, no malfunction (for information) |
| 40 s interruption | IEC 60255-11 | |
| Ripple (frequency fluctuations) | IEC 60255-11 | 12% Vn at f=100Hz or 120Hz12% Vn at f=200Hz for information |
| Supply variations | IEC 60255-6 | Vn +/- 20% |
| AC Voltage dips & short interruptions | EN 61000-4-11 | 2ms to 20ms & 50ms to 1s50 ms at Vn, no malfunction (for information |
| Frequency fluctuations | IEC 60255-6 | 50 Hz : from 47 to 54 Hz60 Hz : from 57 to 63 Hz |
| Voltage withstand | | 2 Vn during 10 ms (for information) |
| High Frequency Disturbance | IEC 60255-22-1IEC 61000-4-12<br>IEEE C37.90.1 | Class 3 : 2.5kV (CM) / 1kV (DM) |
| | | Class 2 : 1kV (CM) |
| Electrostatic discharge | IEC 60255-22-2IEC 61000-4-2 | Class 4 :8kV contact / 15 kV air |
| Radiated Immunity | IEC 60255-22-3IEC 61000-4-3 | Class 3 :10 V/m – 80 to 1000 MHz& spot tests |
| | IEEE C37.90.2 | 35 V/m – 25 to 1000 MHz |
| Fast Transient Burst | IEC 60255-22-4IEC 61000-4-4<br>IEEE C37.90.1 | Class 4 :4kV – 2.5kHz (CM & DM) |
| | | Class 32 kV - 2,5 kHz MC |
| | | Class 3 :2kV – 5kHz (CM) |
| Surge immunity | IEC 61000-4-5 | Class 4 :4kV (CM) – 2kV (DM) |
| | | Class 3 :2kV (CM) on shield<br>Class 4 :4kV (CM) for information |
| | | Class 3 :1 kV MC |

| Type Test Name | Type Test Standard | Conditions |
|---|---|---|
| High frequency conducted immunity | IEC 61000-4-6 | Class 3 :10 V, 0.15 – 80 MHz |
| Harmonics Immunity | IEC 61000-4-7 | 5% & 10% de H2 à H17 |
| Power Frequency Magnetic Field Immunity | IEC 61000-4-8 | Class 4 :50 Hz – 30 A/m permanent – 300 A/m short time |
| | | Class 5 :100A/m for 1mn<br>1000A/m for 3s |
| Power Frequency | IEC 61000-4-16 | CM 500 V / DM 250 V via 0.1 µF |
| Conducted emission | EN 55022 | Gr. I, class A and B : from 0.15 to 30 MHz |
| Radiated emission | EN 55022 | Gr. I, class A and B : from 30 to 1000 MHz, 10m |

## Communication Standards

## UCA2:

## CASM 1.6 - Common Application Service Models and Mapping to MMS

## GOMSFE 0.91 - Generic Object Models for Substation & Feeder Equipment

## IEC 61850:

IEC 61850-8-1: Communication networks and systems in substations – Part 8-1: Specific communication service mapping (SCSM) – Mapping to MMS(ISO/IEC 9506 Part 1 and Part 2

## Telecontrol protocol:

IEC 608670-5-101

IEC 608670-5-104.

## Legacy protection protocol

IEC 60870-5-103 International standards – First release 1997-12

MODBUS

## Automation Standard

IEC 61131-3

The Substation Automation System (SAS) shall be installed, tested and commissioned to control and monitor all the sub-station equipment from remote control center (SCADA) as well as from local SCADA.

The SAS shall contain the following main functional parts:

Bay control Intelligence Electronic Devices (IEDs) for Control and Monitoring.

Bay Protection Intelligent Electronic device (IEDs) for Protection as detailed in previous chapter

Metering server (Industrial Grade) and protocol converter.

Station Main & Hot Standby Redundant Human Machine Interface (HMI)

Redundant managed switched Ethernet Local Area Network communication infrastructure with hot standby.

The managed Ethernet switch shall have sufficient port redundancy (Both Fibre & Copper ports).

The IED shall have two fiber optic ports for connecting Ethernet Switch of each LAN i.e. (PRP,architecture).

Integrated Switches (built-in bay IEDs) are not acceptable. All the IEDs shall be directly connected to the Ethernet Interbay LAN without the use of any gateways.

Gateway for remote control via industrial grade hardware (to SLDC) through IEC60870-5-101 & 104 protocol. All the IEDs shall be directly connected to the Ethernet PRP LAN without use of any gateways.

The communication protocol between the bays, with the Gateway and HMI shall be UCA2/IEC 61850 in order to permit 100 Mbps peer-to-peer communications.

Within a bay it shall be UCA2/IEC 61850 protocol.

All IEDs shall have redundant power card.

Gateway for Control from Remote end and State Load Dispatch Center (SLDC). The gateway should be able to communicate with SLDC on IEC 60870-5-101 & 104 protocol. The specific protocol to be implemented shall be handed over to successful bidder. It shall be the bidder's responsibility to integrate his offered system with existing SLDC system for exchange of desired data. The bidder shall ensure that proposed automation system is compatible with the existing SCADA network. Equipment required for data transfer to the existing SCADA network to interface communication equipment is in the bidder's scope of work and it will be included in the bid price.

Gateway shall also have redundancy and redundant Gateway shall not be housed in a single cabinet. The Gateway shall also have sufficient future expandability and this shall excludes data for all future provision bays as per Project Requirement. The Gateways shall have redundant power cards.

The communication link (PLCC / Fiber Optic) to SLDC is not in the scope of the bidder. However, the bidder will provide required modem both for PLCC and Fibre Optic communications to the nearest Wide Band Locations of STU/CTU which are connected to SLDC. It shall be the bidder's responsibility to integrate the offered system for desired exchange of telemetry data to SLDC.

Redundant Local HMI & DR Work Station.

Peripheral equipment like printers, display units, key boards, Mouse etc. 3.4.1.5. 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.

Gateway IEDs shall have redundant power card.

Gateway shall also have 100% redundancy for it's all functions like power, AI & BI/BO card etc. The Gateway shall also have sufficient future expandability and this shall excludes data for all future provision bays as per Project Requirement. The Gateways shall have redundant power cards

### License of 15 years for the commissioned Sub Station Automation System (SAS) shall be provided.

Vulnerability Audit and Penetration Testing by CERT-In empanelled firm: After successful commissioning of SAS, the successful Bidder shall do cyber Audit of the system by a CERT-In empanelled Cyber Security Auditor (to be approved by AEGCL). For that the company shall do Vulnerability assessment and Penetration testing of the SAS system and submit the report to AEGCL. The company shall fix any vulnerabilities found during the VA/PT.

It shall include communication gateway, intelligent electronic devices (IED) for bay control and inter IED communication infrastructure. A model architecture drawing for SAS is enclosed at the end of this chapter as Annexure I.

Bay level intelligent electronic devices (IED) for protection and control and the Managed Ethernet Switch shall be provided in the C&R panels installed in the local control room. Each IED will be directly connected to the Hot-standby Server PC (HMI) of the Station Automation System through a PRP Ethernet LAN on fiber optic medium and shall communicate as per the IEC61850 standard.

The communication gateway shall facilitate the information flow with SLDC/Remote Control Centre.

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.

The Integration of IEC61850 communication based monitoring equipment like Online Insulating Oil drying system, Digital RTCC Relays etc with substation automation system shall be carried out and shall be included in the scope of work.

Further the Gateways shall have licenses sufficient for all the bays covered in the present scope as well as all the mentioned future bays.

All the numerical IEDs must be fully IEC 61850 compliant and must have the following features.

Have peer-to-peer communication using GOOSE messages (IEC 61850) for interlocking.

Should be interoperable with third party IEC 61850 compliant devices

Should generate XML file for integration/engineering with vendor independent SCADA systems.

Should be directly connected to the inter bay bus on IEC 61850 without the use of any gateways. Connections of bay protection IEDs to the IEC 61850 bus through the bay control units is not acceptable.

## 15.2. SYSTEM DESIGN

### General System Design

The Substation Automation System (SAS) shall be suitable for operation and monitoring of the complete substation including all future extensions as per Project Requirement..

The systems shall be of the state-of-the art architecture and shall be 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 SCADA 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, signaling 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 isolator, earth switches and instrument transformer), bay mimic along with relay and protection panels and Station HMI in Control Room building for overall optimization.

## 15.3. Ethernet Switches

Ethernet switches that fulfill the hardened requirements concerning temperature, power supply (80-250 V DC from the Station Battery) and complying to IEC 61850 suitable to be installed in substations shall be provided, i.e. the same data as common for numerical protection. The Managed Ethernet Switch shall have dual Power supply provision. The use of Ethernet Hubs is not permitted as they do not provide collision free transmission. Suitable port monitoring software shall be provided for monitoring of ports healthiness and should generate alarm in SAS.

## 15.4. SYSTEM ARCHITECTURE

The SAS shall be based on a PRP architecture and on a concept of bay-oriented, distributed intelligence.

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

At bay level, the IEDs shall provide all bay level functions regarding control, monitoring and protection, inputs for status indication and outputs for commands. The IEDs should be directly connected to the switchgear without any need for additional interposition or transducers. But incase of Circuit Breaker SF6 Gas Pressure, Operating Mechanism Pressure (i.e. Air/ Pneumatic, Hydraulic and Nitrogen Pressures), if SF6 CTs are Utilizing the Pressure of SF6 Gas, Transformer Oil/ Winding temperatures, fire fighting or any Other with Transformer management Relay and OLTC Tap Position & Operation can be interfaced with BCU or any Other device interface through Transducers. The tap changing operation, synchronization of sources and trip transfer operation shall be performed through the BCU in addition to above. These parameters shall appear in Substation Automation System at Local HMI.

In 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 for the all the signals from the GIS Bays. In case there is any limitation of number of inputs in the BCU, additional BCUs or additional Cards( In case of Modular BCU) are required to be provided without any cost implication to AEGCL. These inputs shall be used for necessary monitoring, control and protection purpose.

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.

Tagging for Report generation shall be provided for sufficient number of signals for incorporation of all present and future bays, including 20% spare.

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 fiber optic cables, thereby guaranteeing disturbance free communication. Data exchange is to be realized using IEC 61850 protocol with a redundant managed switched Ethernet communication infrastructure.

The communication shall be in parallel mode, and such that failure of one set of fiber shall not affect the normal operation of the SAS. However, it shall be alarmed in SAS. Each fiber optic cable shall have four (4) spare fibers. IED shall have two fibre ports and one port shall be connected to individual Ethernet Switch of each LAN.

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

Clear control priorities shall prevent operation of a single switch at the same time from more than one of the various control levels, i.e. RCC, station HMI, bay level or apparatus level. The priority shall always be on the lowest enabled control level.

The station level contains the station-oriented functions, which cannot be realized at bay level, e.g. alarm list or event list related to the entire substation, gateway for the communication with remote control centers.

The GPS time synchronizing signal for the synchronization of the entire system with redundancy shall be provided.

The SAS shall contain the functional parts as described in para above.

## 15.5. FUNCTIONAL REQUIREMENTS

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

Remote control centers/SLDC

Station HMI.

Local Bay controller IED

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

The operation shall depend on the conditions of other functions, such as interlocking, synchro check etc.

### Select-before-Execute

For security reasons the command is always to be given in two stages: selection of the object and command for operation under all mode of operation except emergency operation. Final execution shall take place only when selection and command are actuated.

### Command Supervision

### Bay/station interlocking and blocking

Software Interlocking is to be provided to ensure that inadvertent incorrect operation of switchgear causing damage and accidents in case of false operation does not take place.

It shall be a simple layout, easy to test and simple to handle when upgrading the station with future bays. For software interlocking the bidder shall describe the scenario while an IED of another bay is switched off or fails.

A software interlock override function shall be provided which can be enabled to bypass the interlocking function.

### Run Time Command Cancellation

Command execution timer (configurable) must be available for each control level connection. If the control action is not completed within a specified time, the command should get cancelled.

### Self-supervision

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

### 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

## 15.6. 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 in bay control / protection unit.

Bay protection functions with support of Numerical Relays defined in CRP Section.

## 15.7. Bay Control Functions

### Overview

### Functions:

Control mode selection

Select-before-execute principle

Command supervision:

Interlocking and blocking

Double command

Synchro-check, voltage selection

Run Time Command cancellation

Transformer Tap Changer control (raise / lower tap) (for Power Transformer bays)

Operation counters for Circuit Breakers and Pumps.

Transformer cooling gear, pump control and runtime supervision

Operating pressure Monitoring & supervision (CB SF6 Gas Pressure, CB Operating Pneumatic Pressure / spring status).

Display of interlocking and blocking

Breaker position indication (per phase for single pole)

Alarm annunciation

Measurement display. (Electrical Parameters & Transformer Parameters)

Local HMI (local guided, emergency mode)

Interface to the station HMI.

Data storage for at least 500 events

Extension possibilities with additional I/O's inside the unit or via fiber optic communication and process bus

### 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 SCADA) and the installation can be controlled only remotely. Control operation from lower levels shall not be possible in this operating mode.

### Synchronism and energizing check

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

Settable voltage, phase angle, and frequency difference.

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

Synchronizing 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.

### Transformer Tap Changer control

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

### Protection Transfer Control

From BCU, necessary control shall be provided for transferring bay to TBC.

## 15.8. Bay Protection Functions

### General

The Protection functions are independent of Bay Control function. The Protection shall be provided by separate Protection IEDs (numerical relays) and other Protection devices as per section Relay & Protection.

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

### Event and disturbance recording function

Each IED should contain an event recorder capable of storing at least 200 time-tagged events. This shall give alarm if 70% memory is full. The disturbance recorder function shall be as detailed in section C&R.

### Bay Monitoring Functions

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.

## 15.9. SYSTEM LEVEL FUNCTIONS

### Status Supervision

Continuous monitoring of switching objects i.e. 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 dedicated one or more IED and all alarm and analogue values shall be monitored and recoded through this IED.

### Measurements

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

In case of Circuit Breaker SF6 Gas Pressure, Operating Mechanism Pressure (i.e. Pneumatic, Spring), if SF6 CTs are Utilizing the Pressure of SF6 Gas, Transformer Oil/ Winding temperatures, Firefighting or any Other with Transformer management Relay and OLTC Tap Position can be interfaced with BCU through Transducers. Max / Min values for the above parameters shall be calculated. These parameters shall appear in Substation Automation System at Local HMI and can monitor regularly.

The measured values 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 every 2 seconds.

Threshold limit values shall be selectable for alarm indications.

### The SAS shall also poll data from the Meter Server to gateway for onward communication to RCC.

### 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 of event/ alarm for various feeders and systems are enclosed as Annexure-II and is not exhaustive, there may be addition during detail engineering or at the time of commissioning.

## 15.10. Station HMI

### Substation HMI Operation:

On the HMI the object has to be selected first. In case of a blocking or interlocking condition 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.

### 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 or keyboard commands.

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, Pressure values (wherever required) and measured values (current, voltage, apparent power, freq & pf) including OLTC Tap Position, WTI, OTI & Analog set values.

Control dialogues with interlocking and blocking details. This control dialogue shall tell the operator whether the device operation is permitted or blocked & Select before Execute.

Measurement dialogues, Statistics & Trends

Bay wise interlock status display and failure of any interlock within the bay by generating alarm and indication in Interlock diagram window.

Alarm list, station / bay-oriented

Event list, station / bay-oriented

Substation Auxiliaries

System status

Printing of sequence of event list, hardcopy and reports. The reports shall be freely configurable using Crystal Report

List of signals to be configured in SAS is mentioned in Annexure-II of this chapter.

### 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

## 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 addition to above Transformer WTIs, OTI, SF6 gas Pressures of Circuit breakers , CTs and CB Operating mechanism Pressures shall also be displayed.

In order to ensure a high degree of security against undesired operation, a "select-before-execute" command procedure shall be provided. After the "selection" of a switch, the operator shall be able to recognize the selected device on the screen, and all other switchgear shall be blocked. As communication between control centre and device to be controlled is established, the operator shall be prompted to confirm the control action and only then final execute command shall be accepted. After the “execution” of the command the operated switching symbol shall flash until the switch has reached its new position.

The operator shall be in a position to execute a command only, if the switch is not blocked and if no interlocking condition is going to be violated. The interlocking statements shall be checked by the interlocking scheme implemented at bay and station level.

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

## System Supervision and Display

The SAS system shall be comprehensively self-monitoring 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, protection couplers and remote communication links, and printers at the station level, etc.

## Event List

The event list shall contain events that are important for the control and monitoring of the substation.

The event and associated time (with 1ms 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/Dot matrix Printer / Line Printer of 132 Column.

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 measurand.

Loss of communication.

Hourly time Stamping

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

## 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.

## 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

SLDC / SAS control

Errors

etc. shall be displayed.

## Control dialogues

The operator shall give commands to the system by means of mouse click located on the single-line diagram. It shall also be possible to use the keyboard for command activation. 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

## User-authority levels

It shall be possible to restrict activation of the process pictures of each object (bays, apparatus...) within a certain user authorization 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), Shift wise operator’s pass word for 3 shift in a day.

Restricted operation (e.g. by-passed interlocking)

System administrator

For maintenance and engineering purposes of the station HMI, the following authorization 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 login procedure. Only the system administrator shall be able to add/remove users and change access rights.

## 15.11. Reports

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

Trend reports:

Day (mean, peak)

Month (mean, peak)

Semi-annual (mean, peak)

Year (mean, peak)

Historical reports of selected analogue Values:

Day (at 15 minutes interval)

Week

Month

Year

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

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

i. Daily voltage and frequency curves depicting time on X-axis and the appropriate parameters on the Y-axis. The time duration of the curve is 24 hours.

ii. Weekly trend curves for real and derived analogue values.

iii. Printouts of the maximum and minimum values and frequency of occurrence and duration of maximum and minimum values for each analogue parameter for each circuit in 24 hr period.

iv. Provision shall be made for logging information about breaker status like number of operation with date and time indications.

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, temperatures (WTIs, OTI) 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 developed by the contractor.

### 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.

### 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.

### Disturbance Analysis

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

### IED Parameter Setting

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

### Automatic Sequences

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

## 15.12. GATEWAY

### Communication Interface

The Substation Automation System shall have the capability to support simultaneous communications with SLDC,

The Substation Automation System shall have communication ports as follows:

(a) Two Ports for RCC & State Load Dispatch Centre from each Gateway.

(b) The redundant Gateway shall work as hot stand by.

The communication interface to the SAS shall allow scanning and control of defined points within the substation automation system. The substation automation system shall simultaneously respond to independent scans and commands from employer's control centers (SLDC).

### SLDC Communication Interface

Employer will supply communication channels between the Substation Automation System and the SLDC. The communication channels provided by Employer will consist either of power line carrier or optical fiber.

### Interface equipment:

The Contractor shall provide interface equipment for communicating between Substation Automation system and State Load Dispatch Centre (PLCC/ FO).

In case of PLCC communication any modem supplied shall not require manual equalization and shall include self-test features such as manual mark/space keying, analogue loop-back, and digital loop-back. The modems shall provide for convenient adjustment of output level and receive sensitivity. The modem should be stand alone complete in all respects including power supply to interface the SAS with communication channel. The configuration of tones and speed shall be programmable and maintained in non-volatile memory in the modem. All necessary hardware and software shall also be in the scope of bidder except the communication link along with communication equipment between substation control room and SLDC.

### Communication Protocol

The communication protocol for gateway to control centre must be open protocol and shall support IEC 60870-5-101,104 and IEC 61850 for all levels of communication for sub-station automation such as Bay to station HMI, gateway to remote station etc.

## 15.13. SYSTEM HARDWARE

### Redundant Station 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 RAM, Hard Disk and Bus should latest and with maximum Values.

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) 500GB space for EMPLOYER'S use.

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

### HMI (Human Machine Interface)

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

For 400kV,220kV, 132kV Substations 70mm VDU high resolution screen showing total SLD, alarm, bay wise real time data to be displayed as shown in the model SAS architecture.

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

The contractor shall provide three display units, one for station HMI, one for redundant HMI and one for DR work station. These shall have high resolution and reflection protected picture screen. High stability of the picture geometry shall be ensured. The screen shall be at least 25" diagonally (3:4) in size or more and capable of colour graphic displays.

The display shall accommodate resolution of 1280 X 1024 pixels or more.

### Printer

It shall be robust & suitable for operation with a minimum of 132 characters per line for Line Printer and Dot Matrix Printer. 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 printers mounted in the control room shall be provided with printer enclosure. The enclosure shall be designed to permit full enclosure of the printers at a convenient level. Plexiglas windows shall be used to provide visual inspection of the printers and ease of reading. The printer enclosures shall be designed to protect the printers from accidental external contact & each should be removable from hinges at the back and shall be provided with lock at the front.

### All reports and graphics prints shall be printed on laser printer

### One Dot Matrix Printer (DMP) shall be exclusively used for hourly log printing.

### Line printer for Events and Alarms Printing

All printers shall be continuously online through directly or printer server.

### 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 of CD-ROM & DVD-ROM with 5GB or more capacity i.e CD Writer & DVD Writer (Both). The unit should support at least Read (48X), Write (24X), and Re-Write (10X) operations, with Multi-Session capability. It should support ISO9660, Rockridge and Joliet File systems. It should support formatting and use under the operating system provided for Station HMI. The monthly back up of data shall be taken on disc. The facility of back up of data shall be inherent in the software.

All the data pertaining to Substation is to store in a system year/ month / day wise. The daily data is stored in a day file of Particular Month and Year automatically from 00.00Hrs to 24.00Hrs.

### Auxiliary BCU

One BCU shall be put in Station level for monitoring Station Auxiliary Supply (AC & DC), Battery Chargers, Nitrogen Fire Fighting System, Fire alarm etc.

Furniture required for HMIs, Printers, and Operators etc. The make of furniture shall be of Godrej or better.

## 15.14. EXTENDIBILITY IN FUTURE

Offered substation automation system shall be suitable for extension in future for all Future Bays as per Project Requirement. 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..

## 15.15. 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 shall not force a shut-down of the parts of the system which are not affected by the system adaptation.

## 15.16. 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.

## 15.17. Bay Level Software

### System Software

The system software shall be structured in various levels. This software shall be placed in a non-volatile memory. The lowest level shall assure system performance and contain basic functions, which shall not be accessible by the application and maintenance engineer for modifications. The system shall support the generation of typical control macros and a process database for user specific data storage. In case of restoration of links after failure, the software along with hardware shall be capable of automatically synchronising with the remaining system without any manual interface. This shall be demonstrated by contractor during integrated system test.

### Application software

In order to ensure robust quality and reliable software functions, the main part of the application software shall consist of standard software modules built as functional block elements. The functional blocks shall be documented and thoroughly tested. They form part of a library.

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

### Simulation

Simulation tools shall be provided with the system to emulate a missing equipment on UCA2/IEC61850.

The simulation tools shall be set up by the system configuration tool and be able to execute scenario defined by the user.

## 15.18. 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 work-station and shall be easy to use, user friendly and menu based. The NMS shall monitor all the devices in the SAS and report if there is any fault in the monitored devices. The NMS shall

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

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

(c) Issue alarms when error conditions occur

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

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

## 15.18(a) Cyber Security features

wherever applicable All Intelligent electronic equipment, Numerical relays, Bay control units, Bay protection units, Gateways, Transformer Tap controller/changer, etc. with IEC 61850 communication protocol shall be cyber security compliant as per latest “CEA (Cyber security in power sector) Guidelines”. Specifications shall also be compliant to latest revision of IEEE 1686

## 15.19. TESTS

The substation automation system offered by the bidder shall be subjected to following tests to establish compliance with IEC 61850 for EHV substation equipment and specified conditions:

### Type 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

## 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 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. If the FAT comprises only a certain portion of the system for practical reason, it has to be assured that this test configuration contains at least one unit of each and every type of equipment incorporated in the delivered system.

If the complete system consists of parts from various suppliers 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).

## Integrated Testing

The integrated system tests shall be performed as detailed in subsequent clauses as per following configuration:

Redundant Station HMI, DR work station, two switches ( i.e. for two diameter) along with all IEDs for the Dia and printers.

All other switches for complete sub-station shall be simulated as needed.

## 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.

## Integrated System Tests:

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

## Site Acceptance Tests:

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

## 15.20. SYSTEM OPERATION

## Substation Operation

## NORMAL 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 4 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

iv) Real time bus energization status with distinguishable colours i.e. for live & dead section of SLD.

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.

## 15.21. POWER SUPPLY

Power for the substation automation system shall be derived from substation 220/110V DC system.

Inverter of suitable capacity shall be provided for station HMI and its peripheral devices e.g. printer etc. In the event of Power failure, necessary safeguard software shall be built for proper shutdown and restart.

## 15.22. DOCUMENTATION

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

(a) System Architecture Drawing

(b) Hardware Specification

(c) Sizing Calculations of various components

(d) Response Time Calculation

(e) Functional Design Document

(f) Clear procedure describing how to add an IED/ bay in future covering all major suppliers

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 and also acrobat 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 )

Control Room Lay-out

Test Specification for Factory Acceptance Test (FAT)

Product Technical Manuals

Application Manuals

Assembly Drawing

Operator's Manual

Testing and Commissioning Manuals

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.

## 15.23. TRAINING, SUPPORT SERVICES, MAINTENANCE AND SPARES

### Training at Contractor's Premises

The contractor shall arrange on its own cost all hardware and software 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 provide training comprehensively covering following courses.

### S. No. Name of Course Participants from Employer Duration

1 Computer System Hardware 2 per sub-station 7 day

2 Computer System Software 6 per sub-station 7 day

3 Application Software 2 per sub-station 7 day

A. Computer Hardware Course: The course will contain configuration of system hardware, equipment maintenance and diagnostic procedure of each element of the SAS including modems, routers, processors, technique for system expansion, and maintenance of IEDs. It will be a hand-on training.

B. Computer System Software Course: The course will cover programming language, OS software, network software, database software, system configuration, development of logic circuits. This will also be a hands-on training

C. Application Software: It will also a hands-on training and the course will contain application software and data flow, associated maintenance and expansion training,

preparation and integration of new software etc.

### Training offered shall be free of cost to the Employer except the logistic.

### On Site Training:

After successful commissioning of the entire SAS, the contractor will impart on-site training in following areas:

### S. No. Name of Course Participants from Employer Duration

1 Computer System Hardware 2 per sub-station 7 day

2 Computer System Software 6 per sub-station 7 day

3 Application Software 2 per sub-station 7 day

Hands on training logic development, system configuration for extension of addition of bay, IED fault finding, trouble shooting, data analysis, changing of equipment parameters/ input data, preventive maintenance of each equipment

The site training will be also of similar nature as outlined in the previous clause, except that here the training will be on actual commissioned system and all aspects shall be covered. The training shall be conducted at each substation separately, covered in the package.

The Contractor shall submit the training modules for approval of the Employer. The training durations mentioned above is tentative only. Actual duration of the training shall be as per approved training module.

## 15.24. MAINTENANCE

### Maintenance Responsibility during Pre-Commissioning and Commissioning Activities

During Pre-Commissioning and Commissioning activities, 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.

### Maintenance Responsibility during Guarantee Period

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 free of any charge to the Employer.

## 15.25. 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 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 above due to an event directly related to the SAS or unit of SAS. In the event, the Employer 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 = Σ 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.

## 15.26. 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 during the pre-commissioning and commissioning periods. 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 700 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 700 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 along with the whole facilities.

## 15.27. SPARES

### Consumables

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

### Availability Spares:

In addition to mandatory spares as listed in below for SAS, the bidder is required to list the recommended spares along with unit prices, which may be required for ensuring the guaranteed availability of the system. During the entire guarantee period including the pre-commissioning and commissioning periods, the successful contractor will have to make available at site his recommended spares.

Based on the requirement of recommended spares during the entire guarantee period, the Employer will decide the final list of spares that the Employer will procure for safe running of the system after the guaranteed period. The contractor is bound to supply these spares promptly.

### LIST OF MANDATORY SPARES

(a) FO cables with terminations for each type and length between IEDs (One FO cable for each type/length).

(b) Patch/Cu cable with terminations of each type and length between IEDs of Station level (One cable for each type/length)

(c) Any interface/Protocol converter (One for each type).

(d) BI/BO card for each type of IED (one no each).

(e) Power card for each type of IED (one no each).

(f) Transducers of each type (one no each)

(g) Industrial grade computer. (one number)

## 15.28. Major Component of SAS

Following minimum equipment shall comprise the Substation Automation System.

i) Station HMI & Redundant Station HMI (in Hot-stand by mode) of Latest Configuration and Latest OS Software with CD & DVD Multilayer Read, write, Rewrite with Possible all types of formats, Hard disk capacity of 1TB, Key Board, Optical Mouse, integrated VGA, Integrated LAN, 25” or More TFT Monitor (4:3 Screen).

ii) Engineering Station & Disturbance Recorder Work Station (Maintenance HMI)

iii) Gateways with PLCC/Fibre Optic Modem

iv) Required Inverter/UPS for 3 hour back up

v) List of Printers with / without Printer server

1. Colour Laser Printer– 1 No. (Print, Scan, Fax & Xerox) (For Reports & Disturbance records),

2. Line Printer - (For Alarms and Sequence of Event recorder)

3. Dot matrix printer Multi sheet paper Model – For log sheets, regular parameters at 15 min duration).

vi) All interface equipment for gateway to SLDC.

vii) Communication infrastructure between Bay level units, Station HMI, Printers, gateways, redundant LAN etc. as required. (Armoured FO and Cu Cables) as required.

viii) BCUs for Sub Station Auxiliaries.

ix) Any other equipment as necessary.

For all the SAS equipment, the power supply unit shall have dual mode i.e. main & redundant card, in case of any one card fail, the IED/Component of SAS shall have to switch over to redundant card and to generate alarm for the outage of the card.

## All the type of cables used for LAN (Bay level & Station level) shall be Armoured type.

## 15.29. Erection, Testing & Commissioning

The bidder shall depute their Engineer to the various sites for carrying out the testing and commissioning of C&R panel.

## 15.30. GUARANTEES REQUIRED

## The availability for the complete SAS shall be guaranteed by the Contractor.

The Guarantee period will be stipulated for 1 year and beyond which Annual Maintenance Contract (AMC) will come into force.

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 during the pre-commissioning and commissioning periods. 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 700 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 700 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 along with the whole facilities.

AMC shall be started after warranty period is over. During AMC, Manufacturer Engineer shall have to visit half yearly or as and when defects are developed. For any defects developed, Engineers are to attend the defects within three (3) working days of reporting. The entire cost incurred for attending the issues raised/the regular yearly, half yearly visits shall be covered under the AMC. Manufacturer has the responsibility to take care of replacement of all items if required to restore the system. During AMC, if any element is added up, integration of same is the responsibility of Manufacturer without any cost involvement to Employer.

## ANNEXURE-I: SAS Architecture

Notes:

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) The IEDs for control, protection & metering (ABT compliant electronic TVM) shall be installed in the swing type simplex C & R panels inside the control room, all connections shall be realized as per IEC 61850 protocol.

3) Required Inverter of Numeric make, 3 KVA capacity shall be provided by the bidder.

4) Necessary furniture for installation of complete equipment of SAS is also in the scope of supply. The successful bidder shall submit list of complete furniture including enclosure for printers.

5) For gateway, it shall communicate with Remote Control Centre and State Load Despatch Centre (SLDC) on IEC 60870-5-101 & 104 protocol.

6) The SLD displayed in the HMI shall be capable of distinguishing the Bus for different voltage level, bus live & dead status, bay equipment live & dead status and future extension indicating through different colours.

7) The printers shall be connected to station bus directly and can be managed from station HMI, as well as disturbance recorder work station.

The above Architecture is typical. The contractor is to consider the SLD of respective substation for detail BoQ, particularly for Ethernet Switches & BCUs.

## ANNEXURE II

## List of Analogue and Digital Inputs/ Outputs for SAS

## Basic Monitoring requirements are:

o Switchgear status indication

o Measurements (U, I, P,MVA Q, f, sequence components, pf, phase angle, THD & TDD, Synchrocheck information i.e. $\Delta F$, $\Delta V$, $\Delta\phi$; Active & Reactive energy)

o Event

o Alarm

o Winding temperature if transformers/ reactors

o Ambient temperature

o Status and display of station auxiliary ac & dc supply

o Status display of transformer fire protection system

o Acquisition of all counters in PLCC panels

o from PLCC or independently by counting the receive/send commands

o Acquisition of alarm and fault record from protection relays

o Disturbance records

o Monitoring the state of batteries by displaying DC voltage, charging current and load current etc for both 220/110-volt station & communication 48-volt batteries

o Tap-position of Transformer

## 2. List of Inputs: The list of input for typical bays is as below:-

### 1) Analogue inputs

For line R, Y, B phase line currents & R-N, Y-N, B-N phase voltages

For transformers ■■R, Y, B phase line currents for HV & LV

OTI & WTI

Tap position

For bus coupler R, Y, B phase line currents

Common

R-N, Y-N, B-N phase voltages for all buses

Frequency of all buses

Outside ambient temperature

LT ac voltages

220/ 110-volt station battery voltage

48-volt battery voltage

### 2) Digital inputs

Line bays

Status of each pole of CB

Status of isolator, earth switch

CB trouble

CB operation / closing lock out

Pole discrepancy operated

Trip circuit faulty

LBB operated

Bus bar protection trip operated

Breaker auto reclosure operated

Tie/ transfer breaker auto reclosure operated

AR lock out

Trip transfer sent/ received

Main I / II DPR operated

Directional E/F operated

Fuse failure alarm

PSB alarm

Broken Conductor alarm

Under voltage alarm

SOTF trip

Carrier aided trip

Main I/ II Zone 2/ Zone III trip

Back up O/C or E/F operated

PLCC protection channel I/ II failed

PLCC speech failed

BCU/ BPU failed

Transformer bays

Status of CB, isolator, earth switch

CB trouble

CB operation/ closing lock out

Pole discrepancy operated

Trip circuit I/ II faulty

BCU/ BPU failed

LBB operated

Bus bar protection operated

REF operated

Differential operated

Over flux alarm/ trip

OTI/ WTI alarm/ trip

Buchholz alarm/ trip

OLTC OSR trip

Low oil alarm

PRD I/ II operated

Back up O/C or E/F operated

Zero sequence current

Discrimination of PT fuse fail and circuit dead

Bus bar Protection

Bus bar main I/ II trip

Bus bar zone I/II open

Bus protection relay fail

BCU/ BPU failed

## Other Signal to be incorporated in DR/SAS:

Standard DR Signal

## For transmission Line (One & half breaker scheme)

| | MAIN-1 | |
|---|---|---|
| A | Configuration of ANALOG CHANNELS | |
| S.No. | Channel Description | Standardized Channel Name |
| 1 | R Phase Current | I-R PH. |

| | MAIN-1 | |
|---|---|---|
| 2 | Y Phase Current | I-Y PH. |
| 3 | B Phase Current | I-B PH. |
| 4 | Neutral Current | I-N PH. |
| 5 | R Phase Voltage | V-R PH. |
| 6 | Y Phase Voltage | V-Y PH. |
| 7 | B Phase Voltage | V-B PH. |
| 8 | Open Delta Voltage | V-N (Open Delta) |

| B | Configuration of Digital Channels for 32 channels | | | | |
|---|---|---|---|---|---|
| S.No. | Channel Description | (Limited to 16 Characters) | 7 characters | Triggers | COMMENTS |
| 1 | MAIN CB R-PHASE OPEN | MAIN_CB_R_OPEN | M CB_RO | Y | |
| 2 | MAIN CB Y-PHASE OPEN | MAIN_CB_Y_OPEN | M CB_YO | Y | |
| 3 | MAIN CB B-PHASE OPEN | MAIN_CB_B_OPEN | M CB_BO | Y | |
| 4 | TIE CB R-PHASE OPEN | TIE_CB_R_OPEN | T CB_RO | Y | |
| 5 | TIE CB Y-PHASE OPEN | TIE_CB_Y_OPEN | T CB_YO | Y | |
| 6 | TIE CB B-PHASE OPEN | TIE_CB_B_OPEN | T CB_BO | Y | |
| 7 | MAIN1 TRIP | MAIN1_TRIP | M1_TRIP | Y | |
| 8 | MAIN2 TRIP | MAIN2_TRIP | M2_TRIP | Y | MAIN-2 |
| 9 | AUTO RECLOSE OPTD MAIN CB | MAIN_CB_A/R_OPTD | M CB_AR | Y | |
| 10 | MAIN CB AR LOCKOUT | MAIN CB AR LO | MCB AR LO | N | |
| 11 | AUTO RECLOSE OPTD TIE CB | TIE_CB_A/R_OPTD | T CB_AR | Y | |
| 12 | TIE CB AR LOCKOUT | TIE CB A/R_LO | AR_L/O | N | |
| 13 | MAIN1/2 CARRIER RECEIVE | MAIN1/2_CARR_REC | M1/2_CR | N | MAIN-1/2 |
| 14 | DT RECEIVE CHANNEL-1/2 | DT_REC_CH1/2 | DTRC1/2 | Y | |
| 15 | 3 PH. GROUP A/B OPERATED | 3PH_GR_A/B_OPTD | GRA/B_OPD | Y | |
| 16 | OVER VOLTAGE STAGE-1 OPERATED | O/V_STG1_OPTD | O/V_ST1 | Y | |
| 17 | OVER VOLTAGE STAGE-2 OPERATED | O/V_STG2_OPTD | O/V_ST2 | Y | |
| 18 | POWER SWING BLOCK OPERATED | PS BLK OPTD | PSB_OP | N | |
| 19 | STUB/TEED OPERATED | STUB_OPTD | SB_OPD | Y | Where ever Applicable |
| 20 | BUSBAR OPERATED (M1/M2) | BUSBAR_OPTD | BB_OPD | Y | |
| 21 | MAIN/TIE LBB OPERATED | M/T_LBB_OPTD | M/T_LBB | Y | |
| 22 | MAIN 1 ZONE-1 OPTD. | MAIN1_Z1_OPTD | M1Z1_OP | Y | |
| 23 | MAIN 1 ZONE-2 START | MAIN1_Z2_START | M1Z2_ST | N | |
| 24 | MAIN 1 ZONE-2 OPTD. | MAIN1_Z2_OPTD | M1Z2_OP | Y | |
| 25 | MAIN 1 ZONE-3 START | MAIN1_Z3_START | M1Z3_ST | N | |
| 26 | MAIN 1 ZONE-3 OPTD. | MAIN1_Z3_OPTD | M1Z3_OP | Y | |
| 27 | MAIN 1 REVERSE ZONE OPTD | MAIN1_ZR_OPTD | M1ZR_OP | Y | |
| 28 | MAIN 1/2 SOTF OPTD | M1/2_SOTF_OPD | M12SOTF | Y | |
| 29 | MAIN 1/2 DEF OPTD | DEF_OPD | DEF_OPD | Y | MAIN-1/2 |
| 30 | MAIN1/2 CARR. SEND | M1/2 CARR. SEND | M12CRSD | N | MAIN-1/2 |
| 31 | DIRECT TRIP SEND | DIR_TR SEND | DT_SEND | Y | |

| B | Configuration of Digital Channels for 32 channels | | | | |
|---|---|---|---|---|---|
| 32 | CARRIER AIDED TRIP | CARR_AID_TRIP | CAR_AID | Y | |

| | MAIN-2 | |
|---|---|---|
| A | Configuration of ANALOG CHANNELS | |
| S.No | Channel Description | Standardized Channel Name |
| 1 | R Phase Current | I-R PH. |
| 2 | Y Phase Current | I-Y PH. |
| 3 | B Phase Current | I-B PH. |
| 4 | Neutral Current | I-N PH. |
| 5 | R Phase Voltage | V-R PH. |
| 6 | Y Phase Voltage | V-Y PH. |
| 7 | B Phase Voltage | V-B PH. |
| 8 | Open Delta Voltage | V-N (Open Delta) |

| B | Configuration of Digital Channels for 32 channels | | | | |
|---|---|---|---|---|---|
| S.No. | Channel Description | (Limited to 16 Characters) | 7 characters | Triggers | COMMENTS |
| 1 | MAIN CB R-PHASE OPEN | MAIN_CB_R_OPEN | M CB_RO | Y | |
| 2 | MAIN CB Y-PHASE OPEN | MAIN_CB_Y_OPEN | M CB_YO | Y | |
| 3 | MAIN CB B-PHASE OPEN | MAIN_CB_B_OPEN | M CB_BO | Y | |
| 4 | TIE CB R-PHASE OPEN | TIE_CB_R_OPEN | T CB_RO | Y | |
| 5 | TIE CB Y-PHASE OPEN | TIE_CB_Y_OPEN | T CB_YO | Y | |
| 6 | TIE CB B-PHASE OPEN | TIE_CB_B_OPEN | T CB_BO | Y | |
| 7 | MAIN1 TRIP | MAIN1_TRIP | M1_TRIP | Y | MAIN-1 |
| 8 | MAIN2 TRIP | MAIN2_TRIP | M2_TRIP | Y | |
| 9 | MAIN 2 ZONE-1 OPTD. | MAIN2_Z1_OPTD | M2Z1_OP | Y | |
| 10 | MAIN 2 ZONE-2 START | MAIN2_Z2_START | M2Z2_ST | N | |
| 11 | MAIN 2 ZONE-2 OPTD. | MAIN2_Z2_OPTD | M2Z2_OP | Y | |
| 12 | MAIN 2 ZONE-3 START | MAIN2_Z3_START | M2Z3_ST | N | |
| 13 | MAIN 2 ZONE-3 OPTD. | MAIN2_Z3_OPTD | M2Z3_OP | Y | |
| 14 | MAIN 2 REVERSE ZONE START | MAIN2_ZR_START | M2ZR_ST | N | |
| 15 | MAIN 2 REVERSE ZONE OPTD | MAIN2_ZR_OPTD | M2ZR_OP | Y | |
| 16 | POWER SWING DET. | PS_DETECTED | PS_DET | N | |
| 17 | POWER SWING BLOCK OPERATED | PS BLK OPTD | PSB_OP | N | |
| 18 | OVER VOLTAGE STAGE-1 OPERATED | O/V_STG1_OPTD | O/V_ST1 | Y | |
| 19 | OVER VOLTAGE STAGE-2 OPERATED | O/V_STG2_OPTD | O/V_ST2 | Y | |
| 20 | MAIN/TIE CB POLE DISCREPANCY | M/T_CB_POLE_DISC | M/T_PLDSC | N | |
| 21 | CARRIER AIDED TRIP | CAR_AID_TRP | CAR_TRP | Y | |
| 22 | MAIN-1 VT FUSE FAIL | VT_FUS_FAIL_M1 | VT_FF_M1 | N | MAIN-1 |
| 23 | MAIN-2 VT FUSE FAIL | VT_FUS_FAIL_M2 | VT_FF_M2 | N | |
| 24 | MAIN-2 CARRIER RECEIVE | MAIN2_CARR_REC | M2_CR_RC | N | |
| 25 | OPTIONAL | | | | |
| 26 | OPTIONAL | | | | |
| 27 | OPTIONAL | | | | |

| B | Configuration of Digital Channels for 32 channels | | | | |
|---|---|---|---|---|---|
| 28 | OPTIONAL | | | | |
| 29 | OPTIONAL | | | | |
| 30 | OPTIONAL | | | | |
| 31 | OPTIONAL | | | | |
| 32 | OPTIONAL | | | | |

| | MAIN-1/2 | | | |
|---|---|---|---|---|
| Configuration of Digital Channels for 16 channels | | | | |
| S.No. | DIGITAL CHANNELS | (Limited to 16 Characters) | 7 characters | Triggers |
| 1 | MAIN CB R-PHASE OPEN | MAIN_CB_R_OPEN | M CB_RO | Y |
| 2 | MAIN CB Y-PHASE OPEN | MAIN_CB_Y_OPEN | M CB_YO | Y |
| 3 | MAIN CB B-PHASE OPEN | MAIN_CB_B_OPEN | M CB_BO | Y |
| 4 | TIE CB R-PHASE OPEN | TIE_CB_R_OPEN | T CB_RO | Y |
| 5 | TIE CB Y-PHASE OPEN | TIE_CB_Y_OPEN | T CB_YO | Y |
| 6 | TIE CB B-PHASE OPEN | TIE_CB_B_OPEN | T CB_BO | Y |
| 7 | MAIN1 TRIP | MAIN1_TRIP | M1_TRIP | Y |
| 8 | MAIN2 TRIP | MAIN2_TRIP | M2_TRIP | Y |
| 9 | AUTO RECLOSE OPTD M/T CB | M/T_CB_A/R_OPTD | M/TCBAR | Y |
| 10 | MAIN1/2 CARRIER RECEIVE | MAIN1/2_CARR_REC | M1/2_CR | N |
| 11 | MAIN 1/2 DEF OPTD | DEF_OPD | DEF_OPD | Y |
| 12 | DT RECEIVE CHANNEL-1/2 | DT_REC_CH-1/2 | DTRC1/2 | Y |
| 13 | OVER VOLTAGE STAGE-1/2 OPERATED | O/V_STG1/2_OPTD | OVST1/2 | Y |
| 14 | STUB/TEED/SOTF OPERATED | ST_TEE_SOTF_OPTD | STF_OPD | Y |
| 15 | BUSBAR OPERATED (M1/M2) | BUSBAR_OPTD | BB_OPD | Y |
| 16 | MAIN/TIE CB LBB OPERATED | M/T_LBB_OPTD | M/T_LBB | Y |

## DR for Transmission Line (Double Bus cum Transfer)

## Main 1

| A | Configuration of ANALOG CHANNELS | |
|---|---|---|
| S.No. | Channel Description | Standardized Channel Name |
| 1 | R Phase Current | I-R PH. |
| 2 | Y Phase Current | I-Y PH. |
| 3 | B Phase Current | I-B PH. |
| 4 | Neutral Current | I-N PH |
| 5 | R Phase Voltage | V-R PH. |
| 6 | Y Phase Voltage | V-Y PH. |
| 7 | B Phase Voltage | V-B PH. |
| 8 | Open Delta Voltage | V-N-Open Delta |

| B | Configuration of Digital Channels for 32 channels | | | | |
|---|---|---|---|---|---|
| S.No. | Channel Description | (Limited to 16 Characters) | 7 characters | Triggers | COMMENTS |
| 1 | MAIN CB R-PHASE OPEN | MAIN_CB_R_OPEN | M CB_RO | Y | |
| 2 | MAIN CB Y-PHASE OPEN | MAIN_CB_Y_OPEN | M CB_YO | Y | |
| 3 | MAIN CB B-PHASE OPEN | MAIN_CB_B_OPEN | M CB_BO | Y | |
| 4 | TBC CB R-PHASE OPEN | TBC_CB_R_OPEN | T CB_RO | Y | |

| B | Configuration of Digital Channels for 32 channels | | | | |
|---|---|---|---|---|---|
| 5 | TBC CB Y-PHASE OPEN | TBC_CB_Y_OPEN | T CB_YO | Y | |
| 6 | TBC CB B-PHASE OPEN | TBC_CB_B_OPEN | T CB_BO | Y | |
| 7 | MAIN1 TRIP | MAIN1_TRIP | M1_TRIP | Y | |
| 8 | MAIN2 TRIP | MAIN2_TRIP | M2_TRIP | Y | MAIN-2 |
| 9 | AUTO RECLOSE OPTD MAIN CB | MAIN_CB_A/R_OPTD | M CB_AR | Y | |
| 10 | MAIN CB AR LOCKOUT | MAIN CB AR LO | MCB AR LO | N | |
| 11 | AUTO RECLOSE OPTD TBC CB | TBC_CB_A/R_OPTD | T CB_AR | Y | |
| 12 | TBC CB AR LOCKOUT | TBC_CB_A/R_LO | AR_L/O | N | |
| 13 | MAIN1/2 CARRIER RECEIVE | MAIN1/2_CARR_REC | M1/2_CR | N | MAIN-1/2 |
| 14 | DT RECEIVE CHANNEL-1/2 | DT_REC_CH1/2 | DTRC1/2 | Y | |
| 15 | 3 PH. GROUP A/B OPERATED | 3PH_GR_A/B_OPTD | GRA/B_OPD | Y | |
| 16 | OVER VOLTAGE STAGE-1 OPERATED | O/V_STG1_OPTD | O/V_ST1 | Y | |
| 17 | OVER VOLTAGE STAGE-2 OPERATED | O/V_STG2_OPTD | O/V_ST2 | Y | |
| 18 | POWER SWING BLOCK OPERATED | PS BLK OPTD | PSB_OP | N | |
| 19 | MAIN-1 VT FUSE FAIL | VT_FUS_FAIL_M1 | VT_FF_M1 | N | |
| 20 | BUSBAR OPERATED (M1/M2) | BUSBAR_OPTD | BB_OPD | Y | |
| 21 | MAIN/TBC LBB OPERATED | M/T_LBB_OPTD | M/T_LBB | Y | |
| 22 | MAIN 1 ZONE-1 OPTD. | MAIN1_Z1_OPTD | M1Z1_OP | Y | |
| 23 | MAIN 1 ZONE-2 START | MAIN1_Z2_START | M1Z2_ST | N | |
| 24 | MAIN 1 ZONE-2 OPTD. | MAIN1_Z2_OPTD | M1Z2_OP | Y | |
| 25 | MAIN 1 ZONE-3 START | MAIN1_Z3_START | M1Z3_ST | N | |
| 26 | MAIN 1 ZONE-3 OPTD. | MAIN1_Z3_OPTD | M1Z3_OP | Y | |
| 27 | MAIN 1 REVERSE ZONE OPTD | MAIN1_ZR_OPTD | M1ZR_OP | Y | |
| 28 | MAIN 1/2 SOTF OPTD | M1/2_SOTF_OPD | M12SOTF | Y | |
| 29 | MAIN 1/2 DEF OPTD | DEF_OPD | DEF_OPD | Y | MAIN-1/2 |
| 30 | MAIN1/2 CARR. SEND | M1/2 CARR. SEND | M12CRSD | N | MAIN-1/2 |
| 31 | DIRECT TRIP SEND | DIR_TR SEND | DT_SEND | Y | |
| 32 | CARRIER AIDED TRIP | CARR_AID_TRIP | CAR_AID | Y | |

| | MAIN-2 | |
|---|---|---|
| A | Configuration of ANALOG CHANNELS | |
| S.No. | Channel Description | Standardized Channel Name |
| 1 | R Phase Current | I-R PH. |
| 2 | Y Phase Current | I-Y PH. |
| 3 | B Phase Current | I-B PH. |
| 4 | Neutral Current | I-N PH. |
| 5 | R Phase Voltage | V-R PH. |
| 6 | Y Phase Voltage | V-Y PH. |
| 7 | B Phase Voltage | V-B PH. |
| 8 | Open Delta Voltage | V-N (Open Delta) |

| B | Configuration of Digital Channels for 32 channels | | | | |
|---|---|---|---|---|---|
| S.No. | Channel Description | (Limited to 16 Characters) | 7 characters | Triggers | COMMENTS |
| 1 | MAIN CB R-PHASE OPEN | MAIN_CB_R_OPEN | M CB_RO | Y | |
| 2 | MAIN CB Y-PHASE OPEN | MAIN_CB_Y_OPEN | M CB_YO | Y | |
| 3 | MAIN CB B-PHASE OPEN | MAIN_CB_B_OPEN | M CB_BO | Y | |
| 4 | TBC CB R-PHASE OPEN | TBC_CB_R_OPEN | T CB_RO | Y | |
| 5 | TBC CB Y-PHASE OPEN | TBC_CB_Y_OPEN | T CB_YO | Y | |
| 6 | TBC CB B-PHASE OPEN | TIE_CB_B_OPEN | T CB_BO | Y | |
| 7 | MAIN1 TRIP | MAIN1_TRIP | M1_TRIP | Y | MAIN-1 |
| 8 | MAIN2 TRIP | MAIN2_TRIP | M2_TRIP | Y | |
| 9 | MAIN 2 ZONE-1 OPTD. | MAIN2_Z1_OPTD | M2Z1_OP | Y | |
| 10 | MAIN 2 ZONE-2 START | MAIN2_Z2_START | M2Z2_ST | N | |
| 11 | MAIN 2 ZONE-2 OPTD. | MAIN2_Z2_OPTD | M2Z2_OP | Y | |
| 12 | MAIN 2 ZONE-3 START | MAIN2_Z3_START | M2Z3_ST | N | |
| 13 | MAIN 2 ZONE-3 OPTD. | MAIN2_Z3_OPTD | M2Z3_OP | Y | |
| 14 | MAIN 2 REVERSE ZONE START | MAIN2_ZR_START | M2ZR_ST | N | |
| 15 | MAIN 2 REVERSE ZONE OPTD | MAIN2_ZR_OPTD | M2ZR_OP | Y | |
| 16 | POWER SWING DET. | PS_DETECTED | PS_DET | N | |
| 17 | POWER SWING BLOCK OPERATED | PS BLK OPTD | PSB_OP | N | |
| 18 | OVER VOLTAGE STAGE-1 OPERATED | O/V_STG1_OPTD | O/V_ST1 | Y | |
| 19 | OVER VOLTAGE STAGE-2 OPERATED | O/V_STG2_OPTD | O/V_ST2 | Y | |
| 20 | MAIN/TBC CB POLE DISCREPANCY | M/T_CB_POLE_DISC | M/T_PLDSC | N | |
| 21 | CARRIER AIDED TRIP | CAR_AID_TRP | CAR_TRP | Y | |
| 22 | DIRECT TRIP SEND | DIR_TR SEND | DT_SEND | Y | |
| 23 | MAIN-2 VT FUSE FAIL | VT_FUS_FAIL_M2 | VT_FF_M2 | N | |
| 24 | MAIN-2 CARRIER RECEIVE | MAIN2_CARR_REC | M2_CR_RC | N | |
| 25 | OPTIONAL | | | | |
| 26 | OPTIONAL | | | | |
| 27 | OPTIONAL | | | | |
| 28 | OPTIONAL | | | | |
| 29 | OPTIONAL | | | | |
| 30 | OPTIONAL | | | | |
| 31 | OPTIONAL | | | | |
| 32 | OPTIONAL | | | | |

| Configuration of Digital Channels for 16 channels | | | | |
|---|---|---|---|---|
| S.No. | DIGITAL CHANNELS | (Limited to 16 Characters) | 7 characters | Triggers |
| 1 | MAIN CB R-PHASE OPEN | MAIN_CB_R_OPEN | M CB_RO | Y |
| 2 | MAIN CB Y-PHASE OPEN | MAIN_CB_Y_OPEN | M CB_YO | Y |
| 3 | MAIN CB B-PHASE OPEN | MAIN_CB_B_OPEN | M CB_BO | Y |
| 4 | TBC CB R-PHASE OPEN | TBC_CB_R_OPEN | T CB_RO | Y |
| 5 | TBC CB Y-PHASE OPEN | TBC_CB_Y_OPEN | T CB_YO | Y |
| 6 | TBC CB B-PHASE OPEN | TBC_CB_B_OPEN | T CB_BO | Y |
| 7 | MAIN1 TRIP | MAIN1_TRIP | M1_TRIP | Y |

| Configuration of Digital Channels for 16 channels | | | | |
|---|---|---|---|---|
| 8 | MAIN2 TRIP | MAIN2_TRIP | M2_TRIP | Y |
| 9 | AUTO RECLOSE OPTD M/T CB | M/T_CB_A/R_OPTD | M/TCBAR | Y |
| 10 | MAIN1/2 CARRIER RECEIVE | MAIN1/2_CARR_REC | M1/2_CR | N |
| 11 | MAIN 1/2 DEF OPTD | DEF_OPD | DEF_OPD | Y |
| 12 | DT RECEIVE CHANNEL-1/2 | DT_REC_CH-1/2 | DTRC1/2 | Y |
| 13 | OVER VOLTAGE STAGE-1/2 OPERATED | O/V_STG1/2_OPTD | OVST1/2 | Y |
| 14 | SOTF OPERATED | SOTF_OPTD | STF_OPD | Y |
| 15 | BUSBAR OPERATED (M1/M2) | BUSBAR_OPTD | BB_OPD | Y |
| 16 | MAIN/TBC CB LBB OPERATED | M/T_LBB_OPTD | M/T_LBB | Y |

DR for Transformer (one and half breaker scheme)

| A | Configuration of ANALOG CHANNELS | | |
|---|---|---|---|
| S.No. | Channel Description | Standardized Channel Name | COMMENTS |
| 1 | HV R Phase Current | I-R PH. HV | |
| 2 | HV Y Phase Current | I-Y PH. HV | |
| 3 | HV B Phase Current | I-B PH. HV | |
| 4 | HV Neutral Current | I-N HV | |
| 5 | IV R Phase Current | I-R PH. IV | |
| 6 | IV Y Phase Current | I-Y PH. IV | |
| 7 | IV B Phase Current | I-B PH. IV | |
| 9 | IV Neutral Current | I-N IV | |
| 10 | R Phase DIFFERENTIAL Current (CALCULATED) | IR DIFF | |
| 11 | Y Phase DIFFERENTIAL Current (CALCULATED) | IY DIFF | |
| 12 | B Phase DIFFERENTIAL Current (CALCULATED) | IB DIFF | |
| 13 | LV R Phase Current | L-R PH. IV | OPTIONAL |
| 14 | LV Y Phase Current | L-Y PH. IV | OPTIONAL |
| 15 | LV B Phase Current | L-B PH. IV | OPTIONAL |
| 16 | LV Neutral Current | L-N IV | OPTIONAL |
| 17 | HV R Ph Voltage | V-R PH HV | OPTIONAL |
| 18 | HV Y Ph Voltage | V-Y PH HV | OPTIONAL |
| 19 | HV B Ph Voltage | V-B PH HV | OPTIONAL |

| B | Configuration of Digital Channels for 32 channels | | | | |
|---|---|---|---|---|---|
| S.No. | Channel Description | (Limited to 16 Characters) | 7 characters | Triggers | COMMENTS |
| 1 | MAIN CB OPEN (HV SIDE) | HV_M_CB_OPEN | HV_MCBO | Y | |
| 2 | TIE CB OPEN (HV SIDE) | HV_T_CB_OPEN | HV_TCBO | Y | |
| 3 | MAIN CB OPEN (IV SIDE) | IV_M_CB_OPEN | IV_MCBO | Y | |
| 4 | TIE/TBC CB OPEN (IV SIDE) | IV_T_CB_OPEN | IV_TCBO | Y | |
| 5 | DIFFERENTIAL PROTECTION OPERATED | DIFF_PROTN_OPTD | DIF_OPD | Y | |
| 6 | REF PROTECTION OPERATED | REF_PROTN_OPTD | REF_OPD | Y | |
| 7 | HV OC PROTECTION OPERATED | HV_B/U_PROTN_OPD | HVBUOPD | Y | |
| 8 | HV EF PROTN OPERATED | HV_EF_PROTN_OPD | HVEFOPD | Y | |

| B | Configuration of Digital Channels for 32 channels | | | | |
|---|---|---|---|---|---|
| 9 | HV OVER FLUXING OPERATED | HV_OVERFLUX_OPTD | HVOFOPD | Y | |
| 10 | IV OVER FLUXING OPERATED | IV_OVERFLUX_OPTD | IVOFOPD | Y | |
| 11 | PRV TRIP | PRV_TRIP | PRV_TRP | Y | |
| 12 | WTI TRIP | WTI_TRIP | WTI_TR | Y | HV/IV/LV |
| 13 | OSR TRIP | OSR_TRIP | OSR_TRP | Y | |
| 14 | OTI TRIP | OTI_TRIP | OTI_TRP | Y | |
| 15 | BUCHHOLZ TRIP | BUCHHOLZ_TRIP | BCZ_TRP | Y | |
| 16 | 3 PH. GROUP A OPERATED | 3PH_GR_A_OPTD | GRA_OPD | Y | |
| 17 | 3 PH. GROUP B OPERATED | 3PH_GR_B_OPTD | GRB_OPD | Y | |
| 18 | MAIN CB (HV SIDE) LBB OPTD. | HV_MAIN_LBB_OPTD | H_M_LBB | Y | |
| 19 | MAIN CB (IV SIDE) LBB OPTD. | IV_MAIN_LBB_OPTD | I_M_LBB | Y | |
| 20 | TIE CB (HV SIDE) LBB OPTD. | HV_TIE_LBB_OPTD | H_T_LBB | Y | |
| 21 | TIE/TBC CB (IV SIDE) LBB OPTD. | IV_T_LBB_OPTD | I_T_LBB | Y | |
| 22 | BUSBAR OPERATED | BUSBAR_OPTD | BB_OPD | Y | |
| 23 | DTOC OPTD | DTOC_OPTD | DTOCOPD | Y | IF APPLICABLE |
| 24 | OLTC OIL SURGE TRIP | OLTC_OIL SGTR | OL_SR_TR | Y | |
| 25 | HV VT FUSE FAIL ALARM | HVVT_FUS_FAIL | HVVT_FF | N | |
| 26 | WTI ALARM | WTI_ALARM | WTI_AL | N | HV/IV/LV |
| 27 | OTI ALARM | OTI_ALARM | OTI_AL | N | |
| 28 | OVER LOAD ALARM | OL_ALARM | OL_AL | N | |
| 29 | | | | | OPTIONAL |
| 30 | | | | | OPTIONAL |
| 31 | | | | | OPTIONAL |
| 32 | | | | | OPTIONAL |

| Configuration of Digital Channels for 16 channels | | | | |
|---|---|---|---|---|
| S.No. | DIGITAL CHANNELS | (Limited to 16 Characters) | 7 characters | Triggers |
| 1 | MAIN CB OPEN (HV SIDE) | HV_M_CB_OPEN | HV_MCBO | Y |
| 2 | TIE CB OPEN (HV SIDE) | HV_T_CB_OPEN | HV_TCBO | Y |
| 3 | MAIN CB OPEN (IV SIDE) | IV_M_CB_OPEN | IV_MCBO | Y |
| 4 | TBC/TIE CB OPEN (IV SIDE) | IV_T_CB_OPEN | IV_TCBO | Y |
| 5 | DIFFERENTIAL PROTECTION OPERATED | DIFF_PROTN_OPTD | DIF_OPD | Y |
| 6 | REF PROTECTION OPERATED | REF_PROTN_OPTD | REF_OPD | Y |
| 7 | HV BACKUP PROTECTION OPERATED | HV_B/U_PROTN_OPD | HVBUOPD | Y |
| 8 | HV/IV OVER FLUXING OPERATED | HV/IV_O/F_OPD | O/F_OPD | Y |
| 9 | PRV TRIP | PRV_TRIP | PRV_TRP | Y |
| 10 | OTI/WTI TRIP | OTI/WTI_TRIP | OT/WT_T | Y |
| 11 | BUCHHOLZ/OSR TRIP | BUCH/OSR_TRIP | B_OSR_T | Y |
| 12 | MAIN/TIE CB (HV SIDE) LBB OPTD. | M/T_HV_LBB | HV_LBB | Y |

| Configuration of Digital Channels for 16 channels | | | | |
|---|---|---|---|---|
| 13 | MAIN/TBC CB (IV SIDE) LBB OPTD. | M/T_IV_LBB | IV_LBB | Y |
| 14 | BUSBAR OPERATED | BUSBAR_OPTD | BB_OPD | Y |
| 15 | DTOC OPTD | DTOC_OPTD | DTOCOPD | Y |
| 16 | 3 PH. GROUP A/B OPERATED | 3PH_GR_A/B_OPTD | GRA/B_OPD | Y |

## DR for Bus/Line Reactor for one and half breaker scheme

For back up Impedance Relay

| A | Configuration of ANALOG CHANNELS | | |
|---|---|---|---|
| S.No. | Channel Description | Standardized Channel Name | COMMENTS |
| 1 | R Phase Current | I-R PH. | |
| 2 | Y Phase Current | I-Y PH. | |
| 3 | B Phase Current | I-B PH. | |
| 4 | Neutral Current | I-N PH. | |
| 5 | R Phase Voltage | V-R PH. | |
| 6 | Y Phase Voltage | V-Y PH. | |
| 7 | B Phase Voltage | V-B PH. | |
| 8 | Neutral voltage | V-N PH. | |

| B | Configuration of Digital Channels for 32 channels | | | |
|---|---|---|---|---|
| S.No. | Channel Description | (Limited to 16 Characters) | 7 characters | Triggers |
| 1 | MAIN CB OPEN | MAIN_CB_OPEN | M_CB_O | Y |
| 2 | TIE CB OPEN | TIE_CB_OPEN | T_CB_O | Y |
| 3 | DIFFERENTIAL PROTECTION OPERATED | DIFF_PROTN_OPTD | DIF_OPD | Y |
| 4 | REF PROTECTION OPERATED | REF_PROTN_OPTD | REF_OPD | Y |
| 5 | BACKUP IMPEDANCE PROTN OPERATED | BU_IMP_PROTN_OPD | BUIMPOP | Y |
| 6 | PRV TRIP | PRV_TRIP | PRV_TRP | Y |
| 7 | WTI TRIP | WTI_TRIP | WTI_TRP | Y |
| 8 | WTI ALARM | WTI_ALARM | WTI_AL | Y |
| 9 | OTI TRIP | OTI_TRIP | OTI_TRP | Y |
| 10 | OTI ALARM | OTI_ALARM | OTI_AL | Y |
| 11 | BUCHHHOLZ TRIP | BUCHHHOLZ_TRIP | BCZ_TRP | Y |
| 12 | BUCHHHOLZ ALARM | BUCHHHOLZ_ALARM | BCZ_AL | Y |
| 13 | MAIN LBB OPERATED | MAIN_LBB_OPD | MLBBOPD | Y |
| 14 | TIE LBB OPERATED | TIE_LBB_OPD | TLBBOPD | Y |
| 15 | BUS BAR OPERATED | BUSBAR_OPTD | BB_OPD | Y |
| 16 | 3 PH. GROUP A OPERATED | 3PH_GR_A_OPTD | GRA_OPD | Y |
| 17 | 3 PH. GROUP B OPERATED | 3PH_GR_B_OPTD | GRB_OPD | Y |
| 18 | NGR PROTECTION OPERATED | NGR_PROTN_OPTD | NGR_OPD | Y |
| 19 | TEED PROTECTION OPERATED | TEED_PROTN_OPTD | TEE_OPD | Y |
| 20 | VT FUSE FAIL ALARM | VT_FUS_FAIL | VT_FF | N |

| B | Configuration of Digital Channels for 16 channels | | | |
|---|---|---|---|---|
| S.No. | Channel Description | (Limited to 16 Characters) | 7 characters | Triggers |

| B | Configuration of Digital Channels for 16 channels | | | |
|---|---|---|---|---|
| 1 | MAIN CB OPEN | MAIN_CB_OPEN | M_CB_O | Y |
| 2 | TIE CB OPEN | TIE_CB_OPEN | T_CB_O | Y |
| 3 | DIFFERENTIAL PROTECTION OPERATED | DIFF_PROTN_OPTD | DIF_OPD | Y |
| 4 | REF PROTECTION OPERATED | REF_PROTN_OPTD | REF_OPD | Y |
| 5 | BACKUP IMPEDANCE PROTN OPERATED | BU_IMP_PROTN_OPD | BUIMPOP | Y |
| 6 | PRV TRIP | PRV_TRIP | PRV_TRP | Y |
| 7 | WTI TRIP | WTI_TRIP | WTI_TRP | Y |
| 8 | TEED PROTECTION OPERATED | TEED_PROTN_OPTD | TEE_OPD | Y |
| 9 | OTI TRIP | OTI_TRIP | OTI_TRP | Y |
| 10 | BUCHHHOLZ TRIP | BUCHHHOLZ_TRIP | BCZ_TRP | Y |
| 11 | MAIN LBB OPERATED | MAIN_LBB_OPD | MLBBOPD | Y |
| 12 | TIE LBB OPERATED | TIE_LBB_OPD | TLBBOPD | Y |
| 13 | BUS BAR OPERATED | BUSBAR_OPTD | BB_OPD | Y |
| 14 | 3 PH. GROUP A OPERATED | 3PH_GR_A_OPTD | GRA_OPD | Y |
| 15 | 3 PH. GROUP B OPERATED | 3PH_GR_B_OPTD | GRB_OPD | Y |
| 16 | NGR PROTECTION OPERATED | NGR_PROTN_OPTD | NGR_OPD | Y |

For Main Differential Relay

| A | Configuration of ANALOG CHANNELS | |
|---|---|---|
| S.No. | Channel Description | Standardized Channel Name |
| 1 | R Phase Current | I-R PH. |
| 2 | Y Phase Current | I-Y PH. |
| 3 | B Phase Current | I-B PH. |
| 4 | Neutral Current | I-N PH. |
| 5 | R Phase Current NEUTRAL SIDE | I-RN PH. |
| 6 | Y Phase Current NEUTRAL SIDE | I-YN PH. |
| 7 | B Phase Current NEUTRAL SIDE | I-BN PH. |
| 8 | R Phase DIFFERENTIAL Current (CALCULATED) | IR DIFF |
| 9 | Y Phase DIFFERENTIAL Current (CALCULATED) | IY DIFF |
| 10 | B Phase DIFFERENTIAL Current (CALCULATED) | IB DIFF |

| B | Configuration of Digital Channels for 32 channels | | | |
|---|---|---|---|---|
| S.No. | Channel Description | (Limited to 16 Characters) | 7 characters | Triggers |
| 1 | MAIN CB OPEN | MAIN_CB_OPEN | M_CB_O | Y |
| 2 | TIE CB OPEN | TIE_CB_OPEN | T_CB_O | Y |
| 3 | DIFFERENTIAL PROTECTION OPERATED | DIFF_PROTN_OPTD | DIF_OPD | Y |
| 4 | REF PROTECTION OPERATED | REF_PROTN_OPTD | REF_OPD | Y |
| 5 | BACKUP IMPEDANCE PROTN OPERATED | BU_IMP_PROTN_OPD | BUIMPOP | Y |
| 6 | PRV TRIP | PRV_TRIP | PRV_TRP | Y |
| 7 | WTI TRIP | WTI_TRIP | WTI_TRP | Y |
| 8 | WTI ALARM | WTI_ALARM | WTI_AL | Y |
| 9 | OTI TRIP | OTI_TRIP | OTI_TRP | Y |
| 10 | OTI ALARM | OTI_ALARM | OTI_AL | Y |

| B | Configuration of Digital Channels for 32 channels | | | |
|---|---|---|---|---|
| 11 | BUCHHHOLZ TRIP | BUCHHHOLZ_TRIP | BCZ_TRP | Y |
| 12 | BUCHHHOLZ ALARM | BUCHHHOLZ_ALARM | BCZ_AL | Y |
| 13 | MAIN LBB OPERATED | MAIN_LBB_OPD | MLBBOPD | Y |
| 14 | TIE LBB OPERATED | TIE_LBB_OPD | TLBBOPD | Y |
| 15 | BUS BAR OPERATED | BUSBAR_OPTD | BB_OPD | Y |
| 16 | 3 PH. GROUP A OPERATED | 3PH_GR_A_OPTD | GRA_OPD | Y |
| 17 | 3 PH. GROUP B OPERATED | 3PH_GR_B_OPTD | GRB_OPD | Y |
| 18 | NGR PROTECTION OPERATED | NGR_PROTN_OPTD | NGR_OPD | Y |
| 19 | TEED PROTECTION OPERATED | TEED_PROTN_OPTD | TEE_OPD | Y |

| B | Configuration of Digital Channels for 16 channels | | | |
|---|---|---|---|---|
| S.No. | Channel Description | (Limited to 16 Characters) | 7 characters | Triggers |
| 1 | MAIN CB OPEN | MAIN_CB_OPEN | M_CB_O | Y |
| 2 | TIE CB OPEN | TIE_CB_OPEN | T_CB_O | Y |
| 3 | DIFFERENTIAL PROTECTION OPERATED | DIFF_PROTN_OPTD | DIF_OPD | Y |
| 4 | REF PROTECTION OPERATED | REF_PROTN_OPTD | REF_OPD | Y |
| 5 | BACKUP IMPEDANCE PROTN OPERATED | BU_IMP_PROTN_OPD | BUIMPOP | Y |
| 6 | PRV TRIP | PRV_TRIP | PRV_TRP | Y |
| 7 | WTI TRIP | WTI_TRIP | WTI_TRP | Y |
| 8 | TEED PROTECTION OPERATED | TEED_PROTN_OPTD | TEE_OPD | Y |
| 9 | OTI TRIP | OTI_TRIP | OTI_TRP | Y |
| 10 | BUCHHHOLZ TRIP | BUCHHHOLZ_TRIP | BCZ_TRP | Y |
| 11 | MAIN LBB OPERATED | MAIN_LBB_OPD | MLBBOPD | Y |
| 12 | TIE LBB OPERATED | TIE_LBB_OPD | TLBBOPD | Y |
| 13 | BUS BAR OPERATED | BUSBAR_OPTD | BB_OPD | Y |
| 14 | 3 PH. GROUP A OPERATED | 3PH_GR_A_OPTD | GRA_OPD | Y |
| 15 | 3 PH. GROUP B OPERATED | 3PH_GR_B_OPTD | GRB_OPD | Y |
| 16 | NGR PROTECTION OPERATED | NGR_PROTN_OPTD | NGR_OPD | Y |

## Standard list of Sequence of Events (SOE)

| SCADA SIGNAL LIST FOR VARIOUS PROTECTION & CONTROL SIGNALS | | | |
|---|---|---|---|
| | | | |
| | | | |
| REQUIRED SIGNALS FOR DISTANCE RELAYS | | | |
| SL. NO. | TYPE | EVENT/ALARM NAME | WHETHER ALARM TO BE GENERATED |
| 1 | SPI | OVERVOLATGE STAGE 1 START | |
| 2 | SPI | OVERVOLATGE STAGE 1 GEN TRIP | Y |

| SCADA SIGNAL LIST FOR VARIOUS PROTECTION & CONTROL SIGNALS | | | |
|---|---|---|---|
| 3 | SPI | OVERVOLATGE STAGE 2 GEN TRIP | Y |
| 4 | SPI | DEF START | |
| 5 | SPI | DEF GEN TRIP | Y |
| 6 | SPI | STUB PROTECTION OPERATED | Y |
| 7 | SPI | SOTF OPERATED | Y |
| 8 | SPI | START, Z1 R PH | |
| 9 | SPI | START, Z1 Y PH | |
| 10 | SPI | START, Z1 B PH | |
| 11 | SPI | START, Z2 | |
| 12 | SPI | START, Z3 | |
| 13 | SPI | START, Z4 | |
| 14 | SPI | START, Z5 | |
| 15 | SPI | TRIP, Z1 R PH | Y |
| 16 | SPI | TRIP, Z1 Y PH | Y |
| 17 | SPI | TRIP, Z1 B PH | Y |
| 18 | SPI | GENERAL TRIP, Z2 | Y |
| 19 | SPI | GENERAL TRIP, Z3 | Y |
| 20 | SPI | GENERAL TRIP, Z4 | Y |
| 21 | SPI | GENERAL TRIP, Z5 | Y |
| 22 | SPI | CARRIER SEND | Y |
| 23 | SPI | CARRIER RECEIVE | Y |
| 24 | SPI | CARRIER AIDED SCHEME OPERATED | Y |
| 25 | SPI | POWER SWING DETECTED | Y |
| 26 | SPI | POWER SWING BLOCKING | Y |
| 27 | SPI | DISTANCE RELAY GENERAL TRIP | Y |
| 28 | DINT | FAULT LOCATOR DISTANCE | |
| 29 | SPI | CVT FUSE FAIL | Y |
| 30 | System Diagnosis (SON) | TIME SYNCHRONIZATION ERROR | Y |
| 31 | System Diagnosis (SON) | M1 IED UNHEALTHY | Y |
| 32 | SPI | START AR | |
| 33 | SPI | LINE ISOLATOR OPEN FOR STUB ACTIVATION | |
| 34 | SPI | DT SEND CH 1 | Y |
| 35 | SPI | DT SEND CH 1 | Y |
| 36 | SPI | DT RECEIVE CH 1 | Y |
| 37 | SPI | DT RECEIVE CH 2 | Y |
| 38 | SPI | MAIN CB R PH OPEN | |
| 39 | SPI | MAIN CB Y PH OPEN | |
| 40 | SPI | MAIN CB B PH OPEN | |
| 41 | SPI | TIE CB R PH OPEN | |
| 42 | SPI | TIE CB Y PH OPEN | |
| 43 | SPI | TIE CB B PH OPEN | |
| 44 | SPI | TRIP RELAY 86 A HEALTHY (SUPERVISION) | |

| SCADA SIGNAL LIST FOR VARIOUS PROTECTION & CONTROL SIGNALS | | | |
|---|---|---|---|
| 45 | SPI | TRIP RELAY 86 B HEALTHY (SUPERVISION) | |
| 46 | SPI | GR A RELAY OPERATED | Y |
| 47 | SPI | GR B RELAY OPERATED | Y |
| 48 | SPI | CARRIER CHANNEL 1/2 OUT OF SERVICE | Y |
| 49 | SPI | CARRIER CHANNEL 1 FAIL | Y |
| 50 | SPI | CARRIER CHANNEL 2 FAIL | Y |
| 51 | SPI | MAIN 2/1 RELAY FAIL | Y |
| 52 | SPI | GOOSE RECEIPT FAIL/TROUBLE | Y |
| 53 | | ANY ADDITIONAL SIGNAL AS PER SCHEME | |

| REQUIRED SIGNALS FOR ICT DIFFERENTIAL RELAYS | | | |
|---|---|---|---|
| SL. NO. | TYPE | EVENT/ALARM NAME | WHETHER ALARM TO BE GENERATED |
| 1 | SPI | OVEREXCITATION HV START | |
| 2 | SPI | OVEREXCITATION HV ALARM | Y |
| 3 | SPI | OVEREXCITATION HV TRIP | Y |
| 4 | SPI | DIFFERENTIAL CURRENT ALARM | Y |
| 5 | SPI | DIFFERENTIAL PROTECTION TRIP | Y |
| 6 | INT | RESTRAINED MODE (RESTRAINED OR UNRESTRAINED) | |
| 7 | SPI | GENERAL TRIP | Y |
| 8 | System Diagnosis (SON) | TIME SYNCHRONIZATION ERROR | Y |
| 9 | System Diagnosis (SON) | DIFFRENTIAL IED UNHEALTHY | Y |
| 10 | SPI | DIFFERENTIAL RELAY GENERAL TRIP | Y |
| 11 | SPI | OTI ALARM | Y |
| 12 | SPI | WTI HV ALARM | Y |
| 13 | SPI | WTI IV ALARM | Y |
| 14 | SPI | WTI MV ALARM | Y |
| 15 | SPI | BUCCHOLZ TRIP | Y |
| 16 | SPI | OSR 1 TRIP | Y |
| 17 | SPI | PRD 1 TRIP | Y |
| 18 | SPI | FIRE PROTECTION OPERATED | Y |
| 19 | SPI | LOW OIL LEVEL | Y |
| 20 | SPI | OTI R PH ALARM | Y |
| 21 | SPI | OTI Y PH ALARM | Y |
| 22 | SPI | OTI B PH ALARM | Y |
| 23 | SPI | OTI SPARE ICT ALARM | Y |
| 24 | SPI | WTI HV R PH ALARM | Y |
| 25 | SPI | WTI HV Y PH ALARM | Y |
| 26 | SPI | WTI HV B PH ALARM | Y |
| 27 | SPI | WTI HV SPARE ICT ALARM | Y |
| 28 | SPI | WTI MV R PH ALARM | Y |

| REQUIRED SIGNALS FOR ICT DIFFERENTIAL RELAYS | | | |
|---|---|---|---|
| 29 | SPI | WTI MV Y PH ALARM | Y |
| 30 | SPI | WTI MV B PH ALARM | Y |
| 31 | SPI | WTI MV SPARE ICT ALARM | Y |
| 32 | SPI | WTI IV R PH ALARM | Y |
| 33 | SPI | WTI IV Y PH ALARM | Y |
| 34 | SPI | WTI IV B PH ALARM | Y |
| 35 | SPI | WTI IV SPARE ICT ALARM | Y |
| 36 | SPI | BUCCHOLZ R PH TRIP | Y |
| 37 | SPI | BUCCHOLZ Y PH TRIP | Y |
| 38 | SPI | BUCCHOLZ B PH TRIP | Y |
| 39 | SPI | BUCCHOLZ SPARE ICT TRIP | Y |
| 40 | SPI | OSR 1 R PH TRIP | Y |
| 41 | SPI | OSR 1 Y PH TRIP | Y |
| 42 | SPI | OSR 1 B PH TRIP | Y |
| 43 | SPI | OSR 1 SPARE ICT TRIP | Y |
| 44 | SPI | PRD 1 R PH TRIP | Y |
| 45 | SPI | PRD 1 Y PH TRIP | Y |
| 46 | SPI | PRD 1 B PH TRIP | Y |
| 47 | SPI | LOW OIL LEVEL R PH | Y |
| 48 | SPI | LOW OIL LEVEL Y PH | Y |
| 49 | SPI | LOW OIL LEVEL B PH | Y |
| 50 | SPI | LOW OIL LEVEL SPARE ICT | Y |
| 51 | SPI | FIRE PROTECTION R PH OPERATED | Y |
| 52 | SPI | FIRE PROTECTION Y PH OPERATED | Y |
| 53 | SPI | FIRE PROTECTION B PH OPERATED | Y |
| 54 | SPI | FIRE PROTECTION SPARE ICT OPERATED | Y |
| 55 | SPI | MAIN CB R PH OPEN | |
| 56 | SPI | MAIN CB Y PH OPEN | |
| 57 | SPI | MAIN CB B PH OPEN | |
| 58 | SPI | TIE CB R PH OPEN | |
| 59 | SPI | TIE CB Y PH OPEN | |
| 60 | SPI | TIE CB B PH OPEN | |
| 61 | SPI | TRIP RELAY 86 A HEALTHY (SUPERVISION) | Y |
| 62 | SPI | TRIP RELAY 86 B HEALTHY (SUPERVISION) | Y |
| 63 | SPI | GR A RELAY OPERATED | Y |
| 64 | SPI | GR B RELAY OPERATED | Y |
| 65 | SPI | REF RELAY FAIL | Y |
| 66 | SPI | GOOSE RECEIPT FAIL/TROUBLE | Y |
| 67 | SPI | ANY ADDITIONAL SIGNAL AS PER SCHEME | |

| REQUIRED SIGNALS FOR ICT REF RELAYS | | | |
|---|---|---|---|
| SL. NO. | TYPE | EVENT/ALARM NAME | WHETHER ALARM TO BE GENERATED |

| REQUIRED SIGNALS FOR ICT REF RELAYS | | | |
|---|---|---|---|
| 1 | SPI | OVEREXCITATION MV START | |
| 2 | SPI | OVEREXCITATION MV ALARM | Y |
| 3 | SPI | OVEREXCITATION MV TRIP | Y |
| 4 | System Diagnosis (SON) | TIME SYNCHRONIZATION ERROR | Y |
| 5 | System Diagnosis (SON) | DIFFRENTIAL IED UNHEALTHY | Y |
| 6 | SPI | REF RELAY ALARM | Y |
| 7 | SPI | REF TRIP | Y |
| 8 | SPI | GENERAL TRIP | Y |
| 9 | SPI | REF TRIP | Y |
| 10 | SPI | OTI TRIP | Y |
| 11 | SPI | WTI HV TRIP | Y |
| 12 | SPI | WTI MV TRIP | Y |
| 13 | SPI | WTI LV TRIP | Y |
| 14 | SPI | OSR 2 TRIP | Y |
| 15 | SPI | PRD 2 TRIP | Y |
| 16 | SPI | BUCCHOLZ ALARM | Y |
| 17 | SPI | OTI R PH TRIP | Y |
| 18 | SPI | OTI Y PH TRIP | Y |
| 19 | SPI | OTI B PH TRIP | Y |
| 20 | SPI | OTI SPARE ICT TRIP | Y |
| 21 | SPI | WTI HV R PH TRIP | Y |
| 22 | SPI | WTI HV Y PH TRIP | Y |
| 23 | SPI | WTI HV B PH TRIP | Y |
| 24 | SPI | WTI HV SPARE ICT TRIP | Y |
| 25 | SPI | WTI MV R PH TRIP | Y |
| 26 | SPI | WTI MV Y PH TRIP | Y |
| 27 | SPI | WTI MV B PH TRIP | Y |
| 28 | SPI | WTI MV SPARE ICT TRIP | Y |
| 29 | SPI | WTI IV R PH TRIP | Y |
| 30 | SPI | WTI IV Y PH TRIP | Y |
| 31 | SPI | WTI IV B PH TRIP | Y |
| 32 | SPI | WTI IV SPARE ICT TRIP | Y |
| 33 | SPI | BUCCHOLZ R PH ALARM | Y |
| 34 | SPI | BUCCHOLZ Y PH ALARM | Y |
| 35 | SPI | BUCCHOLZ B PH ALARM | Y |
| 36 | SPI | BUCCHOLZ SPARE ICT ALARM | Y |
| 37 | SPI | OSR 2 R PH TRIP | Y |
| 38 | SPI | OSR 2 Y PH TRIP | Y |
| 39 | SPI | OSR 2 B PH TRIP | Y |
| 40 | SPI | OSR 2 SPARE ICT TRIP | Y |
| 41 | SPI | PRD 2 R PH TRIP | Y |
| 42 | SPI | PRD 2 Y PH TRIP | Y |
| 43 | SPI | PRD 2 B PH TRIP | Y |
| 44 | SPI | PRD 2 SPARE ICT TRIP | Y |
| 45 | SPI | GOOSE RECEIPT FAIL/TROUBLE | Y |
| 46 | | ANY ADDITIONAL SIGNAL AS PER SCHEME | |

| REQUIRED SIGNALS FOR DIRECTIONAL OVERCURRENT AND EARTH FAULT RELAYS | | | |
|---|---|---|---|
| SL. NO. | TYPE | EVENT/ALARM NAME | WHETHER ALARM TO BE GENERATED |
| 1 | SPI | DEF START | |
| 2 | SPI | DEF GEN TRIP | Y |
| 3 | SPI | DIRECTIONAL OVERCURRENT START | Y |
| 4 | SPI | DIRECTIONAL OVERCURRENT TRIP | Y |
| 5 | SPI | GENERAL TRIP | Y |
| 6 | System Diagnosis (SON) | TIME SYNCHRONIZATION ERROR | Y |
| 7 | System Diagnosis (SON) | M1 IED UNHEALTHY | Y |
| 8 | SPI | GOOSE RECEIPT FAIL/TROUBLE | Y |
| 9 | | ANY ADDITIONAL SIGNAL AS PER SCHEME | |

| REQUIRED SIGNALS FOR REACTOR DIFFERENTIAL RELAYS | | | |
|---|---|---|---|
| SL.NO. | TYPE | EVENT/ALARM NAME | WHETHER ALARM TO BE GENERATED |
| 1 | SPI | DIFFERENTIAL PROTECTION TRIP | Y |
| 2 | SPI | DIFFERENTIAL CURRENT ALARM | Y |
| 3 | SPI | TEE DIFFERENTIAL PROTECTION TRIP | Y |
| 4 | System Diagnosis (SON) | TIME SYNCHRONIZATION ERROR | Y |
| 5 | System Diagnosis (SON) | DIFFRENTIAL IED UNHEALTHY | Y |
| 6 | SPI | DIFFERENTIAL RELAY GENERAL TRIP | Y |
| 7 | SPI | OTI ALARM | Y |
| 8 | SPI | WTI ALARM | Y |
| 9 | SPI | BUCCHOLZ TRIP | Y |
| 10 | SPI | OSR TRIP | Y |
| 11 | SPI | PRD TRIP | Y |
| 12 | SPI | FIRE PROTECTION OPERATED | Y |
| 13 | SPI | LOW OIL LEVEL | Y |
| 14 | SPI | OTI R PH ALARM | Y |
| 15 | SPI | OTI Y PH ALARM | Y |
| 16 | SPI | OTI B PH ALARM | Y |
| 17 | SPI | OTI SPARE PH ALARM | Y |
| 18 | SPI | WTI R PH ALARM | Y |
| 19 | SPI | WTI Y PH ALARM | Y |
| 20 | SPI | WTI B PH ALARM | Y |
| 21 | SPI | WTI SPARE ICT ALARM | Y |
| 22 | SPI | BUCCHOLZ R PH TRIP | Y |
| 23 | SPI | BUCCHOLZ Y PH TRIP | Y |
| 24 | SPI | BUCCHOLZ B PH TRIP | Y |
| 25 | SPI | BUCCHOLZ SPARE PH TRIP | Y |
| 26 | SPI | OSR R PH TRIP | Y |

| REQUIRED SIGNALS FOR REACTOR DIFFERENTIAL RELAYS | | | |
|---|---|---|---|
| 27 | SPI | OSR Y PH TRIP | Y |
| 28 | SPI | OSR B PH TRIP | Y |
| 29 | SPI | OSR SPARE ICT TRIP | Y |
| 30 | SPI | PRD R PH TRIP | Y |
| 31 | SPI | PRD Y PH TRIP | Y |
| 32 | SPI | PRD B PH TRIP | Y |
| 33 | SPI | LOW OIL LEVEL R PH | Y |
| 34 | SPI | LOW OIL LEVEL Y PH | Y |
| 35 | SPI | LOW OIL LEVEL B PH | Y |
| 36 | SPI | LOW OIL LEVEL SPARE ICT | Y |
| 37 | SPI | FIRE PROTECTION R PH OPERATED | Y |
| 38 | SPI | FIRE PROTECTION Y PH OPERATED | Y |
| 39 | SPI | FIRE PROTECTION B PH OPERATED | Y |
| 40 | SPI | FIRE PROTECTION SPARE ICT OPERATED | Y |
| 41 | SPI | MAIN CB R PH OPEN | Y |
| 42 | SPI | MAIN CB Y PH OPEN | Y |
| 43 | SPI | MAIN CB B PH OPEN | Y |
| 44 | SPI | TIE CB R PH OPEN | Y |
| | | | |
| 45 | SPI | TIE CB Y PH OPEN | Y |
| 46 | SPI | TIE CB B PH OPEN | Y |
| | | | |
| 47 | SPI | TRIP RELAY 86 A HEALTHY (SUPERVISION) | Y |
| 48 | SPI | TRIP RELAY 86 B HEALTHY (SUPERVISION) | Y |
| 49 | SPI | GR A RELAY OPERATED | Y |
| 50 | SPI | GR B RELAY OPERATED | Y |
| 51 | SPI | REF RELAY FAIL | Y |
| | | | |
| 52 | SPI | REACTOR CB R PH OPEN | APPLICABLE FOR SWITCHABLE REACTOR APPLICATION |
| 53 | SPI | REACTOR CB Y PH OPEN | |
| | | | |
| 54 | SPI | REACTOR CB B PH OPEN | |
| 55 | SPI | REACTOR CB SPARE PH OPEN | |
| 56 | SPI | GR A RELAY OPERATED | Y |
| 57 | SPI | GR B RELAY OPERATED | Y |
| 58 | SPI | GOOSE RECEIPT FAIL/TROUBLE | Y |
| 59 | SPI | ANY ADDITIONAL SIGNAL AS PER SCHEME | |

| REQUIRED SIGNALS FOR REACTOR REF RELAYS | | | |
|---|---|---|---|
| SL. NO. | TYPE | EVENT/ALARM NAME | WHETHER ALARM TO BE GENERATED |
| 1 | System Diagnosis (SON) | TIME SYNCHRONIZATION ERROR | Y |
| 2 | System Diagnosis (SON) | DIFFRENTIAL IED UNHEALTHY | Y |

| REQUIRED SIGNALS FOR REACTOR REF RELAYS | | | |
|---|---|---|---|
| 3 | SPI | REF RELAY ALARM | Y |
| 4 | SPI | REF TRIP | Y |
| 5 | SPI | GENERAL TRIP | Y |
| 6 | SPI | REF TRIP | Y |
| 7 | SPI | OTI TRIP | Y |
| 8 | SPI | WTI TRIP | Y |
| 9 | SPI | BUCCHOLZ ALARM | Y |
| 10 | SPI | OTI R PH TRIP | Y |
| 11 | SPI | OTI Y PH TRIP | Y |
| 12 | SPI | OTI B PH TRIP | Y |
| 13 | SPI | OTI SPARE ICT TRIP | Y |
| 14 | SPI | WTI R PH TRIP | Y |
| 15 | SPI | WTI Y PH TRIP | Y |
| 16 | SPI | WTI B PH TRIP | Y |
| 17 | SPI | WTI SPARE PH TRIP | Y |
| 18 | SPI | BUCCHOLZ R PH ALARM | Y |
| 19 | SPI | BUCCHOLZ Y PH ALARM | Y |
| 20 | SPI | BUCCHOLZ B PH ALARM | Y |
| 21 | SPI | BUCCHOLZ SPARE PH ALARM | Y |
| 22 | SPI | GOOSE RECEIPT FAIL/TROUBLE | Y |
| 23 | | ANY ADDITIONAL SIGNAL AS PER SCHEME | |

| REQUIRED SIGNALS FOR REACTOR BACKUP IMPEDANCE PROTECTION RELAY | | | |
|---|---|---|---|
| SL. NO. | TYPE | EVENT/ALARM NAME | WHETHER ALARM TO BE GENERATED |
| 1 | SPI | START Z1 | |
| 2 | SPI | Z1 TRIP | Y |
| 3 | SPI | GENERAL TRIP | Y |
| 4 | DINT | FAULT LOCATOR DISTANCE | |
| 5 | SPI | CVT FUSE FAIL | Y |
| 6 | System Diagnosis (SON) | TIME SYNCHRONIZATION ERROR | Y |
| 7 | System Diagnosis (SON) | M1 IED UNHEALTHY | Y |
| 22 | SPI | GOOSE RECEIPT FAIL/TROUBLE | Y |
| 8 | | ANY ADDITIONAL SIGNAL AS PER SCHEME | |

| REQUIRED SIGNALS FOR BUS BAR PROTECTION RELAYS | | | |
|---|---|---|---|
| SL.NO. | TYPE | EVENT/ALARM NAME | WHETHER ALARM TO BE GENERATED |
| 1 | SPI | BUS ZONE 1 TRIP | Y |
| 2 | SPI | BUS ZONE 2 TRIP | Y |

| REQUIRED SIGNALS FOR BUS BAR PROTECTION RELAYS | | | |
|---|---|---|---|
| 3 | SPI | BUS BAR BLOCKED EXTERNAL | Y |
| 4 | SPI | BUS BAR BLOCKED DUE TO COMMUNICATIONN ERROR | Y |
| 5 | SPI | BUS BAR BLOCKED DUE TO INTERMEDIATE STATUS | Y |
| 6 | | CT CIRCUIT ERROR | Y |

| REQUIRED SIGNALS FOR BREAKER FAILURE PROTECTION RELAY PROTECTION RELAY | | | |
|---|---|---|---|
| SL. NO. | TYPE | EVENT/ALARM NAME | WHETHER ALARM TO BE GENERATED |
| 1 | SPI | BREAKER FAILURE PROTECTION START | Y |
| 2 | SPI | BREAKER FAILURE TRIP | Y |
| 3 | SPI | BREAKER FAILURE RETRIP | Y |
| 4 | System Diagnosis (SON) | TIME SYNCHRONIZATION ERROR | Y |
| 5 | System Diagnosis (SON) | M1 IED UNHEALTHY | Y |
| 6 | SPI | GOOSE RECEIPT FAIL/TROUBLE | Y |
| 7 | | | |
| 8 | | ANY ADDITIONAL SIGNAL AS PER SCHEME | |

| REQUIRED SIGNALS FOR BAY CONTROL UNIT | | | | |
|---|---|---|---|---|
| SL.NO. | TYPE | EVENT/ALARM NAME | WHETHER ALARM TO BE GENERATED | ADDITIONAL REMARKS |
| 1 | INT | BCU IN LOCAL/ REMOTE | | |
| 2 | SPI | CLOSE COMMAND FROM BCU FOR AUTORECLOSE | | |
| 3 | SPI | BLOCK AUTORECLOSE FUNCTION | Y | |
| | | | | |
| 4 | INT | STATUS 1 AUTORECLOSE FUNCTION READY | | |
| | | STATUS 2 AUTORECLOSE IN PROGRESS | Y | |
| | | STATUS 3 AUTORECLOSE SUCCESSFUL | Y | |
| | | STATUS 10 AUTORECLOSE UNSUCCESSFUL | Y | Available in Edition 2 IEDs, not in Edition 1 IEDs |
| 5 | CMD | BAY_CB_COMMAND | | |
| 6 | SPI | BAY_CB_OPEN PERMITTED OR ENABLED | | |
| 7 | SPI | BAY_CB_CLOSE PERMITTED OR ENABLED | | |
| 8 | DPI | BAY_CB R PH POSITION | | |
| 9 | DPI | BAY_CB Y PH POSITION | | |
| 10 | DPI | BAY_CB B PH POSITION | | |
| 11 | DPI | BAY_89A_ISOLATOR POSITION | | |

| REQUIRED SIGNALS FOR BAY CONTROL UNIT | | | | |
|---|---|---|---|---|
| 12 | CMD | BAY_89A_ISO COMMAND | | |
| 13 | SPI | BAY_89A_ISO OPEN PERMITTED OR ENABLED | | |
| 14 | SPI | BAY 89A_CLOSE PERMITTED OR ENABLED | | |
| 15 | DPI | BAY_89AE_ISOLATOR POSITION | | IF BUS EARTH SWITCH IS IN THE BAY FOR WHICH THE ASSIGNMENT IS BEING DONE, CSWI3 SHALL BE USED FOR 89 AE 1, i.e. BUS EARTH SWITCH. FOR BAY SIDE EARTH SWITCH (89AE2) SEPARATE LOGICAL NODE CSWI 10 IS PROVIDED BELOW |
| 16 | CMD | BAY_89AE_ISO COMMAND | | |
| 17 | SPI | BAY_89AE_ISO OPEN PERMITTED OR ENABLED | | |
| 18 | SPI | BAY_89AE_CLOSE PERMITTED OR ENABLED | | |
| 19 | DPI | BAY_89 B_ISOLATOR POSITION | | |
| 20 | CMD | BAY_89 B_ISO COMMAND | | |
| 21 | SPI | BAY_89 B_ISO OPEN PERMITTED OR ENABLED | | |
| 22 | SPI | BAY_89 B_CLOSE PERMITTED OR ENABLED | | |
| 23 | DPI | BAY_89 BE_ISOLATOR POSITION | | |
| 24 | CMD | BAY_89 BE_ISO COMMAND | | |
| 25 | SPI | BAY_89 BE_ISO OPEN PERMITTED OR ENABLED | | |
| 26 | SPI | BAY_89 BE_CLOSE PERMITTED OR ENABLED | | |
| 27 | DPI | BAY_89 C/L/T_ISOLATOR POSITION | | FOR 3 PHASE TRANSFORMERS CSWI7 MAY BE USED FOR 89 T BUT FOR SINGLE PHASE TRANSFORMERS SAME HAS BEEN SEPARATELY MENTIONED |
| 28 | CMD | BAY_89 C/L/T_ISO COMMAND | | |
| 29 | SPI | BAY_89 C/L/T_ISO OPEN PERMITTED OR ENABLED | | |
| 30 | SPI | BAY_89 C/L/T_CLOSE PERMITTED OR ENABLED | | |
| 31 | DPI | BAY_89 CE/LE/TE_ISOLATOR POSITION | | FOR 3 PHASE TRANSFORMERS CSWI7 MAY BE USED FOR 89 TE BUT FOR SINGLE PHASE TRANSFORMERS SAME HAS BEEN SEPARATELY MENTIONED |
| 32 | CMD | BAY_89 CE/LE/TE_ISO COMMAND | | |
| 33 | SPI | BAY_89 CE/LE/TE_ISO OPEN PERMITTED OR ENABLED | | |
| 34 | SPI | BAY_89 CE/LE/TE_CLOSE PERMITTED OR ENABLED | | |
| 35 | DPI | BAY_89 R_ISOLATOR POSITION | | |

| REQUIRED SIGNALS FOR BAY CONTROL UNIT | | | | |
|---|---|---|---|---|
| 36 | CMD | BAY_89 R_ISO COMMAND | | |
| 37 | SPI | BAY_89 R_ISO OPEN PERMITTED OR ENABLED | | |
| 38 | SPI | BAY_89 R_CLOSE PERMITTED OR ENABLED | | |
| 39 | DPI | BAY_89 RE_ISOLATOR POSITION | | |
| 40 | CMD | BAY_89 RE_ISO COMMAND | | |
| 41 | SPI | BAY_89 RE_ISO OPEN PERMITTED OR ENABLED | | |
| 42 | SPI | BAY_89 RE_CLOSE PERMITTED OR ENABLED | | |
| 43 | DPI | BAY_89AE 2_ISOLATOR POSITION | | USED FOR SECOND EARTH SWITCH OF ISOLATOR, WHEN BUS EARTH SWITCH IS PROVIDED |
| 44 | CMD | BAY_89AE 2_ISO COMMAND | | |
| 45 | SPI | BAY_89AE 2_ISO OPEN PERMITTED OR ENABLED | | |
| 46 | SPI | BAY_89AE 2_CLOSE PERMITTED OR ENABLED | | |
| THE LOGICAL NODES FOR ISOLATOR & EARTHSWITCHES FOR 3 PH ICTs & REACTORS , e.g 89 RR,RR1,RR2 & RE and for 89TR,TR1,TR2,TRE MAY BE ASSIGNED AS PER AVAILABILITY | | | | |
| | | | | |
| 47 | System Diagnosis (SON) | TIME SYNCHRONIZATION ERROR | Y | |
| 48 | System Diagnosis (SON) | BCU UNHEALTHY | Y | |
| 49 | SPI | CONDITIONS OK FOR SYNCHRONIZATION | | |
| 50 | SPI | SPRING DISCHARGED | Y | ANNUNCIATION FOR CIRCUIT BREAKER |
| 51 | SPI | AC MOTOR SUPPLY FAIL | Y | |
| 52 | SPI | SF6 GAS LOW | Y | |
| 53 | SPI | OPERATION LOCKED OUT | Y | |
| 54 | SPI | CB READY FOR AUTORECLOSURE | Y | |
| 55 | SPI | DC SUPPLY FAIL | Y | |
| 56 | SPI | TC-1 FAIL | Y | |
| 57 | SPI | TC-2 FAIL | Y | |
| 58 | SPI | POLE DISCREPANCY RELAY OPTD | Y | |
| 59 | SPI | COMPRESSOR SUPPLY FAIL | Y | |
| 60 | SPI | AIR PRESSURE LOW | Y | |
| 61 | SPI | COMPRESSOR RUN TIME SUPERVISION | Y | |
| 62 | SPI | CSD FAIL | Y | |
| 63 | SPI | GAS COMPARTMENT n Alarm Stage n | Y | ANNUNCIATION FOR GIS BAYS |
| 64 | SPI | LCC PANEL AC SUPPLY FAIL | Y | |
| 65 | SPI | LCC PANEL DC SUPPLY FAIL | Y | |

| REQUIRED SIGNALS FOR BAY CONTROL UNIT | | | | |
|---|---|---|---|---|
| 66 | SPI | SELECTOR SWITCH POSITION LOCAL/REMOTE | Y | |
| 67 | SPI | BUS VT MCB TRIP | Y | FOR BCUs HAVING BUS VT INPUT |
| 6 | SPI | GOOSE RECEIPT FAIL/TROUBLE | Y | |
| 68 | SPI | ADDL SIGNALS FOR CB TROUBLE ETC AS PER SCHEME | | |

6. List of Signal for Station Auxiliaries Panel (SAS)

## 110V DC

Voltage of 110V DCDB-1

Voltage of 110V DCDB-2

Current from 110V Battery Set -1

Current from 110V Battery Set -2

Current from 110V Battery Charger -1

Current from110V Battery charger 2

Battery 1 Output Voltage

Battery 2 Output Voltage

Charger Trouble 1

Charger Trouble 2

Charger 1 on Boost

Charger 1 on Float

Charger 1 Failure (Float)

Charger 1 Failure (FCBC)

Charger 2 on Boost

Charger 2 on Float

Charger 2 Failure (Float)

Charger 2 Failure (FCBC)

Charger 1 Float Current

Charger 1 Boost Current

Charger 2 Float Current

Charger 2 Boost Current

Input MCCB Incomer-1 ON (DCDB)

Input MCCB Incomer-2 ON (DCDB)

DCDB Bus coupler MCCB OFF

DC Earth Fault Relay Operated Sec-I

DC Earth Fault Relay Operated Sec-II Separate Signal for both

415 V AC Supply MCCB-1 Trip Charger 1, Charger 2,

415 V AC Supply MCCB-2 Trip DCDB 1 and DCDB 2

Over Temperature Indication

DC Overvoltage and Undervoltage relay operated

AC Supply Trouble (Charger)

## 48 V DC

Voltage of 48 V DCDB 1

Voltage of 48 V DCDB 2

Current from 48 V Battery set 1

Current from Battery Set 2

Current from 48 V Charger 1

Current from 48 V Charger 2

Battery 1 Output Voltage

Battery 2 Output Volatge

Charger Trouble 1

Charger Trouble 2

Charger 1 on Boost

Charger 1 on Float

Charger 1 Failure (Float)

Charger 1 Failure (FCBC)

Charger 2 on Boost

Charger 2 on Float

Charger 2 Failure (Float)

Charger 2 Failure (FCBC)

Charger 1 Float Current

Charger 1 Boost Current

Charger 2 Float Current

Charger 2 Boost Current

Input MCCB Incomer-1 ON (DCDB)

Input MCCB Incomer-2 ON (DCDB)

DCDB Bus coupler MCCB OFF

DC Earth Fault Relay Operated Sec-I

DC Earth Fault Relay Operated Sec-II

415 V AC Supply MCCB-1 Trip

415 V AC Supply MCCB-2 Trip

Over Temperature Indication

DC Overvoltage and Undervoltage relay operated

AC Supply Trouble (Charger)

DG Set

DG Set Breaker ON

DG Set Breaker OFF

Low Lube Oil Pressure

High Water Temperature

Engine Over Speed

Low Fuel in Service Tank

Over load Trip

Voltage RY, YB and BR

Current from DG set R, Y and B

Fire Fighting

Zone 1 Fire

Zone 2 Fire

Zone 3 Fire

Zone 4 Fire

Zone 5 Fire

Other Signal

PLCC Exchange Fail

Time Synch. Signal Fail

GPS Signal Fail

Current from Station transformer

Voltage from Station Transformer

Isolator Status of Station Transformer

Ambient Temperature .