

PART 2: EMPLOYER'S REQUIREMENTS

CHAPTER 12A:

SCADA-GENERAL SPECIFICATIONS

TABLE OF CONTENT

12. SCADA (CONTROL AND MONITORING)	5
12.1 BROAD SCOPE	5
12.1.1 GENERAL	5
12.2 STANDARDS	6
12.3 BRIEF DESCRIPTION OF SCADA SYSTEM	8
12.3.1 GENERAL	8
12.4 SCOPE OF WORK	9
12.5 POWER SUPPLY MANAGEMENT	10
12.5.1 TRACTION POWER SUPPLY MANAGEMENT	10
12.5.2 AUXILIARY POWER SUPPLY MANAGEMENT	10
12.6 POWER SUPPLY SYSTEM DESCRIPTION	12
12.6.1 POWER SUPPLY SYSTEM ARCHITECTURE	12
12.6.2 RECEIVING SUB STATIONS (RSS): 220KV	12
12.6.3 25 kV TRACTION SUPPLY TSS	12
12.6.4 SUB-SECTIONING AND PARALLELING POSTS (SSP)	13
12.6.5 AUXILIARY NETWORK-33 kV POWER SUPPLY AMS-ASS	14
12.6.6 LOCAL DISTRIBUTION	15
12.6.7 AUXILIARY SUBSTATIONS (ASS)	16
12.7 CORRIDOR DETAILS	17
12.8 EQUIPMENTS TO BE CONTROLLED AND MONITORED	20
12.8.1 25 kV ELEVATED TRACTION SWITCHING POSTS	20
12.8.2 ELEVATED ASS STATIONS	20
12.8.3 DEPOT FEEDING POST	20
12.8.4 DEPOT ASS	21
12.9 SCADA SYSTEM OVERVIEW	21
12.9.1 DESCRIPTION	21
12.9.2 FIELD CONTROL & MONITORING DEVICES	21
12.9.3 MASTER STATION EQUIPMENT	22
12.9.4 DEDICATED/ DARK FO COMMUNICATION NETWORK	23
12.9.5 GENERAL ARCHITECTURE OF SCADA SYSTEM	23
12.9.6 CONTROL PHILOSOPHY	26
12.10 DESIGN AND FUNCTIONAL REQUIREMENT	28
12.10.1 GENERAL REQUIREMENT	28
12.11 SCADA FUNCTIONS	30
12.11.1 REMOTE MONITORING	30
12.11.2 NETWORK COLOURING	31
12.11.3 EVENT MANAGEMENT	32
12.11.4 ALARM MANAGEMENT	35

12.11.5	REMOTE CONTROL	38
12.11.6	LEVEL OF CONTROL.....	41
12.11.7	TRANSFER OF POWER SUPPLY ON RSS FAILURE	42
12.11.8	LOGICS & INTERLOCKING	42
12.11.9	TELE MEASURING.....	44
12.11.10	INFORMATION SEARCH & RETRIEVAL (IS&R) AND REPORT GENERATION	45
12.11.11	OPERATIONAL AIDS	47
12.11.12	TRENDING	48
12.11.13	REDUNDANCY.....	48
12.12	TRAINING SIMULATOR SYSTEM	49
12.12.1	TRAINING SIMULATOR SETUP	49
12.12.2	TRAINING SIMULATOR SOFTWARE	49
12.12.3	TRAINER WORKSTATIONS.....	49
12.12.4	TRAINEE WORKSTATIONS	50
12.12.5	FUNCTIONAL REQUIREMENT OF TRAINING SIMULATOR	51
12.13	ENERGY MANAGEMENT SYSTEM	53
12.13.1	GENERAL.....	53
12.13.2	FUNCTIONAL REQUIREMENT	53
12.13.3	ENERGY MANAGEMENT REPORTS.....	54
12.13.4	ENERGY MANAGEMENT SYSTEM HARDWARE	54
12.13.5	ENERGY MANAGEMENT SYSTEM SOFTWARE.....	54
12.14	POWER BLOCK MANAGEMENT SYSTEM.....	56
12.14.1	POWER BLOCK IDENTIFICATION	56
12.14.2	GRANTING THE POWER BLOCK	56
12.14.3	CANCELLING THE POWER BLOCK.....	56
12.15	SUBSTATION AUTOMATION SYSTEM IN RSS.....	56
12.15.1	GENERAL.....	57
12.15.2	FUNCTIONAL REQUIREMENTS.....	57
12.15.3	STATION HUMAN MACHINE INTERFACE (HMI)	58
12.15.4	SYSTEM DESIGN	58
12.15.5	SYSTEM ARCHITECTURE	59
12.15.6	FUNCTIONAL REQUIREMENTS.....	60
12.15.7	SELECT-BEFORE-EXECUTE.....	60
12.15.8	SELF-SUPERVISION.....	60
12.15.9	USER CONFIGURATION.....	61
12.15.10	SYSTEM LEVEL FUNCTIONS.....	61
12.15.11	STATION HMI.....	62
12.15.12	EVENT LIST	65
12.15.13	ALARM LIST	65
12.15.14	REPORTS.....	66
12.15.15	TREND DISPLAY (HISTORICAL DATA).....	67
12.15.16	AUTOMATIC DISTURBANCE FILE TRANSFER	67

12.15.17	DISTURBANCE ANALYSIS	67
12.15.18	IED PARAMETER SETTING	68
12.15.19	AUTOMATIC SEQUENCES	68
12.15.20	LOCAL SCADA RTU	68
12.15.21	SYSTEM HARDWARE	68
12.15.22	EXTENDIBILITY IN FUTURE	69
12.15.23	SOFTWARE STRUCTURE	70
12.15.24	TESTS	71
12.16	USER INTERFACE	73
12.16.1	GENERAL CONCEPT OF THE WORKSTATION SCREENS	73
12.16.2	TYPICAL WORKSTATION SCREEN DESIGN	73
12.16.3	SCADA VIEWS	74
12.17	PERFORMANCE REQUIREMENT	76
12.17.1	TRANSFER TIME	76
12.17.2	SYSTEM CAPACITY	76
12.17.3	HOT-STANDBY CHANGEOVER TIME	76
12.17.4	CHRONOLOGICAL ANALYSIS	76
12.17.5	USABLE SERVICE LIFE	77
12.17.6	INTEROPERABILITY	77
12.18	INTERFACE REQUIREMENT	78
12.18.1	INTERFACE WITH DEPOT CIVIL CONTRACTOR	78
12.18.2	INTERFACE WITH DEPOT E&M CONTRACTOR	78
12.18.3	INTERFACE WITH RSS CONTRACTOR	78
12.18.4	INTERFACE WITH SIGNALLING CONTRACTOR	78
12.18.5	INTERFACE WITH TELECOM CONTRACTOR	78
12.18.6	INTERFACE WITH STATION E&M CONTRACTOR	78
12.19	TESTING & ACCEPTANCE	79
12.19.1	GENERAL REQUIREMENTS	79
12.19.2	TESTS	79
12.20	INPUT / OUTPUT REQUIREMENT	81
12.20.1	DESCRIPTION	81
12.20.2	INPUT OUTPUT SIGNAL LIST	81

12. SCADA (CONTROL AND MONITORING)

12.1 BROAD SCOPE

12.1.1 General

- 12.1.1.1 This Specification applies to the engineering, manufacture, supply, erection, testing and commissioning of the Supervisory Control and Data Acquisition (SCADA) System for the corridors of BI-RIDE Rail i.e. Corridor 2 & Corridor 4, as under: -
- **Corridor 02:** Baiyyappanahalli to Chikkabanavara (incl. 2 no. RSS i.e. Mathkhere RSS & Soladevnahalli RSS)
 - **Corridor 04:** Heelalige to Rajankunte (incl. 2 no. RSS i.e. Benniganahalli & Yelahanka)
- 12.1.1.2 The Control and Monitoring System is required to supervise, control and acquire the various specified data from the 'Controlled Stations' along the Line, such as Receiving Substations (incl. Auxiliary Main Substation & Traction Substation), Auxiliary Substations, 25 kV Traction Network and 33 kV Auxiliary Network, Metro Stations, 25 kV Traction Switching Stations (SP, SS, SSP, FP, etc.) along the Line, Depot etc.
- 12.1.1.3 The works to be executed under the package include the engineering, manufacture & development, supply, installation, integrating, testing, commissioning, supply of contract spares, operation and maintenance manuals, training, as-built documentation, coordination with other designated contractors, maintenance support during warranty / Defect Liability Period and AMC for the SCADA System.
- 12.1.1.4 The Main Operation Control Centre (OCC) shall be located at Yeshwanthpur and Backup Control Centre (BCC) shall be located at Soladevanahalli or at other location to be finalized later.
- 12.1.1.5 The SCADA system vendor shall have the necessary domain experience in implementation of the complex functional requirements for the Traction Application.

12.2 STANDARDS

The design and installation of SCADA system shall be based on this particular specification (PS) and based upon best engineering practices and conforming to the following specifications, IEC/EN/ISO/Indian equivalent standards.

[IEC 61508]	Functional safety of electrical/electronic/programmable electronic safety related systems
[EN 50126]	Railway applications – The specification and demonstration of Reliability, Availability Maintainability and Safety (RAMS) [IEC 62278 series]
[IEC 60850]	Railway Applications - Supply Voltages of Traction Systems
[IEC 62443-5]	Industrial communications networks – Network and System Security – Security for industrial automation and control systems – Part 5: Technical security requirements for industrial automation and control systems
[IEC 62236]	Railway Applications – Electromagnetic Compatibility
[EN 50121]	Railway applications - Electromagnetic compatibility

[EN 50011]	Limits and methods of measurement of radio disturbance characteristics of industrial, scientific and medical radio frequency equipment
[IEC 60870-2-1]	Tele-Control equipment and systems- Operating conditions – Power Supply and electromagnetic compatibility
[IEC 60870-2-2]	Tele-Control equipment and systems- Operating conditions – Environmental Condition.
[IEC 60870-3]	Tele-Control equipment and systems - interfaces (electrical characteristic)
[IEC 60870-4]	Tele-Control equipment and systems- Performance Requirement
[IEC 60870-5-101]	Tele-control equipment and systems- Transmission protocols - Companion standard for basic tele-control tasks
[IEC 60870-5-103]	Tele-control equipment and systems- Transmission protocols -companion standard for the informative interface of protection equipment
[IEC 60870-5-104]	Tele-control equipment and systems- Transmission protocols - Network access for IEC 60870-5-101 using standard transport profiles
[IEC 61850]	Series of Standards - Communication networks and systems in substations
[IEEE 802 series]	Local Area Network
[IEC 61131-3]	Programmable Controllers – Programming Language
[IS:6911-1992]	Specification for Stainless Steel and Strip
[IEC 60297]	Specification for 19-inch rack
[IEC 60529]	Degree of protection provided by enclosures (IP Code)
[IEC 62040]	Specification for UPS
[IEC 60146]	Specification for Semiconductor Converter
[IS 694]	PVC Insulated cables for working voltages up to and including 1100 Volts.
[IS 1554-Part I]	PVC Insulated Cable (Heavy Duty) Electric Cables
[IEC 60255-5]	Insulation coordination for measuring relays and protection equipment – Requirements and tests
[IEC 60255-21]	Vibration, shock, bump and seismic tests on measuring relays and protection equipment
[IEC 60255-22]	Measuring relays and protection equipment - Part 22-5: Electrical disturbance tests
[BS 6651]	Lightning Protection
[IEC 61643]	Components of low-voltage surge protection devices
[IEC 61312]	Protection against lightning electromagnetic impulse
[IEC 61024]	Protection of structure against lightning
[IS 3043-1987]	Code of Practice for Earthing
[EN 50122-1]	Railway applications - Fixed installations - Protective provisions relating to electrical safety and earthing
[BS 7671-2001]	Requirement for wiring Installation, IEE Electrical Wiring Regulations 17th Edition.
[IEC 61000-4]	Series of standards - Electromagnetic compatibility – Generic standards –Testing and Measurement Techniques
[IEC 61000-6-1]	Immunity standard for residential, commercial and light-industrial environments

[IEC 61000-6-2]	Immunity standard for Industrial environments
[IEC 61000-6-3]	Emission standard for residential, commercial and light-industrial environments
[IEC 61000-6-4]	Emission standard for Industrial environments

12.3 BRIEF DESCRIPTION OF SCADA SYSTEM

12.3.1 General

- 12.3.1.1 The Power supply equipment's will be in unmanned switchgear room and normally remotely controlled & monitored by power controller from the Operational Control Centre (OCC) and Backup Control Centre (BCC).
- 12.3.1.2 The SCADA system shall consist of group of equipment's distributed over the various locations. It shall essentially consist of following:
- Master Station Equipment or OCC/BCC Setup
 - Remote Terminal Units
 - SCADA Dedicated/ Dark Fiber Optic Network
- 12.3.1.3 The OCC shall consist of Main Control room i.e. OCC theatre room, SCADA Equipment/ Server room, Telecom equipment room, SCADA Training Simulator room, Uninterrupted Power Supply (UPS) & Battery room. Operator Workstations and Large Video Display Screen (LVDS) shall be installed at the OCC theatre room, whereas other equipment's shall be installed at their respective rooms.
- 12.3.1.4 The back up control facilities shall be set up at independent Backup Control Centre (BCC). System design of the BCC shall be like the system design of the OCC except LVDS.
- 12.3.1.5 A Power Controller shall be stationed at this Back up control centre (BCC). He shall be able to execute all functions entitled to Power Controller at OCC when authorized by Power Controller of OCC or upon failure of OCC. Suitable control logic shall be implemented in SCADA to avoid any conflicting command to power equipment.
- 12.3.1.6 Both the control centres will work as backup control centres to each other through dark fiber. All the RTUs of station, depot and Gateway at RSS will communicate with both control centres directly through a new redundant network over dark fiber (provided by Telecom contractor).
- 12.3.1.7 RTUs shall be installed in all Elevated ASSs along the corridors and Depot. The RTU shall include CPU module, Communication module, digital input/output modules, analogue input modules, transducers, memory, modems, communication switch, interposing contactors, power supply units, surge arrestors and other items necessary for its proper functioning.
- 12.3.1.8 Receiving Substations having SAS (Substation Automation System) with Local SCADA shall be hooked to OCCs from designated Gateway. Gateway will be different hardware from SAS and will communicate parallelly with SAS and relays of RSS. SAS with Local SCADA and Gateway at RSS shall be provided by RSS contractor.

- 12.3.1.9 All the RTU's and RSS Gateway in the corridors 2 and corridor 4 shall communicate with SCADA Servers at OCC and BCC over SCADA dedicated/ dark FO network on IEC 60870-5-104 protocol through OFC backbone network to be provided by designated Telecom contractor.
- 12.3.1.10 Telecom contractor will lay the optical fibre backbone network along the corridors and shall provide/reserve dark fibre or dedicated fibre cores to SCADA for SCADA communication only. All the RTUs shall be connected to these dedicated fibre cores through direct ODF (Optical Distribution Frame) interface at TER.
- 12.3.1.11 A dedicated Network Management System shall be installed at OCC/BCC for the monitoring of status and statistics of each active network node and network link of SCADA dedicated FO network system.

12.4 SCOPE OF WORK

The Scope of Work of Traction SCADA contractor shall essentially consist, but not limited to the following.

- a) All equipment related to SCADA in the Main Control Centre i.e. OCC (including power and communication cabling works, servers, networking devices, workstations, monitors, LVDS etc.).
- b) All equipment related to SCADA System in the BCC (including power and communication cabling works, servers, networking devices, workstations, monitors etc.).
- c) Database/Main servers and Communication/Front-End servers at OCC & BCC shall be provided in hot-standby configuration with adequate capacity to control complete corridor 1, corridor 2, corridor 3 & corridor 4 of Bi-RIDE rail project and future extensions as per BoQ.
- d) SCADA software, operating systems and all required licenses. The software shall be capable of being augmented or modified as and when required for making necessary changes in the application and for addition or deletion of equipment controlled under SCADA.
- e) Uninterrupted power supply (UPS) with batteries in the OCC/BCC for all SCADA equipment. UPS Supply OCC/BCC will be provided by PST Contractor.
- f) All RTUs and control cabling at each elevated, at grade and depot.
- g) Establishing SCADA training facilities and training simulator system at OCC.
- h) Energy Management System at OCC for energy data analysis and reporting.
- i) A Disturbance Recorder System shall be provided at OCC and BCC with necessary configuration tool and software for fetching the disturbance records & stored data in the relays/IEDs and analysis of the fault waves thereof.
- j) Integration of devices like Earthquake Sensor and Wind Speed Sensor at OCC/BCC shall be configured through RTUs.
- k) Complete Engineering of SCADA HMI, Installation of RTU and equipment at OCC/BCC and Integrated Testing & Commissioning of entire SCADA system.
- l) Supply of Spare and Tools.
- m) Design and installation of SCADA Dedicated/ Dark Fiber Optic Network for integration of field RTUs and RSS Gateways with OCC/BCC.
- n) Network Management System at OCC/BCC for the monitoring of status and statistics of each active network node and network link of SCADA dedicated FO network system.
- o) Training & Manuals, Test Reports (Type Test, FAT, Acceptance Test, Integrated Test etc.).

- p) Interface with telecom contractor for dark fiber cores in FO backbone network and communication ports in Optical Distribution Frame (ODF) rack at TER for establishing SCADA dedicated FO network over communication backbone for communication in between SCADA equipment in OCC/BCC and RTUs.
- q) Interface with RSS contractor for integrating all RSS through Gateway provided at RSS-by-EPC contractor.
- r) DLP / Warranty for complete SCADA system and all equipment supplied under this contract for 2 years.
- s) AMC of Complete SCADA System for 3 Years after 2 years of DLP.
- t) Any update in SCADA software, RTU software and IT equipment's software or any other updates (patch update, version upgrade etc.) required in SCADA system during the DLP and AMC period without any additional cost.
- u) Any other equipment and works for meeting the requirement of this specification.
- v) Provision of data logging or printing devices.
- w) Provision of suitable furniture and Rack with access control for smooth and secure SCADA.
- x) As built drawing and documents for station RTUs as well as RSS network.
- y) The station list for C1 and C3 are as follows.

Corridor 1	Corridor 3
1. KSR Bengaluru City	1. Kengeri
2. Srirampura	2. Jnanabharati
3. Malleswaram	3. Nayandahalli
4. Yeswanthpur	4. Krishnadevaraja
5. Muthyalnagar	5. Jagajeevanram Nagar
6. Lottegollahalli	6. KSR Bengaluru City
7. Kodigehalli	7. Kumara Park
8. Judicial Layout	8. Bengaluru Cantt.
9. Yelahanka	9. Baiyyappanahalli
10. Nitte Meenakshi	10. Krishnarajapuram
11. Betthalasuru	11. Hoddi
12. Doddajala	12. Whitefield
13. Airport Trumpet	
14. Devanahalli	

12.5 Power Supply Management

The field of activities of the Power Supply Management team comprises: Power Supply management of the Receiving substation (RSS), Traction power management at the line side SS, SSP, SP, FP, and depot FP, Auxiliary power supply management including medium voltage distribution from the AMS, the Auxiliary power supply management in the stations and the Depot ASS.

The main functions shall be to visualise the condition of the power supply network, as well as the visual monitoring panel, to control the pieces of equipment, to inform the operator of any change in the status of power supply network, to indicate several electrical parameters (voltage, power...), to print a pre-determined log of events and data, to store log of events.

The Power Supply management can be divided in two main functions: the traction power supply management and the facility power supply management. These are both under the responsibility of the same Power Operator.

12.5.1 Traction Power Supply Management

The Power is supplied to the catenary at 25 kV AC which is fed directly to the EMU trains. The

power supply is separated between up and down tracks to allow service to run on one track and work being done on the other. Basically, the Traction Power Supply function allows the Power Operator to energise or de-energise the different Traction Power sections of the line on demand of the Traffic Operator.

The controls related to the Power Supply equipment are performed: either from the Power Workstation or the Traction Desk, or locally from the equipment.

The equipment under supervision shall be: Equipment of the high voltage substations (TSS), Feeding Posts, Paralleling and sub-sectioning stations, Catenary voltage supervision.

12.5.2 Auxiliary Power Supply Management

The purpose of this function is to provide power supply to the various types of equipment used in the system: signalling and telecommunication, heavy maintenance tools in the depot, escalator, elevators, pumps, fans, ventilators, air-conditioning, lighting, low voltage distribution, etc.

12.6 POWER SUPPLY SYSTEM DESCRIPTION

12.6.1 Power supply system architecture

Power System is divided into the following subsystems:

- 220 KV Receiving substation (RSS).
- 25 kV Traction substation (TSS).
- 33 kV Power supply AMS and the 415 V low voltage distribution, 33 kV Power supply ASS.

12.6.2 Receiving Sub Stations (RSS): 220KV

The 220 KV RSS is made up of two incoming bays, each one supplying the bus bars. The RSS mainly consist of:

- Two incoming sections
- One coupling section with its isolators and circuit breaker to realise the coupling between busbars
- Two outgoing sections supplying both 3 phase transformers (220/33 kV - 3 phase transformers)
- Two outgoing sections supplying both 2 phase traction transformers (220/25 kV - 2 phase transformers)
- Associated measuring, protective and cabling devices.

12.6.3 25 kV Traction Supply TSS

12.6.3.1 Traction Sub-Station (TSS)

The TSS located beside the Receiving substation ensures the voltage transformation (220/25 KV) for supplying traction power to main line OHE.

The TSS shall mainly be composed of:

- Two incoming circuit breakers and their downstream isolators
- One Coupling facility made of 1 motorised interrupter, and its either side isolators
- Outgoing circuits made of 1 Circuit breaker, and their either side isolators
- One outgoing feeder circuit for depot (if required)
- 2 Bypass Isolators
- Associated measuring, protective and cabling devices.

12.6.3.2 Traction supply principles

The Rail Corridor line shall be divided into different traction supply sections. Each traction supply section shall be supplied from one Traction Sub Station.

A traction supply section will be bound on each side either by a Traction Sub Station or a Sectioning and Paralleling Post. The transition between two adjacent traction supply sections will be achieved by a neutral section or by an insulated overlap. Two adjacent sections will be normally isolated from one another.

If alignment allows it, Feeding Posts will also have neutral sections.

If required, electrical connection between two adjacent traction supply sections may be performed.

In order to reduce OHE voltage, drop, the two tracks are paralleled at regular intervals along the traction supply section.

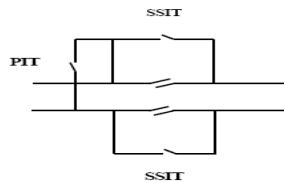
When a fault occurs on a section, local protection equipment will trip in the Traction Sub Station and de-energise the faulty OHE of the traction supply. In switching posts, the paralleling between the two tracks of the section will be removed.

To counteract frequent transient faults and to ensure quick power supply restoration on fault-free tracks, an automatic re-closure sequence may be implemented in the feeder stations. This sequence allows, after tripping, one (and only one) re-closure of the circuit breaker supplying each track of the traction supply section. This sequence will be implemented in control panel at RSS. The paralleling being isolated, the fault-free track (or both if it were a transient fault) will therefore be re-energised without any necessary controller action.

And only when both tracks are stable re-energised, paralleling can be restored.

12.6.4 Sub-Sectioning and Paralleling posts (SSP)

At crossovers, junctions or switched overlap, Sub Sectioning and paralleling Post will allow separation of the various adjacent traction subsections and where needed ensure paralleling between the two tracks of a sub section.



Sub sectioning and paralleling Post simplified diagram

Symbol shown in SLD are indicative only and shall be provided as required by purchaser.

For operation purpose, the Traction Line shall be divided into longitudinal OHE sub- sections.

The Sub sectioning Posts ensure this division and where required also ensure the paralleling of OHE sub-sections.

12.6.4.1 Control of paralleling switches (PIT) or Bridging Interrupters

Automatic opening of a PIT (ring opening) when the tracks are de-energized. This allows rapid troubleshooting by the power operator who does not have to open all PIT's one after the other to isolate tracks. Under these conditions, when resetting, it will be possible to locate the fault since the tracks are electrically independent.

12.6.5 Auxiliary network-33 kV Power Supply AMS-ASS**12.6.5.1 General**

The Auxiliary power supply network transforms the 220 KV supply into 33 kV by means of transformers. Then distributes the 33 kV through adequate protection and cables to the auxiliary sub-stations located in passenger stations, which feed in 415 V supply to the electrical and electromechanical installations.

It is mainly composed of an auxiliary main substation (AMS) 33 kV distributing cables and an auxiliary sub-station (ASS) in each building.

When a fault appears on a 33 kV networks, the relevant upstream protection equipment will trip and de-energise the affected circuits. The load shall not be automatically transferred to the other supply circuit to maintain the faulty switchgear de-energised until its isolation by the operator.

The transfer shall be automatic only in case of upstream power supply failure.

The same procedure shall apply in case of failure of the receiving substation auxiliary supply dedicated circuit.

12.6.5.2 Auxiliary Main substations (AMS)**12.6.5.2.1 33 kV network**

In order to feed the Auxiliary facilities of the Corridor, the AMS shall be equipped with 33 kV distribution equipment.

The power supply from two power transformers (220/33 kV) shall be distributed through 33 kV switchgear and cables to the Auxiliary substation located in stations and depot.

AMS distribution equipment shall include one Auxiliary 33 kV cable bridge metal-clad type cubicles This bridge shall be divided into two half bridges, each one comprising:

- 1 Auxiliary Bridge Circuit Breaker (LBCB cubicle),
- 1 Auxiliary 33 kV cable Circuit Breaker (RCCB or MCCB) cubicles,
- 1 Low voltage Auxiliary Transformer Circuit Breaker (LVATCB) cubicle,
- 1 spare CB (LFCB) cubicles.

These two half bridges shall be linked through:

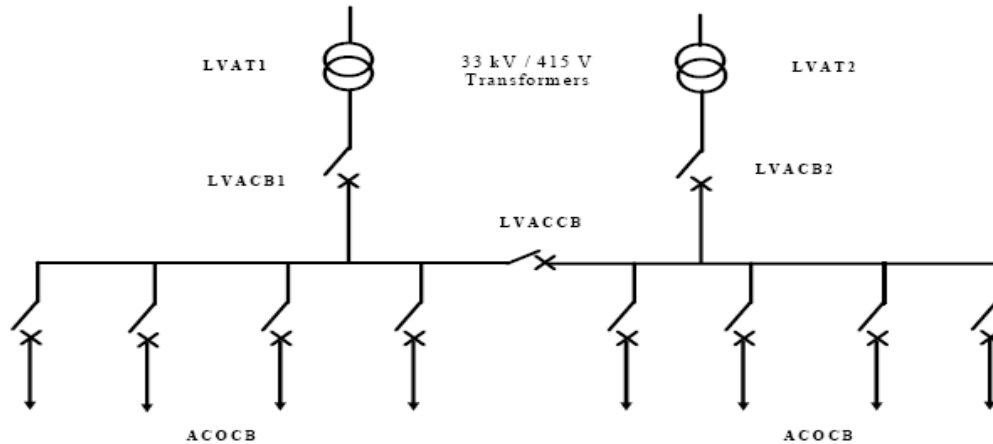
- 1 Coupling Circuit Breaker (LBCCB) cubicle
- 1 bus riser cubicle.

A circuit breaker complying with all necessary safety conditions and interlocks shall be capable of being mounted inside each CB cubicle.

Each outgoing cubicle shall supply a 33 kV auxiliary cable or auxiliary transformer cable in 33 kV cable-way situated beneath the cubicle.

12.6.6 Local distribution

Supplied at 33kV in antenna mode, the Auxiliary Sub Stations transform the 33kV supply to 415V and ensure the 415V main protection.



Local distribution Simplified Diagram

Symbol shown in SLD are indicative only and shall be provided as required by purchaser.

Distribution equipment for 415/240 V AC auxiliaries:

Both auxiliary transformers, with a unit power of 200 kVA (or as designed) are intended to supply the auxiliary power needed for operation of substation equipment, as well as for the supply of the Auxiliary installation of these installations.

12.6.6.1 Changeover**12.6.6.1.1 Automatic mode**

An automatic changeover switch shall manage LVACB1, LVACB2 and LVACCB.

In normal operation LVACB1 and LVACB2 are closed, LVACCB is open. In case of supply failure on one of the two bus bar, the relevant circuit breaker trips and the coupling circuit breaker closes with a delay sufficient to determine whether the supply failure is confirmed or not; this is to avoid a change for a transient supply failure.

Upon return of the normal supply voltage, the coupling circuit breaker shall trip with a delay suitable to ensure the restoration of supply, and the tripped circuit breaker shall close within 300 ms to ensure not to parallel both auxiliary transformers.

12.6.6.1.2 Manual mode

This mode can be selected on the operator's Workstation image. A dedicated area can be ticked off on the relevant view to choose the switching mode.

In manual mode, the transfer can be carried out with breaking or without breaking. The detail of the transfer procedure is given in clause 12.11.6

12.6.7 Auxiliary substations (ASS)

In addition to the traction network, there is an auxiliary network as required by all fixed low voltage electrical installations and all fixed electromechanical installations on the Line.

This network is connected to the high voltage Receiving Sub Station by means of medium voltage (33 kV) cables, feeding 33 kV / 415V transformer stations (ASS).

ASS shall be fed from the AMS, by main 33 kV cables consisting of two cables passing through each substation in 33 kV cable cut-off modes.

The 33 KV auxiliary Network is divided into various loops to utilise power from different RSS available in the section.

On the loop, only n-1 switchgears should be active. This restriction is applicable when AMS CB1 and CB2 are closed. n is the maximum number of switchgears of the loop including the end ones.

If one is close and the other alienated, then all the switchgears of the loop can be closed simultaneously. Closing of all switchgear simultaneously with both CB closed is forbidden.

The 33KV/415 V transformer will be feeding 415 V Bus of MDB Panel via Low voltage switchgears LVCB1, LVCB2 & LVCCB. Changeover of Low Voltage switchgear should be possible from SCADA. The details of the transfer procedure is given in clause 12.11.6.

12.7 CORRIDOR DETAILS

Following facilities shall be equipped with control & monitoring system:

Corridor 02 Receiving Substations

S. No.	RSS Name
1	SOLADEVANAHALLI
2	MATHIKERE

Corridor 04 Receiving Substations

S. No.	RSS Name
1	YELAHANKA
2	BENNIGANNAHALLI

Corridor 02 - Station (ASS)

S.No	Station Name	Chainage, Km
1	Baiyyappanahalli Panel	0
2	Kasturi Nagar	1.14
3	Sevanagar	3.16
4	Banaswadi	4.17
5	Kaveri Nagar	5.47
6	Nagavara	7.17
7	Kanakanagar	8.69
8	Hebbal	11.63
9	Lottegollahalli (common for corridor-2 & 1)	14.35
10	Yeshwantpura (Common for C2 & C1)	17.135
11	Jalahalli	20.24
12	Shettyhalli	21.46
13	Myadarahalli	23.75
14	Chikkabanavara	25.010

Corridor 02 – OHE Switching Posts

S. No.	Switching Post Name	Type
1	BENNIGANAHALLI	SP
2	BANASWADI	SSP
3	KANAKA NAGAR	SSP
4	MATHIKERE	SS
5	YESVANTPUR	SSP
6	CHIKKA BANVARA	SSP

7	SOLADEVANAHALLI	SP
8	MATHIKERE	FP
9	SOLADEVANAHALLI	SSP

Corridor 04 – Station (ASS)

S. No	Station Name	Chainage, Km
1	Heelalige	0
2	Bommasandra	1.48
3	Singena Agrahara	3
4	Huskuru	5
5	Ambedkar Nagar	9
6	Carmelaram	10.40
7	Belandur Road	13.69
8	Marathahalli	15.85
9	Kaggadasapura	20.700
10	Benniganahalli	22.650
11	Channasandra	24.45
12	Horamavu	26.10
13	Hennur	27.660
14	Tanisandra	30.960
15	Hegde Nagara	32.64
16	Jakkur	33.91
17	Yelahanka (Common Corridors-1 & 4)	37.825
18	Muddenahalli	42.730
19	Rajankunte	46.240

Corridor 04 – OHE Switching Posts

S. No.	Switching Post Name	Type
1	HEELALIGE	SSP
2	SINGENA AGRAHARA	SS
3	AMBEDKAR NAGAR	SSP
4	BELANDURU	SSP
5	DODDANEKUNDI	SS
6	HORAMAVU	SS
7	THANISANDRA	SP
8	JAKKUR	SS
9	YELAHANKA	Feeders to Depot Feeding Gantry
10	BENNIGANNAHALLI	FP
11	MUDDANA HALLI	SS
12	RAJANKUNTE	SSP

12.8 EQUIPMENTS TO BE CONTROLLED AND MONITORED

12.8.1 25 kV Elevated Traction Switching Posts

The 25 kV elevated trackside switching posts are of the following types namely Sectioning & Paralleling Post (SP), Sub Sectioning Post (SS) and Sub Sectioning and Paralleling Post (SSP) and Feeding Post (FP).

RTU installed in each ASS shall collect data from these traction switching posts for control and monitoring and transmit the data to the main and backup control centres.

RTU installed in ASS will house the required I-O modules & racks with all related components such as relays, transducers, interconnections etc. to cater with requirement of control & monitoring of these switching posts. Design of RTU shall ensure that I/O modules of 25 kV switching posts equipment's and I/O modules of ASS equipment's are separated / independent.

Thus, RTU for ASS and 25 kV switching posts will be a complete one RTU unit with all necessary components such as I-O modules needed to integrate the switching posts with the ASS RTU which in itself is a complete RTU unit duly augmented by independent I-O modules necessary for OHE equipment.

The independent I-O modules & other components required for the control & monitoring of 25 kV elevated switching posts will normally be housed in the RTU enclosure of the nearest ASS as part of the ASS RTU. However, in exceptional cases where switching posts equipment is located very far from the station, these I-O modules can also be provided in a separate enclosure as a slave to ASS RTU & may be located on viaduct in close proximity to OHE equipment and this slave unit equipped with required interface modules will be linked to its master RTU unit at ASS through armoured dual OFC link.

The contractor shall submit the voltage drop calculation to the Engineer in charge for the switching posts located very far from the station for which slave RTU is proposed on viaduct. The contractor shall submit the proposal of slave RTU and its locations to the Engineer in charge for approval.

Automatic Opening of Paralleling Interrupters shall be implemented through RTU only.

12.8.2 Elevated ASS stations

RTU installed in each ASS shall control, monitor and transmit the data to the Main and backup Control centres.

The scope of the control and monitoring include the Bus interrupters/circuit breakers on the 33 kV Bus, 33 kV incoming feeders, 33 kV/415 V transformers, 415 V Outgoing feeders up to Feeder Coupler. Auto-Changeover Logic for 415 V LV Breakers shall be loaded in the RTU.

12.8.3 Depot Feeding Post

RTU independent of Depot ASS RTU is to be provided for control & monitoring of Feeding Post in Train Depot. This RTU shall be installed in Depot Feeding Post area.

12.8.4 Depot ASS

To provide auxiliary power to Train depot & workshop, depot shall be provided with one or two

33 KV Auxiliary substations. RTU will be installed in depot ASS for the control and monitoring.

For the depot with several ASS rooms, separate/independent RTU for each ASS room will be provided.

Low Voltage Circuit Breakers and Low Voltage Coupling Circuit Breaker at Depot ASS will not be connected to SCADA system.

12.9 SCADA SYSTEM OVERVIEW

12.9.1 Description

12.9.1.1 The SCADA system provides the highest level of observation control and command of the Power Supply system. It is an operational nerve centre which allows the power controller to get a real time status of the installations, to make relevant measurements, and to take the appropriate actions during the normal operation as well as during unusual occurrences when efficiency and swift responses are required. Thus

- SCADA System will provide all possible facilities for real-time monitoring of complete power supply installation from a centralized location i.e. OCC/BCC.
- It will help Operation Team (Power Controllers) in making most suitable decisions during normal operation as well as during failures and will ensure transmission of corresponding control command to the equipment on the corridor.
- It will also help Operation team in analysing power supply installation's performance and undertaking improvements. It will also help in diagnosis of a failure, post occurrence.

12.9.1.2 The SCADA system is primarily comprised of below listed sub system.

- a) Field Control & Monitoring Devices (RTUs and associated equipment's)
- b) Master Station Equipment (OCC/BCC SCADA Equipment's)
- c) Dedicated/Dark fiber optic communication network

12.9.2 Field Control & Monitoring Devices

12.9.2.1 To achieve the functionality of data acquisition, the power supply installations such as Auxiliary Substation (ASS), Switching Posts and Depot etc. shall be provided with control & monitoring devices, which shall be interfacing with controlled equipment's for necessary field data collection and data transfer to Operation Control Centre & Backup Control Centre simultaneously. These control & monitoring devices shall comprise of Remote Terminal Unit (RTU). RSS shall be provided with Gateway by RSS contractor for RSS data transfer to control centre.

12.9.2.2 The interface between RTU's and controlled equipment's shall be hardwired by logical interface (i.e. DI, DO), Analog interface (4/20 mA) from transducers or digital communication interface i.e. RS232, RS485, IEC 61850 for IEDs/Relays etc.

12.9.2.3 The RTU's shall have provision to communicate with relays/IEDs over IEC 61850 protocol.

12.9.2.4 The RTU's shall also have provision to communicate with one and multiple control centres over specified protocol.

12.9.2.5 The RTU's shall support peer to peer communication for implementation of logic and field side automation.

12.9.2.6 The key functions of RTUs are as indicated below.

- Provision to fully integrate control and monitoring signals of various electrical and mechanical devices at controlled station
- Provision to communicate with one and more Master Station Equipment
- Accept and execute command from OCC/BCC/Locally
- Perform control priority checks & provide control conflicts data
- Retrieve equipment status upon cold start
- Store and execute operational logic and control function as per system operational requirement
- Perform self-diagnostics in the background and indicate hardware failures
- Provision of data storage
- Provision for RTU's configuration setup and management locally as well as remotely from Master System Equipment
- Accept real time synchronization signal from control centre
- Provide auxiliary power to actuators etc. if connected

12.9.2.7 The RTU generally comprised of followings.

- RTU Panel complete with internal wiring
- PLC/CPU Card, Power Supply Card, Communication cards etc. All applicable Input-Output modules & Transducers etc.
- Power Supply Converter & subsequent distribution inside panel
- Any Networking Switch, LIU, Routers etc. if required.
- Panel Lighting, enclosure heater etc.

12.9.2.8 Any key components of RTU like CPU card, Power Supply Card, Communication Card, Power Supply Converter etc. are considered in dual redundant and auto changeover configuration. Managed Ethernet Switches shall be provided in dual redundant configuration.

12.9.3 Master Station Equipment

12.9.3.1 The Master Station Equipment is set of devices, software's, functional modules, and assemblies that are necessary to implement the polling & supervisory functions over remotely located controlled stations / apparatus. The equipment includes the interface with the communication channel but does not include the interconnecting channel. Master station also includes consoles that provides facilities for observation and control of the system.

12.9.3.2 Master Station Equipment for BI-RIDE Rail Project shall comprise of minimum following functions:

- Centralized Data Acquisition, Control and Monitoring function with provision of Hot-Standby Database/Main & Communication/Front-End Servers.
- Operator Terminal for display of information to Power Controllers and shall be also used to issue control operations.
- Archive Workstation for fetching and analysis of historical data/events stored in Database/Main Servers.
- Provision of LAN with applicable network protection to fully interconnect all devices, modules of SCADA system.
- Provision of large video display terminal / screen for displaying power overview line diagram.
- Provision of Master clock interface over NTP with suitable interface provision with telecom system.
- Provision of data logging or printing devices.
- Provision of Power supply distribution and UPS for fail safe system operation.

- Provision of suitable furniture and Rack with access control for smooth and secure SCADA system.

12.9.3.3 The Master Station Equipment shall be setup inside OCC and BCC.

12.9.4 Dedicated/ Dark FO Communication Network

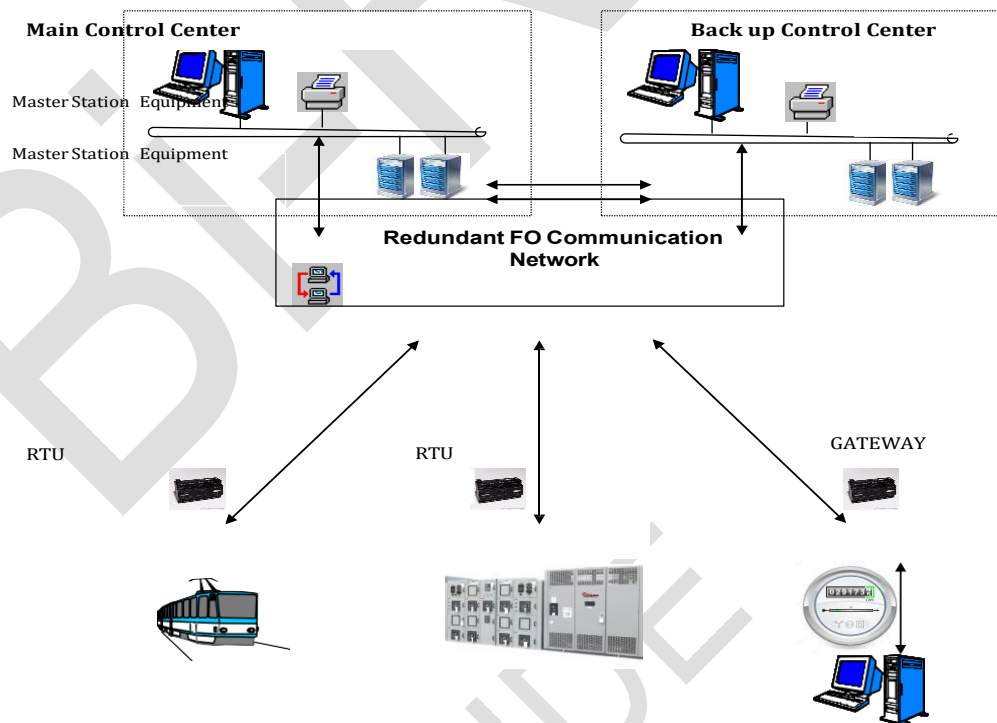
12.9.4.1 The RTU's at Controlled Stations and RSS Gateways along corridor 2 and corridor 4 shall require to exchange data with SCADA system at Main and Backup Control Centres over dedicated/ dark fibre optic communication network to be design and install by SCADA contractor.

12.9.4.2 SCADA contractor is required to interface with designated telecom contractor to ensure the provision of dark fibre cores in the redundant FO communication backbone to be provided telecom contractor. SCADA contractor shall also interface with designated telecom contractor to ensure the provision of communication ports in UP & Down Track optical distribution frame (ODF) rack at TER of station, depot & OCC/BCC.

12.9.5 General Architecture of SCADA system

12.9.5.1 SCADA system will have two Control Centres: Main Operational Control Centre and Backup Control Centre.

12.9.5.2 Relay & Protection Panel – The Numerical relays with be communicating with RTU over IEC 61850 protocol. The relays data shall be collected by RTU and transmitted to SCADA server in OCC/BCC. The Relay & Protection Panel shall be supplied and installed by traction power supply contractor.



- 12.9.5.3 The SCADA Communication/Front-End Server (common for all (corridor 1, corridor 2, corridor 3 and corridor 4) shall be provided in redundant hot-standby configuration at OCC & BCC for communication and integration with field RTUs/Gateway over IEC 60870-5-104 protocol.
- 12.9.5.4 Database/Main Server (common for all (corridor 1, corridor 2, corridor 3 and corridor 4) shall be provided separately in redundant Hot-standby configuration at OCC & BCC complete with necessary database software. It shall also store all operational and user programmable software as well as database, records and historical data/events.
- 12.9.5.5 Multiple Remote desktop connection of all SCADA servers at OCC can be opened in BCC and vice versa at operator terminals/SCADA servers for operational purposes. Remote desktop connection of SCADA system of BCC at OCC shall not affect SCADA of BCC and vice versa. SCADA contractor shall consider the multiple Remote Desktop connection licence (min. 10 client workstation connection) and shall make necessary provision for the same.
- 12.10.5.6 A network attached external storage shall be provided at OCC & BCC to hold all operational and user programmable software as well as database, records and historical data to handle accidental system recovery and data loss.
- 12.9.5.6 An engineering workstation shall be provided at OCC & BCC, which shall serve as development & maintenance machine for SCADA HMI engineering, RTU Configuration, Parameters downloading to RTU through RTU's configuration file (with password protection), Testing and other development and maintenance purpose. Any new development from engineering machine shall be available on main server only after appropriate quality check and published on main server. Any work-in progress work shall not affect the functioning of main server.
- 12.9.5.7 An Energy Management System shall also be provided at OCC for analysis of energy data and reporting.
- 12.9.5.8 A Network Management System shall also be provided at OCC/BCC for the monitoring of status and statistics of each active network node and network link of SCADA dedicated FO network system.
- 12.9.5.9 Engineering server workstation shall be provided behind the network firewall for OCC and BCC.
- 12.9.5.10 One Archive and Backup server shall be provided at OCC & BCC server room for backup storage and historical data/event storage for analysis and reporting. In case of Archive system failure, provision of storage in Main server to be provided.
- 12.9.5.11 Two Operator Workstations each with dual 24" LED monitors for Corridor 1 and Two Operator Workstations each with dual 24" LED monitors for Corridor 2, Two Operator Workstations each with dual 24" LED monitors for Corridor 3 and Two Operator Workstations each with dual 24" LED monitors for Corridor 4 shall be provided in OCC theatre room as well as in BCC.
- 12.9.5.12 A Disturbance Recorder Workstation with 24" LED monitor shall be provided in OCC and BCC server room. The PC-based work station shall have necessary configuration tool and software for fetching the disturbance records & stored data in the relays/IEDs and analysis of the fault waves thereof.

- 12.9.5.13 Suitably sized Large Video Display Wall/Screen shall be provided at OCC only.
- 12.9.5.14 One O&M workstation with dual 24" LED monitors shall be provided at OCC server room only.
- 12.9.5.15 SCADA server and SCADA software shall be scalable & upgradeable and shall be sized & suitably licensed for the control & monitoring requirement of corridor 1, corridor 2, corridor 3 and corridor 4 and its future expansion shall be included. The SCADA software shall be supplied with the license (RTUs and other Subsystems) complete in all respect with 100% installed capacity + 20% installed spares + additional 20% of the total installed capacity (RTU and other Subsystems) shall be included.
- 12.9.5.16 The selected SCADA hardware and software shall be expandable & capable to accommodate additional 75% of the total installed capacity for future expansion if required.
- 12.9.5.17 OCC/BCC SCADA system shall support multi-protocol environment i.e. IEC 60870- 5-104 and OPC DA/UA protocols.
- 12.9.5.18 A separate training simulator setup for SCADA shall be provided at OCC or any other location as decided by engineer in-charge during implementation stage.

12.9.6 Control Philosophy

The power supply equipment is normally remotely controlled and monitored via the SCADA system from the OCC/BCC and as far as possible switching operations shall only be executed through SCADA. Therefore, local control has to be carried out for test and maintenance purposes or in emergency situations (e.g. outage of remote communication).

Following levels of controls should be possible from SCADA system:

- Centralized Control from OCC/BCC for entire corridor.
- Local control mode from RSS control room for RSS equipment's only.
- Local mode from the equipment.

12.9.6.1 Centralized Control from OCC/BCC

It shall be possible to control the all power supply equipment (switchgears, motorized isolator and relay resetting etc.) at RSS, ASS, 25 KV switching stations (SS, SSP, SP, FP) Depot, etc. along the metro lines, from the OCC as well BCC. The Power Controller in OCC will have primary control over the complete power supply network and all the activities with respect to operation of power supply and supervision of maintenance shall be managed from this location. Simultaneous control from OCC and BCC shall not be allowed.

In the event of major incidents which cause a temporary unavailability of the main OCC, the SCADA system shall be fully operable remotely by SCADA equipment installed inside the BCC. However, the operator at OCC can take over the control back from BCC immediately after the availability of the system at main OCC. The control shall also be possible from the Backup control centre under the following conditions:

- When automatically control is transferred to the Backup Control centre when the respective SCADA servers at Main Control centre fails
- When Operator chooses to transfer control manually from Main Control centre to Backup

Control centre.

- Forced control – BCC/RSS controller shall take control in case of fire / emergency in OCC.
- In all the above cases, an Audio / Visual Alarm shall generate in OCC & BCC.

12.9.6.2 Local control mode from RSS control room

Each RSS along the BSTP Rail corridors shall be provided with SAS (Substation Automation System) to carry out the local control & monitoring function of RSS in case of emergency.

The SAS allow the RSS operator to operate from RSS local workstation in case of disturbances such as failure of control centre or RSS communication failure with control centre or manual control transfer from OCC.

In case control authorization is at OCC, then control of RSS equipment shall be blocked at RSS local workstation. In case of manual control transfer from OCC, control of RSS equipment shall be blocked at OCC. Operation of the switchgears from this workstation shall be possible only if OCC has granted permission for Local Operation.

12.9.6.3 Local mode from the equipment

It shall be possible to operate the equipment's locally from the control panels by selecting the local / remote selector switch in the Control Panel/equipment. This selection shall be logged in the event list by SCADA system. Such control shall only be possible after taking "Permission for Local Operation" from the Traction Power Controller. This shall be also logged in the event list by SCADA system. SCADA system shall ensure that no operation is performed without authorization from Operator. However, a bypass switch (for SCADA permissive command) shall be provided in the RTU for equipment local operation in case of communication link failure between Control Centre and RTU.

12.9.6.4 Control Transfer Management

To avoid possibility of control from multiple locations simultaneously, a method of control transfer logic shall be implemented in SCADA system at various control points (OCC/BCC, RSS, RTU, Equipment's) considering the above control philosophy & confirming to operational requirement of metro lines of BI-RIDE Rail Project.

This is to ensure the smooth and safe operation of SCADA system with applicable safety interlocks and to avoid conflicting & parallel control action from multiple control locations.

12.10 DESIGN AND FUNCTIONAL REQUIREMENT

12.10.1 General Requirement

12.10.1.1 The SCADA system shall be constructed with modern techniques in accordance with internationally recognized standards and designed for safe and efficient operation. All materials and equipment to be supplied shall be of a proven design and the major core components of the SCADA System shall have a Service Life of at least fifteen years.

12.10.1.2 The Contractor shall ensure that the SCADA system is designed to accommodate the ambient conditions under which the SCADA is required to operate. In addition, the Contractor shall ensure that condensation does not form in a manner detrimental to the durability or operability of any part of the SCADA system.

- 12.10.1.3 The SCADA system shall be designed to achieve high system availability and to ensure that any single point failure of SCADA Network equipment shall not cause a reduction in SCADA system performance. Redundancy shall be incorporated, where failures cannot be tolerated particularly when associated with safety critical systems.
- 12.10.1.4 The remote terminal units shall be configured to enable logical and sequential functions to be carried out locally, without reference to any servers and/or workstations. The SCADA system shall be capable of transmitting the results of such operations to the main servers for data storage, although the remote terminal units shall also have the capability of storing data.
- 12.10.1.5 SCADA equipment that is not desk-mounted or otherwise free-standing shall be housed in line-replaceable plug-in modules, rack mounted in accordance with DIN standards.
- 12.10.1.6 The racking shall be enclosed within suitable cabinets to suit the climatic conditions of the installation. The arrangement of the SCADA equipment within the cabinets shall be such that all routine maintenance can be carried out through hinged access doors or removable covers, and where possible from the front.
- 12.10.1.7 The design of the cabinets shall ensure adequate ventilation and air circulation without permitting the entry of vermin. Cable entries shall be closed and made vermin proof, by means of non-magnetic, fire-barrier plates. All SCADA equipment shall be identified with permanently affixed labels, written in English.
- 12.10.1.8 All SCADA equipment shall operate satisfactorily in the very high "electrical noise" environment normally associated with electrified mass transit railways due to electrical and magnetic fields created by traction supplies. Equipment shall be immune to the effects of conducted and radiated electrical and magnetic interference. The RTUs shall comply to environment condition prevailing in Bangalore region and in general shall comply to the following environmental requirements:
- | | |
|------------------|--------------------------------------|
| a) EMC Immunity: | As per IEC 60870-2-1 Level 3 or 4 |
| b) EMC Emission: | As per IEC 60870-2-1 Class A |
| c) Temperature: | -10 to 55 deg C as per IEC 60870-2-2 |
| d) Humidity: | 5 to 95% as per IEC 60870-2-2 |
- 12.10.1.9 All SCADA equipment shall be fully protected against the effects of power supply surges and transients.
- 12.10.1.10 The SCADA equipment shall be fully protected against the effects due to lightning strikes in accordance with the requirements of an internationally recognized standard and the Contractor's approved Earthing Policy.
- 12.10.1.11 All surge suppression equipment shall be self-contained and self-resetting. The suppression equipment shall be selected to ensure that the let-through voltage does not exceed the absolute maximum voltage specified for the particular equipment being protected. Signal cables from external sensors at risk from the effects of lightning shall have surge suppressers fitted at both ends of each cable and shall be installed and connected in accordance with the manufacturer's recommendations. Type 3 Pluggable Surge Protection Device in accordance with IEC 61643-11 with KEMA/UL/VDE approved shall be used.

- 12.10.1.12 The Contractor shall provide portable programming devices, including all the associated software, to enable the maintenance personnel to test or interrogate items of the SCADA equipment locally, i.e. without using the SCADA communication network.

12.11 SCADA FUNCTIONS

The following functionalities are to be achieved by the SCADA system proposed to be installed at Main & Backup OCC:

- Remote monitoring: The remote monitoring functions covers the monitoring of equipment status as per the IO list enclosed in section 12.20.
- Remote control: The SCADA system shall provide facility to open /close the breakers, interrupters etc. as per the IO list in section 12.20.
- In case of an emergency or abnormal situation, the Power Controller shall be able to control the various items of equipment, typically:
 - Isolation of the faulty sections or circuit
 - Restoration of the normal configuration after the fault has been remedied.
- Tele-measuring: The voltage and currents measurements as per IO list referred in section 12.20. The RTU shall be provided with necessary analogue input modules to receive the 4 to 20 mA signals from the transducers. The transducers if required at RTU end shall be in the scope of the SCADA Contractor/EPC contractor.
- Logics & Interlocking
- Transfer, to handle the opening/closing of switchgears in bridges.

12.11.1 Remote Monitoring

- 12.11.1.1 The system shall collect and transmit remote monitoring information from the field supervised equipment to the workstations.
- 12.11.1.2 In normal operation, the Power Controller shall be able to monitor the status of the RSS equipment's, HV, traction and auxiliary supply equipment. The Power Controller shall receive alarms relating to different events and alarms on equipment, e.g. low level or loss of voltage on 33kV system, 25 kV Traction System, 33kV cables and 415V CB's etc.
- 12.11.1.3 The SCADA software shall be designed with necessary process display screen to provide a graphical depiction of the power supply network for the Metro Corridors. This shall include the Receiving Substation, Auxiliary Substation, Traction Switching Posts, Auxiliary power network for Main Line and Depot, 25 kV Traction power network etc. Two separate views for complete Traction Line overview & Auxiliary Line overview should also be designed.
- 12.11.1.4 SCADA software shall have provision to show hang status of Server, Workstation and SCADA application running in server and workstation through some pop-up or event.
- 12.11.1.5 Healthy Running status of software (a kind of heartbeat signal) shall be displayed on SCADA system.
- 12.11.1.6 The SCADA System shall collect the operator's request and field information changes. Any change

on the field or any operator request shall be processed as an event. The SCADA System may generate additional events resulting from the processing of the field information and/or operator request. All events processed by the SCADA System shall generate an update of the related dynamic display objects and also be recorded in logging list. The logging list shall contain all the events in chronological order that occurred within a certain period of time. All the events shall have a time stamping of 1 msec. Furthermore, alarm types events shall be recorded in the alarm list and generate an alarm procedure initialization.

- 12.11.1.7 The SCADA System shall be able to handle various types of alarms, typically:
- a) Alarm generated due to change in field information.
 - b) Alarm generated due to fault in SCADA system equipment and communication link.
- 12.11.1.8 The details of the individual parameters to be monitored is provided in the section "Input/Output Requirement" in this specification.
- 12.11.1.9 Followings are important sub-functions of Remote Monitoring that SCADA system must support.
- a) Network Colouring
 - b) Event Management
 - c) Alarm Management
- 12.11.2 Network Colouring**
- 12.11.2.1 The SCADA software proposed shall support necessary busbar colouring feature by which the dynamic status of the bus bar can be depicted during charged and uncharged conditions. The busbar colouring shall be provided for the overall feeding diagram, Auxiliary & Traction overview diagram and Traction/Auxiliary network individual screens etc.
- 12.11.2.2 Coloration scheme shall be work during back feed.
- 12.11.2.3 Auxiliary Network: The colour of each loop in ASS overview diagram and the busbar colouring shall be done based on the breakers and interrupter status. In addition, the status of 415V LV breakers in Main LV Distribution Board shall be depicted in suitable distinct colour.
- 12.11.2.4 Traction Network: Colouring of Traction Network should be done based on Voltage of Traction Line coming from PTs. PTs are provided in every individual elementary section. When the Voltage of Section is > 18.5 KV, it has to be shown in green colour. When the voltage of section is >7.5 kV & < 18.5 kV it should change to Orange colour and when Section voltage is less than 7.5 KV its colour should change to red colour. Isolated siding will have its independent colouring arrangement through independent PTs.
- 12.11.2.5 The busbar coloration of RSS network shall be done based on breaker status and based on voltage values from PTs of incoming & outgoing bays wherever applicable.
- 12.11.2.6 Equipment, other than Battery Charger: Normally all power equipment reflecting in various screens should be in green colour unless and otherwise any alarm, blocking and communication fail event is associated with the equipment. Close and Open State shall not be considered as an alarm state for a switchgear and in both cases, it should be shown in Green colour. In case of occurrence of other alarms its colour should change to Red.

- 12.11.2.7 Normally all power equipment reflecting in various screens should be in green colour unless and otherwise any alarm, blocking and communication fail event is associated with the equipment. Close and Open State shall not be considered as an alarm state for a switchgear and in both cases, it should be shown in Green colour. In case of occurrence of other alarms its colour should change to Red.
- Battery Charger: The status of battery chargers shall be indicated in SCADA as per follows – Green (healthy and in service), Yellow (healthy and standby) and Red (defective).
- 12.11.2.8 Alarm Status: Normally all devices shall show in green colour, unless and otherwise any alarm associated with the device appears from field or it is blocked by the Power Controller. In case of alarm occurrence colour of device should change to red.
- 12.11.2.9 Blocking Status: In case of operator blocks control of any device or section, colour of the blocked device should change to brown.
- 12.11.2.10 Communication Failure: In case of communication failure of an installation, all equipment (including PTs, Busbar and other equipments) of the installation should change to pink colour.
- 12.11.2.11 Earthing Status: Color of earthed section shall be yellow.
- 12.11.2.12 Depot Traction System: Static picture of sectioning diagram of depot OHE not provided with PTs will be provided in the workstation (& LVDS, if required) and will be represented in colors as in the approved sectioning diagram. Depot feeding post and upstream provided with PTs will have dynamic coloration.
- 12.11.3 Event management**
- 12.11.3.1 The EMIS system shall collect the operator's request and field information changes. Any change on the field or any operator request shall be processed as an event. The EMIS system may generate additional events resulting from the processing of the field information and/or operator request. All events processed by the EMIS system shall generate an update of the related dynamic display objects and also be recorded in logging list.
- 12.11.3.2 The logging list shall contain all the events in chronological order that occurred within a certain period of time. All the events shall have a time stamping of 1 msec. Furthermore, alarm types events shall be recorded in the alarm list and generate an alarm procedure initialisation. Event logged in SCADA shall not be erasable.
- 12.11.3.3 The event Logging System of EMIS system shall support the following features and options.
- Historical Storage of events with facility to retrieve the same later •
 - Configurable layout: columns, fonts, toolbars, Colouring, and so on.
 - Configurable scrolling behaviour
 - Configurable presentation modes:
 - log mode /event mode, latest at top/bottom
 - Updating/Frozen presentation modes.

- Easy navigation through scrolling, go to date, time filters.
- Filtering (By Station, Device, and Period etc.)
- Extensive filtering that can be stored and easily called up later
- Find, Sorting by column, Copy/Paste of events to other windows application Printing
- Commenting of events by operator

- 12.11.3.4 The system shall collect the Power Controller's requests and field information changes. Any change in the field or any operator request shall be processed as an event. The SCADA system may generate additional events resulting from the processing of field information and / or operator requests.
- 12.11.3.5 The SCADA system shall record any events caused by faults, malfunctions, warnings or alarm information generated automatically by the selected equipment. A central recording system shall be provided to record the following events, including but not limited to:
- a) Change of state of remote terminal unit input parameters
 - b) Events designated as alarms
 - c) Faults
 - d) Control actions
 - e) Text entered by operations personnel
- 12.11.3.6 System generated messages, e.g. equipment malfunction
- 12.11.3.7 Events shall be given an order of priority to allow events to be classified, sorted and filtered. Subject to the requirements of the approved operations plan, events shall be classified as:
- a) Emergency - this type of fault shall require instant attention in order to minimize interruption of the normal operation or the risk of injury to personnel or passengers and shall be classified as an Alarm
 - b) Urgent - this type of fault shall require reasonably prompt, but not instant attention in order to minimize interruption of the normal operation and shall be classified as an Alarm and
 - c) Non-urgent - this type of fault shall be dealt with in a more convenient manner while more urgent events are dealt with first. This type of event shall not directly result in any degradation of the normal operation. These need not be configured as alarms. These are to be recorded in event list only.
- 12.11.3.8 The event records shall be available as a text table, with each event classified by its priority level and shall be tagged with details of the date and time at which the event occurred. Additionally, the operations personnel identification code shall be recorded for each event that is initiated by the operations personnel. Each event shall be displayed and highlighted until acknowledged by the operations personnel. All events shall continue to be displayed until the event has been acknowledged and cancelled in the automatic event log and provided the fault has been satisfactorily rectified in the equipment which generated the event.
- 12.11.3.9 All data messages transmitted through the SCADA network shall be tagged with the time at origin to an accuracy of at least 1 millisecond and shall be sorted and logged in time tagged order on the central database.

- 12.11.3.10 Each SCADA workstation shall be capable, at any moment in time, of sorting and filtering events in accordance with their priority to the level required by the operations personnel. A facility shall also be provided to enable a summary printed event record report to be prepared, listing not only the current active events, but also any events, including faults and alarms, reported and/or cleared during the period since the previous summary report. The event records shall also be able to be interrogated in a structured manner to determine the trends and associations between different events based on association by location, time or equipment type. All data records associated with the day's railway service once stored within the central database shall be collated, sorted and accessible within one minute of a request being issued by any workstation in the SCADA system.
- 12.11.3.11 The logging list shall have various filter facilities to enable the Power Controller to display different format of events. The filter keys shall typically include:
- a) location
 - b) equipment group
 - c) time period
 - d) event category
 - e) other options
- 12.11.3.12 Any combination of the filter keys shall be possible. When a filter is applied to the logging list, a specific display should be presented to the operator to avoid confusion.
- 12.11.3.13 In the event that a particular incident gives rise to numerous SCADA events, then the SCADA workstations shall be capable of displaying either all such events or only the most all-encompassing event. In the event that the most all-encompassing event is chosen to be displayed, all the associated events shall still be recorded with the most all-encompassing event.
- 12.11.3.14 The SCADA system shall produce regular automatic reports of the overall power system reliability indices with faults categorized by system (e.g. feeders, HV Power etc.) and by location (e.g. RSS, ASS etc.).
- 12.11.3.15 All databases established within the SCADA system shall be accessible for maintenance and exporting of data as required by the Engineer. This requirement shall also include any database used to configure the graphics used on the workstation VDUs. The Contractor shall supply the necessary database tools, manuals, documentation and training required to enable the maintenance and exporting of such data to be performed.
- 12.11.4 Alarm management**
- 12.11.4.1 Alarm Procedure: The purpose of the alarm procedure is to draw the Power Controller's attention and ensure that the information is taken into consideration, whatever activity being performed when the procedure is initiated. The alarm procedure shall generate a specific visual effect and audible warning on the operator workstation. The activation of the audible warning shall be configurable for major alarms. It shall be possible to disable the audible alarms by user for identified conflict alarms in SCADA system. Equipment having alarm should blink in red colour and upon acknowledgment blinking should stop. Disable of specific alarm of any equipment or multiple equipment or any specific signal shall not disable the complete or part or group or equipment alarm other than intended alarm disable condition. Alarm procedures may be generated in case of 'Alarm appearance' and 'Alarm disappearance'.

- 12.11.4.2 Alarms shall be generated in case of any change from “normal” to “alarm” (“Alarm appearance”) value of a monitored state. The processed alarm shall be considered as an alarm appearance event and shall generate an alarm.
- 12.11.4.3 Similarly, alarms shall be generated in case of changes from “alarm” to “normal” (“Alarm disappearance”) value of a monitored or processed alarm. This shall happen whenever a reconfiguration action is required from the operator in order to continue operation. The alarm procedure shall ensure that the operator is informed of the alarm disappearance so that he may restore normal configuration and continue operation.
- 12.11.4.4 Alarm List: All alarm appearance events shall generate a record in the alarm list. The alarms can be removed from Alarm List if the alarm is not present anymore or the alarm has been acknowledged by the operator. Alarm disappearance events, which generate an alarm procedure, shall also generate a record in the alarm list. This record shall only be erased by the SCADA system when the concerned operator has acknowledged the alarm disappearance. All alarms which appear in the SCADA screen shall be logged in the log mode and shall neither be editable nor be erasable. Alarm list shall support sorting/grouping of various columns either by adding or deleting (through drag and drop) any alarming attributes. Operator shall be able to attach a note or any comment to any alarm or a group of alarms in the system. Operator shall be able to select any set of alarms either continuous or random and export to any excel or csv file etc. for providing reporting function to an operator. Operator must be able to jump to respective HMI directly from the selected alarm from alarm list window and vice versa. HMI must be provided the access to related alarms for that particular station only in a separate/same window.
- 12.11.4.5 The SCADA system shall be able to handle various types of alarms, typically:
- a) Monitored alarm: - Shall be directly linked with the value of a field-monitored alarm.
 - b) Complex alarm: - Shall be the result of processing the values of one or more field events. This shall be in the nature of derived (computed) alarms to be defined during engineering.
 - c) Conflicting alarm: - Shall apply to a processed status resulting from several distinct field monitored states, when the sources give inconsistent information
e.g. inconsistent inputs resulting from chattering of breakers or non-zero voltage/current appearing on SLD when corresponding breaker is in open state.
 - d) Control failure alarm: - When performing such remote control, the SCADA system shall check the correct monitored or processed status change. If this event does not occur after a predefined time, the SCADA system shall generate a Control failure alarm.
 - e) Uncontrolled state change alarm: - If a monitored or processed status associated to such remote-control changes without previous control action from the operator or the system, an uncontrolled state change alarm shall be generated.
- 12.11.4.6 Alarm Classification for Display
- a) This classification shall be programmed in the OCC and the local equipment but can be easily modified and reloaded in the OCC as well as in local equipment.
 - b) All alarms shall be classified into four levels of priority. Each level of priority shall be segregated and characterized by a distinguishable colour and a display attribute (flashing, ...) that are the same on all the Workstations and the screens of the system:
 - Level 0:- used for non-severe alarms and events cases that do not need any acknowledgement from a Power Controller; it appears on the relevant view, then disappears when it disappears on site, without any Power Controller action;
 - Level 1:- used for non-severe alarms and events cases that however need acknowledgement from

- Power Controller. It appears flashing on the Workstation. The Operator acknowledges it, and then it is displayed as fixed. When it disappears on site, it disappears also on the Workstation without any other action from the Power Controller.
- Level 2:- used for alarm cases that are self-maintained by the equipment, and then need an erasing control to stop the alarm signalling. The alarm is maintained active until the Power Controller sends an erasing control order that resets the alarm bit if the RTU input is back to the normal state. The alarm appears flashing on the Workstation. When the Power Controller acknowledges the displayed alarm, the alarm becomes fixed. When the RTU input goes back into its normal state, the erasing control becomes possible from the OCC;
 - Level 3:- used for severe alarms that are not self-maintained by the equipment and need acknowledgements after both appearing and disappearing of the alarm. The alarm is maintained active until the Power Controller sends an acknowledgement control. After disappearing of the alarm, i.e. when the input comes back to the normal state, it is also necessary to send an acknowledgement control. The alarm appears as flashing. When the Power Controller acknowledges the alarm, it becomes fixed if the RTU input is always in alarm state. When the alarm disappears, following acknowledgement or return of the RTU input to its normal state, it is displayed in flashing with a different colour. The operator then has to acknowledge the alarm again.
- c) The alarms and events as classified above shall appear in a display window. These shall be displayed on a priority basis. When there are several alarms or events of the same priority, the system will establish another priority between them: the older they are, the lower is their priority.
 - d) Event for an alarm acknowledgment by an operator shall be logged in the event list with details of that alarm (equipment under alarm, alarming state, date & time of alarm generation), date & time of alarm acknowledgment, operator ID shall be logged.

12.11.4.7 Audio Visual Alarm

- a) Generation of alarm shall lead to an audio-visual signal for the Power Controller. The signals shall be generated in such a manner that it immediately draws the attention of the Power Controller.
- b) There shall be different categories of audible alarms easily distinguishable by separate tones or sounds for events classified as emergency, urgent and non- urgent.
- c) A mute facility shall be provided to silence an individual or group of alarm. Once the event causing the alarm has been acknowledged, the alarm shall be muted. It shall be possible to acknowledge alarms individually or in groups from the alarm display page. When the status of an alarm returns to normal condition, a return-to-normal message to this effect shall be generated.
- d) The nature of all audible alarms shall be accompanied with a corresponding message, providing details of the alarm, which is presented on the workstation display. When an alarm is initially received a corresponding visual flashing indicator shall appear on the display. Once the alarm has been acknowledged the flashing indicator shall transfer to a permanent illumination.
- e) In the event of multiple events initiating audible alarms, only one alarm shall be broadcast at any time. The highest category of alarm shall always take priority, even in the event that a lower priority alarm is already being broadcast. Once the higher category has been acknowledged and muted, the next lowest category of alarm shall initiate the alarm broadcast.
- f) To avoid unnecessary and nuisance alarms or alarms generated by testing or chattering of a signal, a facility shall be provided to enable alarm blocking/filtering to inhibit particular or global alarms, from any workstation. Inhibited alarms shall activate an appropriate message, detailing the non- alarmed/blocked parameters and the remote terminal units affected. Blocking of an individual update, control, alarm and event for the various data base points associated with a power supply equipment shall be provided.
- g) Audible warning cancellation: The possibility of implementing an 'audible warning cancellation' facility shall be provided. When an alarm procedure has been initialized, this facility shall allow the Power Controller to stop the audible warning prior to alarm acknowledgement. The audible

warning cancellation shall have no other consequence on the alarm procedure (the visual warning shall remain until alarm acknowledgement) and shall not interfere with the management of the alarm list. It shall also be possible to mute or cancel the audible warning of an individual alarm. Once the audible warning of higher category alarm has been cancelled, the next lowest category of alarm shall initiate the audible alarm broadcast.

12.11.5 Remote Control

12.11.5.1 The SCADA System shall transmit and execute predefined commands from the work stations to the field supervised equipment.

12.11.5.2 It shall be possible to control the breakers and interrupter via Operator request or via automatic control procedures. The control functions shall be Close/Open of the equipment as per IO Lists. The operator initiated Open/Close control functions shall be possible using Select- Check – Execute sequence.

12.11.5.3 The SCADA system shall log the control operations by the operators in the event list so that any closing opening other than issued by the operator from SCADA can be differentiated from the Event list

12.11.5.4 Event shall be logged for.

- Command selection with username.
- Command executed.
- Command successful

In case of failure of command event log shall be generated for unsuccessful operation. Till the status change is received from field, the status shall not change during command execution.

Permissive for Local Operation:

In order to facilitate local maintenance of the equipment and to prevent unauthorised local operations, Permissive for Local operation shall be provided for each equipment so that the field operator can carry out operation of the power equipment only after the above permission is granted from the Control Centre. SCADA system should ensure that no operation is performed without permission from Operator. For RSS automation, SCADA contractor will be required to interface with RSS contractor to ensure necessary provision in bay controllers to implement the above control logic. Remote control inhibition management- Alienation of a Power Supply Equipment

The operator at both Main and Backup OCC shall be able to inhibit /block the control from SCADA system. This blocking action shall be available in the blocking list. The control inhibition/ control blocking shall be possible individually for each equipment being processed. It shall be possible to cancel the blocking also. The user performing the blocking / de-blocking shall be logged in the event list

The blocking and de-blocking actions shall be available in the SCADA system in the form of blocking list:

Identification of the blocked equipment, status of equipment when it has been alienated, time of blocking.

The details of the user /operator who have carried out the blocking action shall also be logged in

the Event List in the SCADA system.

- 12.11.5.5 In normal operation, the Power Controller shall be able to control / operate the RSS equipments, HV, 25 kV traction, 33 kV auxiliary supply equipments and upto 415 V LV Breakers in MDB.
- 12.11.5.6 Controls may be generated by Power Controller or the system and executed by the system. The Power Controller should be able to take actions wherever and whenever required. In case of an emergency or abnormal situation, the Power Controller shall be able to control the various items of equipment, typically: isolation of the faulty sections or circuit, restoration of the normal configuration after the fault has been remedied.
- 12.11.5.7 Group Commands
- The system shall have provision to initiate configured group commands as per user requirement. Group commands whatsoever required by client shall be configured which may be used for issuing and cancelling power blocks, closing paralleling interrupters etc.
- OHE isolation:
- For the protection of maintenance works, the Traction Power Controller may set the isolation of any OHE subsection of the line. Such action shall involve opening of a group of interrupters in the elementary sections of the Traction Line. The menu provided in SCADA for OHE Isolation shall have a drop-down list for selection of elementary sections to be isolated. Once the operator selects the elementary section and select the button to start the isolation, the SCADA system shall trigger an automatic control procedure which will initiate the opening command from the SCADA to the respective BMs. The isolation action by the operator shall be logged in the Event/Alarm list with details of user as well as time of action. It should be possible for the operator to close the BMs from the SCADA system subsequently through normal control function. It should be possible to cancel the isolation of an elementary section.
- 12.11.5.8 The various outputs have been indicated in the section "Input/Output Requirement" in this specification. Following control functions shall be necessarily available in the SCADA:
- The SCADA system shall provide facility to open /close the breakers. It shall be guided by Remote / Manual control selection at the equipment. In case of remote selection, operation can be done from SCADA. In case of manual selection, the operation from SCADA shall be inhibited.
 - It shall be possible to control the breakers and interrupter via Power Controller request or via automatic control procedures. The control functions shall be Close/Open of the equipment's as per IO Lists. The operator initiated Open/Close control functions shall be possible using Select-Check – Execute sequence.
 - Control command logging: The SCADA system shall log the control operations by the operators in the event list so that any closing opening other than issued by the operator from SCADA can be differentiated from the event list.
 - Authorization for Local Operation: In order to facilitate local maintenance of the equipment and to prevent unauthorized local operations, authorization for Local operation shall be provided by way of Access Control Rights so that the field operator can carry out operation of the power equipment only after the above permission is granted from the Control Centre. SCADA system should ensure that no operation is performed without permission from the OCC. Further, even after granting the permission of local operation, the events and parameters shall continue to be monitored.
 - Remote control inhibition management- Alienation of Power Supply Equipment: The Power Controller shall be able to inhibit /block the equipment control from SCADA system. This blocking action shall be available in the blocking list. The control inhibition/ control blocking shall be possible individually for each equipment being processed. The Power Controller shall be

possible to cancel the blocking also. The user performing the blocking / deblocking shall be logged in the event list along with the details such as identity of the Power Controller who alienated the equipment, identification of the alienated equipment, its status when it has been alienated, time at which alienated, identity of the Power Controller that de-alienated the equipment, its status when it has been de- alienated, and corresponding time.

- f) This means that once the equipment is alienated, the “remote control inhibition” shall prevent any Power Controller from sending a remote control to that particular equipment. The SCADA System shall handle, for each controllable item of equipment, a control status, which is a combination of:

- Local / remote operation,
- Remote control inhibition.

12.11.5.9 The SCADA System Power Controller shall have access to a list showing all remote- control inhibitions currently active.

- a) To alienate equipment, the OCC Power Controller shall have proper level of access rights to de-alienate the equipment. An equipment alienated by a Power Controller can be de-alienated by a new Power Controller on condition that he has the same level of access rights
- b) An alienated equipment is displayed in the color corresponding to its status (red, green or blue), and is accompanied with a special alienation symbol.

12.11.5.10 The blocking and deblocking actions shall be available in the SCADA system in the form of blocking list for Identification of the blocked equipment, status of equipment when it has been alienated, time of blocking.

12.11.5.11 Two types of control function as under are possible in the SCADA system:

- Manual control function: - Means the operator has to handle the switching sequence. In this scenario operator has to do the operation by manual judgement as per operational guide line from available SCADA HMI function. However, during this mode of operation, applicable pre-configured interlocks should be in place.
- Automatic control function: - Means the switching sequences are controlled by the programmed function and / or hardwired control sequence interlock of devices itself. The pre-configured control sequence as applicable for emergency tripping etc. are example of such control mode. Such automatic operation as or when required or recommended through operational guide line shall be operator initiated or controlled to avoid any unwanted operation. Applicable alarm or operator alert shall be configured in SCADA application.

12.11.6 Level of Control

The following levels of controls should be possible:

- Centralised Control from control centre.
- Local control mode from RSS control room for local equipment only.
- Local mode from the equipment

12.11.6.1 Centralised control from Control Location

The control shall be possible as default design from the Control centre. The control centre for all Corridors would be at OCC/BCC.

It shall be possible for the station operator to select Local mode and operate the equipment after taking "Permission for Local Operation" from the ECC operator.

- 12.11.6.2 Local Control mode from RSS control room for local equipment only.

Equipment at RSS can be operated from the local control room the local workstation connected to the local area network of Sub-Station automation system. Operation of the switchgears from this workstation shall be possible only if ECC has granted permission for Local Operation.

- 12.11.6.3 Local mode from the equipment:

It shall be possible to operate the equipment locally from the control panels by selecting the local / remote selector switch in the Control Panel/equipment. This selection shall be logged by SCADA in the event list.

- 12.11.6.4 Control Transfer

To avoid possibility of control with more than one place/ ECC, a method of Control Transfer logic shall be implemented in SCADA system, considering the above control philosophy.

- 12.11.6.5 RTU Local/Remote mode

Each RTU shall also have SCADA permissive switch for Local/Remote mode selection. In SCADA software, Status of Local/Remote shall be provided near the CB symbol in all ASS/OHE's single line diagram picture.

12.11.7 Transfer of Power Supply on RSS Failure

- 12.11.7.1 In case of failure of power supply at an RSS feeding a section of the line, traction and auxiliary power supply to the section can be fed from another RSS.

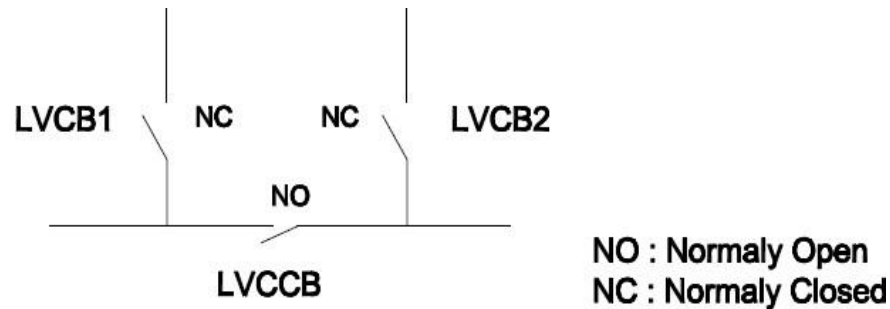
- 12.11.7.2 A logic shall be developed to represent various scenarios of power failure at different RSS feeding the entire line wherein, the healthy RSSs in a designated combination shall feed the line in a particular scenario. In semi-automatic mode, as per the approved logic, the SCADA system shall advise the controller recording the feeding system to be followed in a certain scenario, so that the controller can execute certain group commands to implement the desired feeding arrangement from the healthy RSSs.

- 12.11.7.3 The controller shall also have options of implementing this in automatic mode whereby, the designed feeding arrangement is achieved by SCADA system without the intervention of controller but after confirmation from him/her.

12.11.8 Logics & Interlocking

- 12.11.8.1 To improve the overall power availability, two separate incoming feeds are connected to different sources. In case of outage of a source, appropriate switching should execute so that the other one supply feeds the power.

- 12.11.8.2 In case of power failures, the system redundancies shall be operated to restore power to the system. There shall be a provision to operate these redundancies and interlocks through automatic mode or through manual mode. Several operating modes are possible; in the example above outlined, LVCCB management can be operated from RTU in two modes:



- Remote & Automatic mode
- Remote & Manual transfer mode.

The transfer process for LVCCB management shall be as follows:

Remote & Automatic mode

The sequence should be automatically executed from SCADA. In the event of failure of supply of one feeder, LVCCB should be automatically closed from RTU if the equipment is in Remote Mode & when supply restores LVCCB should be opened and Line CBs should be closed. In case of failure of both the supply SCADA should not take any action. This logic shall be provided in RTU.

Remote & Manual mode

In this mode, OCC Operator will execute the power transfer manually from OCC workstation.

- 12.11.8.3 Control of paralleling switches (PIT) or Bridging Interrupters

Automatic opening of a PIT (ring opening) when the tracks are de-energised. This allows rapid troubleshooting by the power operator who does not have to open all PITs one after the other to isolate tracks. Under these conditions, when resetting, it will be possible to locate the fault since the tracks are electrically independent. The logic shall be provided in RTU.

- 12.11.8.4 Interlocking scheme:

For safer operation interlocking has to be implemented in SCADA system. The following interlocks mainly to be provided but not limited to:

- Breaker-Isolator interlocking – It should not be possible to operate Isolator when consecutive breaker is in Close condition and breaker operation should not be possible when isolator is in open condition.
- 33 KV Network Inter Loop-interlocking:- When Potential Transformer of consecutive loop is showing voltage, extending power from one loop to other should not be possible.
- Interlocking at SPs: - When Potential Transformer of one section in SP's is showing voltage, extending power from adjacent section should not be possible.
- (n-1) interlocking in a 33 KV Network Loops.
- 2/3 interlocking for TSS incomer, RSS Incomer and AMS Incomer and LT Incomer of ASS LT.
- Interlocking at depot FP i.e. feed of TSS and main line should be interlocked.

- g) If neutral section is not operational, then interlocking should be provided at TSS level.
- h) If 25KV bus is charged, then 25KV incomer should not be closed.
- i) If 33KV bus is charged, AMS incomer should not be closed.
- j) Interlocking of 33KV interrupters with earth switch of adjacent ASS.
- k) Provision of under voltage relay in bridging interrupter at SP be made so that in case of extended feed the bridging interrupter at SP is in close condition. An under-voltage relay is provided to open this interrupter when the OHE Voltage falls below a satisfactory operating value.
- l) If bridging Interrupter is in close condition, SCADA Software shall not allow closing of more than one traction incomer CB's of adjacent TSS.
- m) ETS interlocking shall be provided as per design requirement and user specific.
- n) Back feed interlocking shall be provided as per design requirement.

12.11.8.5 In case of a breaker or any equipment operation is interlocked, the SCADA software shall be having the feature of displaying that particular device on the HMI with a tag, crossing line or in a specific colour showing that the device is interlocked. In case interlocking is active, normally the operation of device should be disable. However, SCADA software shall also provide the feature of enabling/disabling the remote operation of the interlocked devices. In addition to this, execution of any forced remote operation of an interlocked device shall be possible from a separate command window. It shall also display a warning message indicating that the device is interlocked and shall ask for an additional confirmation of the operator before executing the command.

12.11.8.6 It shall be possible to read all interlocking conditions in a separate pop-up window which are currently prevailing for an interlocked device. Interlocking text shall be configurable with no limitation of text in interlocking window.

12.11.8.7 There shall be no limitation to the number of interlocking conditions application to single device.

12.11.8.8 The Contractor shall implement any other additional logics or interlocking as required for power supply system security and suggested by Engineer in Charge during implementation stage.

12.11.9 Tele Measuring

12.11.9.1 In the power system, some of the data needs to be measured and monitored like Voltage, Current, Frequency, Power factor, consumption of energy for receiving substation, traction and auxiliary services. Dedicated equipment picks up the relevant information and in turn delivers to the local RTU which translates them into a digital value to be sent to OCC and BCC.

12.11.9.2 The voltage and currents measurement requirements are indicated in IO Requirement Section in this specification. The list shall be covered in scope of the RTU. The RTU shall be provided with necessary analogue input modules to receive the 4 to 20 mA signals from the transducers of equipment like PTs. The transducers if required at RTU end shall be in the scope of the SCADA Contractor/EPC contractor.

12.11.9.3 This information shall be recorded and used for several purposes among which statistics, consumption supervisory, etc. are few examples.

12.11.9.4 The measuring functions shall sum the integrated power consumption of the various equipment (RSS, AMS, TSS, and ASSs), and current values or voltage values on several parts of the network.

12.11.9.5 The energy (i.e. kWh, kVAh, pf) shall be measured for each equipment supplying the network

(e.g. Incoming & Outgoing bays at RSS, AMS & TSS)

- 12.11.9.6 The measuring of maximum demand will be made at a cyclic interval of time. The measurement will be done through latest digital signal processing-based multifunction meters.
- 12.11.9.7 Voltage & Current shall be measured at following points.
- a) Each incoming and outgoing bay at RSS, AMS and TSS
 - b) 33 kV at ASS network
 - c) 25 kV at Traction network
- 12.11.9.8 The analogue value shall be updated in every 2 seconds or instantaneously when crossing a set threshold range. They will be displayed on the Operator Workstation. It shall be possible in SCADA to configure different limit ranges for measurement analogue values. Alarm shall be generated in case of normal limit/range violation with different alarm colour and priority for different limit ranges (normal, warning etc.). 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.
- 12.11.9.9 Energy values from energy meters of the RSS has to be hooked up to main OCC and BCC and also in respective Receiving substation.
- a) Active energy (kWh) (Import and Export)
 - b) Reactive energy (kVARh) (Import and Export)
 - c) Apparent energy (kVAh) (Import and Export)
 - d) frequency,
 - e) power factor,
 - f) instantaneous maximum demand (Active Power, Reactive Power and Apparent Power)
 - g) total harmonic distortion (Rph Voltage THD, Yph Voltage THD, Bph Voltage THD Rph Current THD, Yph Current THD and Bph Current THD)
 - h) The integrated maximum demand can be determine from trends and reports of instantaneous maximum demand. Trends should be configurable for IMD for average of 15 minutes, 30 Minutes for day and Month.

12.11.10 Information Search & Retrieval (IS&R) and Report Generation

- 12.11.10.1 An Archive Workstation shall be provided at OCC & BCC for fetching historical data/events from Database/Main servers for analysis and reporting.
- 12.11.10.2 IS&R function shall provide for periodic history of analogue and status data. History shall take place in standard Database Management System package. IS&R shall also support archival of history data in any mass storage media. The archived data shall be retrievable on demand for analysis. SCADA software shall support configuration of time related measurement reports. Measurement report is used within SCADA's library applications for various types of time related reports such as hourly / daily / weekly / monthly and yearly basis reports. It shall be possible to export the generated reports into MS excel and in PDF format. The reports shall be based on time-related follow-ups of process, metered, entered or calculated data. The data for the reports shall be stored in real time. Report data is collected and calculated cyclically or triggered by events. The most common method is to fetch raw data from the process, and thereafter to scale and store it in the report database. All the events / reports shall be automatically written in text files and stored on hard disk in the reports folder of the application. Periodic backups of reports

shall be possible. The measurement reports shall support the following time related reports:

- a) Hourly report (time resolution: 3 minutes)
- b) Daily report (time resolution: 15 minutes and 30 minutes)
- c) Weekly report (time resolution: 1 day)
- d) Monthly report (time resolution: 1 day)
- e) Yearly report (time resolution: 1 month)

12.11.10.3 Automatic Backup creation of all the historical data/events and records shall be configured in Database/Main SCADA servers on weekly basis or as and when required by Metro Rail maintenance team. Backup file shall be generated and saved in a separate folder in the system. An automatic alarm shall be triggered at the OCC Workstation in the event that the accumulated data and software is stored for more than a pre-defined period without being backed up.

12.11.10.4 All data records generated shall be available for quick recovery in any server/workstation without degrade the performance of the SCADA system. It shall be possible to store historical data, records, software and data backup file in Database/Main SCADA Servers for a period of 2 years without the replacement of storage media. The Database/Main servers shall be provided with adequate storage capacity to hold all historical data, records, software and data backup file.

12.11.10.5 The historical data storage system shall index the storage media to enable rapid retrieval of data by date and time and be capable of event searches based on different selectable criteria.

12.11.10.6 Printers that are connected to the Master Stations shall be used for printing of reports.

12.11.11 Operational Aids

12.11.11.1 Various functions shall be provided in the system to assist the Power Controller for operation. Some of the features are as follows, but not limited to:

12.11.11.2 Log on: Before commencing work on a workstation, Power Controller identification to the system shall be required. Log on window with password protection shall be provided for the purpose. After suitable display prompts, the Power Controller shall enter his / her name, password, and validate them, system access shall be granted to the authorized sessions.

12.11.11.3 Log off: The Power Controller shall log off to end a working session on a workstation. After the current operator has logged off and with no other Power Controller logged on, no supervisory, control, monitoring or other action on the SCADA system shall be possible from the workstation. Log on/Log off the operator working session by power controller shall be logged in the event list with details such as date & time, operator ID, device ID of the workstation/server on which an operator has log on/log off.

12.11.11.4 Trends: The SCADA shall support trends for performing time related follow up of process data. The trends shall be possible for both digital as well as analogy parameters. The trend shall support a maximum of 10 trend parameters. The trends shall be possible in both graphical and tabular forms which shall share the same database. The X-axis and Y-axis of the graphs shall be configurable in scale. It shall be possible to have different scan time variable in single display. The trend display shall support the following features:

- a) Support of Graphical or tabular view modes with zooming facility
- b) Shall support Scrolling with scroll bars and panning

- c) Configurable axes, line properties and legend
- d) Update interval options from 30 seconds to 10 minutes
- e) Trends for calculation formulas; direct, mean, sum and difference shall be possible
- f) Shall have Printout option
- g) Depiction of Update/Frozen modes
- h) Facility to copy to clipboard and export to CSV File and PDF file
- i) Find, sorting by column, Copy/Paste of events to other windows application
- j) Printing
- k) Commenting of events by operator
- l) Search with a provision of easy sorting through several criterion
- m) Inhibits and tags
- n) Calculated Data

12.11.11.5 It shall be possible to define the calculations on real-time data and historical data, periodically and on request. The results shall be incorporated into the database as calculated data available for display & report generation.

12.11.11.6 The user shall be able to define calculated analogue values using database points as the arguments and mathematical functions as the operations. Functions such as addition, subtraction, multiplication, division, maximum value, minimum value, average, count, square root, etc. shall be provided.

12.11.12 **Trending**

12.11.12.1 Trend displays shall enable the user to select real-time and historical data for trending on graphical displays and for tabular displays. In graphical trending it shall be possible to assign minimum 10 number of tags to a single window for trending.

12.11.13 **Redundancy**

12.11.13.1 In order to ensure adequate safety and reliability for the operation, SCADA equipment mainly (SCADA servers, all network devices, key components of RTUs) shall be fully duplicated for redundancy. Such redundancy shall be achieved such that one of the units may be taken out of use without loss of overall functionality. An indication shall be available to the operating personnel of the status of all redundant equipment showing as a minimum the following states:

- a) in use;
- b) hot standby;
- c) initializing;
- d) failed;
- e) available isolated (cold standby); and
- f) Unavailable (disconnected).

12.11.13.2 Once a failed unit has been repaired it shall be possible to re-connect and restart the unit at any time without any interruption to the rest of the SCADA system. The unit shall then update itself to the current state of the SCADA system without other manual intervention and without a change in functionality (other than incorporating the actual unit or providing the availability of a system hot standby).

12.11.13.3 Operations personnel shall be provided with a clear understanding of the actual status of all SCADA equipment and transmission paths at all times. A facility shall be provided in the OCC/BCC to enable the operations personnel to activate an operational changeover between an

on-line and hot standby unit at any time without any disruption to the operation or functionality of the SCADA system.

12.12 TRAINING SIMULATOR SYSTEM

SCADA Training simulator setup shall be used for the training of operation personnel, SCADA maintenance personnel, test configuration or parameters modifications, test application modifications etc.

The key features of the training simulator shall include the following:

12.12.1 Training Simulator Setup

- a) SCADA Training simulator setup shall be proposed to be installed in a separate Training Simulator room in OCC building or at any other designated place.
- b) It shall comprise of one no. Training Simulator Server cum Trainer's workstation with dual 24" LED monitors complete with all necessary Software, three nos. Trainee's workstations each with dual 24" LED monitors, Training RTU (1 no.) with all the interconnections to make a training setup.
- c) The designing, supply, installation, testing & commissioning of simulator shall be in scope of work of PST Contractor, and it will do necessary interfacing for providing Simulator. The contractor shall seek approval of Engineer in charge on the design of Training Simulator prior to procurement.
- d) Based on approved proposal of Training Simulator, Factory Acceptance Test shall be conducted before the delivery of Training Simulator.
- e) The training simulator shall be standalone system and shall run without disturbing the on-line SCADA servers and without being able to send control command to the power supply field equipment.
- f) Contactor shall also supply, soft backup of commissioned system & training manual of the training software.

12.12.2 Training Simulator Software

- a) Software for Training Simulator shall be same as of main SCADA system.
- b) The software shall respond in the similar manner as in live condition.
- c) Training workstations should have all the synoptic of RSS, ASS, 25 kV Traction switching posts and depot etc.
- d) Sequence of operation and time taken can be analyzed through event list.
- e) Bus bar coloration shall be done for traction as well as auxiliary network.
- f) Software should be capable of showing various interlocking provided for failsafe operation.
- g) Software hence provided should have flexibility for addition of many other conditions which may arise time to time.

12.12.3 Trainer Workstations

- a) There shall be a dedicated server or workstation with dual 24" LED monitors for trainer.
- b) In the display monitors, shall show SCADA HMI and alarm lists. Critical and non- critical alarms are shown in different color similar to main SCADA system in OCC/BCC.
- c) Similar HMI, event and alarm display rule shall be implemented as of the main SCADA system in OCC/BCC.
- d) Trainer shall have following provision for simulation of fault:
 - Trainer shall be able to create, save, edit and reuse training sessions.
 - It shall be able to assign various situation to trainees.
 - It shall able to simulate a fault at any location of the power supply network.
 - It shall set time of such fault.
 - It shall also able to set multiple fault and predefined sequence with time gaps.
 - It shall be also possible to set grid level fault causing power failure and restoration, sequence.

12.12.4 Trainee Workstations

- a) Each trainee workstation shall be provided with dual 24" LED monitors.
- b) Similar to trainer workstation, in the default layout for trainee workstation
 - Display monitors shall show SCADA HMI same as of SCADA operator and alarm lists. Critical and non-critical alarms are shown in different colour similar to main SCADA system in OCC/BCC.
 - Power supply network, SCADA HMI, alarms, events etc shall be replicated as same of main SCADA system for OCC/BCC.
 - While navigating the trainee workstation, trainee shall get similar experience as of operation workstation of main SCADA.
- c) It shall be possible to create different training environment / session for different trainees.
- d) User access rights for trainee workstation shall be set by trainer workstation. It shall be possible to set different user access control rights for different trainee workstations.
- e) Further, trainees shall be given various situations by trainer, who when select certain preset fault, immediately all the sequence of events starts in the screen of trainees and trainers both. The sequence of events comes in real time format.
- f) Trainee is supposed to take the following action.
 - He will see the synoptic screen and event list in front of him and will inform the trainer all happenings.
 - Trainee shall take all the action which are necessary for real condition.
 - Software will respond to all the action of the trainee and will update its output accordingly.
 - For all the actions to be taken manually trainee will inform trainer over phone.
 - Different trainees respond differently for same situation. Software shall be capable of responding differently for all different trainees at the same time.

- g) After the simulation is over the software generates summary of all the action taken by trainees. Software also generates standard response which was best for those situations.

12.12.5 Functional Requirement of Training Simulator

- a) Trainer shall generate certain condition in Trainee's workstation and watch all the action of trainee from his monitor.
- b) Trainee will not know in advance what situation is being generated for him.
- c) System shall record actions of trainee and respective time taken by it, which can be used to analyze proficiency of trainee.
- d) It shall be able to create minimum but not limited to following conditions:
 - Power Source Transfer: - Trainer shall be able to simulate the supply failure of RSS. After failure of supply, trainee shall be asked to change over the traction and auxiliary feed to stand-by source as per feeding arrangement. Simulator software should have facility to simulate different supply failure conditions as described in feeding arrangement.
 - Under frequency fault: - Depending upon low level of frequency less critical loads will be isolated. As soon as frequency of grid improved certain important load automatically comes in. Balance non-critical load is connected by the operator manually as per improvement of situation.
 - Fault Isolation: -Trainer shall simulate fault at anywhere on power supply network and subsequently, the trainee shall be assigned to identify and isolate the faulty and restore the power supply. The system shall respond for each actions of trainee in same as a real time main SCADA system shall respond. Sequence of operation and time taken shall be recorded and can be analysed through event list.
 - Master trip relay reset: - Trainer shall have option to trip the traction feeder CB either on DPR or OCR (through MTR). Alarm/Event shall generate for respective tripping.
 - Failure of main RTU: - Trainer shall have option to disable the control action from any RTU
 - Setting Power block: - Trainee shall be assigned to set power block for an equipment or section.
 - OC/Earth fault in 132 kV cable.
 - Failure of two or more power supply sources.
 - Operation of wrong phase coupling relay at any RSS.
 - OC/EF at 33 KV cable in any station.
 - OC/EF at 33 KV cable in Via-Duct.
 - Failure of any circuit of 33 kV network.
 - Cable Fault in 25 kV cable between RSS and FP.
 - OHE fault (25 kV) at (x) KM from TSS.
 - Low voltage of battery charger.
 - Extending power from one line to other and restricting number of trains as per transformer capacity.
 - Identification to fault and communication to field staff/supervisory staff and officers.
 - Giving SCADA permissive/Force operation of switchgear.
 - To create situation for single line operation as per TC's requirement.
 - ETS operation at (X) location.

12.13 Energy Management System

12.13.1 General

- 12.13.1.1 An Energy Management System shall be provided for inspecting, cleaning, transforming, and modelling energy and tele-measurands data with the goal of discovering useful information and generation of MIS reports.
- 12.13.1.2 An Energy management system (EMS) shall be provided at the Operational Control Centre. EMS shall record all energy parameters of all the RSS/AMS/TSS/ASS locations in the section. EMS shall provide logging, storage and visualization functions for data acquired from the sites.
- 12.13.1.3 Such system shall enable configuration and measurement of the energy performance indicators against various functions of sub-system and identify the trends of these energy performance indicators, which shall enable BI-RIDE Rail to implement improvement measures for performance & resource optimization.
- 12.13.1.4 The Contractor shall be required to coordinate with Engineer for finalization of requirement of Energy Management System during Implementation stage. The Contractor shall submit the detail design for Energy Management System based on Engineer's input.
- 12.13.1.5 However, the system shall be provided with minimum 25 nos. pre-configured reports. The system shall be capable of further configuration additional 25 nos. of reports.
- 12.13.1.6 It shall be possible that user can create their own reports.

12.13.2 Functional Requirement

- 12.13.2.1 EMS Shall support real time monitoring of energy values & power quality and data acquisition for interfacing and calculations of parameters.
- 12.13.2.2 EMS Shall provide capability of Visualization of monitored values on a trend display.
- 12.13.2.3 EMS Shall be capable of Configuration of limits of different levels (higher/lower) and alarm parameters settings. Alarm shall be generated in case of normal limit/range violation with different alarm Colour and priority for different limit ranges (normal range, warning range etc.). Suitable provision shall be made in the system to define two level of alarm on either side of the value (minimum 2 levels for higher limit and 2 levels for lower limit) or which shall be user defined for each measurand.
- 12.13.2.4 EMS Shall have data reporting capability and information management tool. It shall be possible to generate and print standard and specific reports such as time/event- based reports/documents.
- 12.13.2.5 EMS Shall be having the feature of displaying energy parameters or any other values on trend display, bar diagrams and graphical representation and in the form of tabular data.

- 12.13.2.6 EMS Shall be capable of showing Load flow display and visualization (direction of electrical current) based on measured electrical current values. Identification of overloaded networks segments and detailed information of individual lines/sections.
- 12.13.2.7 EMS Shall be capable of managing the active loads by time / event-based load change per pre-defined actions for energy savings (for e.g. control of an equipment by limit supervision). Re-energizing of components / stations by the operator.
- 12.13.2.8 On-line help facility to operator.

12.13.3 Energy Management Reports

- 12.13.3.1 Energy Management System shall provide capability through graphical MMI interface; advanced real-time energy data-logging and viewing of historical logs; graphing, and analysis of data; Concurrent MD calculation and alarm.
- 12.13.3.2 Energy management system should have data reporting capability implemented through a separate dedicated module. Reporting module should be able to give report output on screen, in pdf or in XLS/csv format. Reports may be based on pre- configured criteria or based on adhoc query.
- 12.13.3.3 Energy management system shall have provision to generate hierarchical reports (i) Customer wise (ii) utility wise up to individual meter wise etc. as desired by the purchaser from time to time. The detailed formats shall be finalized as per the user requirement.
- 12.13.3.4 Energy Meter installed on HV/LV side of the RSS/AMS/TSS location and ASS (if available) shall be capable of transferring the energy parameters (Voltage, current, MW, MVAR, MVA, PF, frequency, Energy import, Energy export, Maximum demand) on real time basis to RTU. RTU shall transmit the integrated demand / energy data to SCADA where it shall be logged in the historical database. These data shall be further transmitted to EMS for offer analysis and reports on demand / energy data, for visualization. Visualization function like graphs, tabular data, and dashboard shall be provided.

12.13.4 Energy Management System Hardware

- 12.13.4.1 The latest MSSQL Server shall be installed in EMS Server, which shall store all data from SCADA server including energy / demand, traction network profile and the data can be accessed from client machine or as requested by third party application.

12.13.5 Energy Management System Software

- 12.13.5.1 The system should have the capability to generate energy data including frequency to facilitate demand requirement on day ahead, short time demand etc. based on average energy parameters of previous day / month. It shall support following
- a) Integration of data in 15 mins. Time blocks. Data captured in 15 minutes interval against different demands portfolios such as base demand, peak demand, total

demand, maximum demand

- b) It shall support demand aggregation over different period (15 minute to hourly to daily to monthly)
- c) The system shall be able to generate various exceptional reports on events and energy data.
- d) On-line data shall be presented in Tabular format, Graphical formats.
- e) This software shall provide facility to define threshold on the electrical parameters and store them in a database and whenever it finds the limits are exceeding while polling alarms may be generated at the Operator Consoles. Facility to acknowledge one or multiple alarms at a time and facility to save the alarm shall be provided.
- f) Visualization of real time data in the form of trends displaying peak values on time basis.
- g) Real time comparison between actual demands versus scheduled demand.
- h) Comparison of any recorded parameter at different times in history in graphics format.
- i) It should be provided to data storage module. Data storage module perform the loading of the collected energy data to database as per its structure. MSSQL Server or other equivalent RDBMS such as Oracle, Postgre SQL etc. should be permissible.
- j) The system should have capability to import /Export data from txt/xml/Excel file for the purpose of analyses.
- k) It should be sized to store historical data for a period of five years.

Note:

The functionality of EMS shall be achieved through supply item of database server.

12.14 Power Block Management System

12.14.1 Power Block Identification

- 12.14.1.1 Power block for maintenance or inspection shall be granted by the power controller in the OCC/BCC after identification of both the persons granting the block i.e. (the controller and the authorized person requesting the block through a system of passwords & interlocks). The block shall not be cancelled & section is energised unless the block is cancelled by the person who has taken the block. In case a tele- command is attempted for energising the device/ section under block, the command shall be aborted, and a warning/hazard message shall be generated at OCC/BCC and at RTU end (in case command executed locally from RTU).

12.14.2 Granting the power block

- 12.14.2.1 The software shall have facility to select the device/section to be brought under power block and kept under power block or to be taken out of power block.
- 12.14.2.2 It shall be possible to select a number of circuit breakers/ Interrupters required to be operated for making a section dead and a group command shall possible to be issued. The system shall be open all devices, which are put under power block by the operator. The operation shall be confirmed for each device as an event. Predefined sequences/Group commands shall be configured and saved for granting power block.
- 12.14.2.3 Operator shall be able to cut off power to a sub-sector by selecting it and giving and confirming the command. The system shall open all the associated switching devices automatically with confirmation for each device as an event.
- 12.14.2.4 The operator shall have to enter the details of the power block like the operator's code number, and time duration of power block. All power block details like operator's identity, time of imposition and section shall be recorded along with system time.

12.14.3 Cancelling the power block

- 12.14.3.1 On receiving the authorisation of the field supervisor having been granted power block, the operator shall select the devices or the section on which the block has to be cancelled and give power block cancellation command. Group command shall also be possible to cancel the power block. With this the power block of the devices/section shall be removed.
- 12.14.3.2 It shall be possible to display or print the information of all power block details giving clear details regarding operator's identity, time of imposition and its cancellation. Power block details shall be stored in the database for later use.

12.15 SUBSTATION AUTOMATION SYSTEM IN RSS

12.15.1 General

- 12.15.1.1 The Corridor 2 & Corridor 4 of BI-RIDE Rail have four Receiving Substations (RSSs) along the corridor. For corridor 2 the Mathikere RSS and soladevnaahalli (220/33kV) voltage level (AIS type) are located near Mathikere station and soladevnaahalli For Corridor 4 the Benniganahalli RSS & Yelahanka RSS (66/33kV) voltage level (AIS type) is located near Benniganahalli Station and Yelahanka station.

- 12.15.1.2 The Local SCADA system shall be installed at the BI-RIDE Rail receiving substations to control and monitor all the sub-station equipment's.
- 12.15.1.3 Supply of Local SCADA hardware & software by SCADA contractor and all RSS equipments, Intelligent electronic devices (IEDs), Bay control units (BCU) and Protection control units (PCU) is in the scope of EPC contractor.
- 12.15.1.4 The RSSs would be provided with Sub-station automation system. intelligent electronic devices (Bay Controller IEC 61850 compatible), for control, monitoring and protection of various RSS, AMS and TSS equipment's. Redundant Gateway in hot- standby configuration will be provided by EPC contractor at each RSS for control and monitoring from OCC/BCC over IEC 60870-5-104 protocol. Each gateway shall have three communication ports to send data of RSS to both OCC & BCC and third port as spare. The SAS system shall be connected to control centres on a dark fiber optic network using two separate channels.
- 12.15.1.5 All interfacing equipment (such as Managed Ethernet Switches, FO/RJ45 Patch chords, FO cables, LIU Box, Power supply unit etc.) required for communication from gateway port to OCC/BCC shall be in scope of SCADA contractor/EPC contractor. SCADA contractor/EPC contractor shall provide wall mount cubicle for mounting all interfacing equipment at RSS end.
- 12.15.1.6 Further data of Energy meters will not be available from bay controllers. The energy meters will be connected to control centre through RSS gateway.
- 12.15.1.7 DR (Disturbance Records) of the relays shall be made available at OCC/BCC. OCC/BCC SCADA shall be capable of downloading DR of RSS relays of independent manufacturer.
- 12.15.1.8 SCADA contractor will be required to interface with EPC contractor to ensure gateway configuration compatibility with OCC server and for status information required by EPC contractor from SCADA contractor for implementation of Panto- Flash over logic.

12.15.2 Functional Requirements

- 12.15.2.1 The Local SCADA systems shall offer control and monitoring of all substation equipment's like Dedicated Bay Control Units and Bay Protection Units (BPU) which shall be provided for each bay for Control and protection functionality on IEC-61850 standard by EPC contractor. The Bay Control and Protection IEDs shall communicate on the IEC 61850 standard for Communication Networks and shall comply to the IEC 61850-5 for communication data modelling.

12.15.3 Station Human Machine Interface (HMI)

- 12.15.3.1 RTU with dual redundant CPUs shall be provided for remote control and monitoring. The RTU should be able to communicate with OCC/BCC over IEC 60870-104 protocol. The local SCADA system shall be connected to two control centers on a SCADA dedicated fiber optic network. Kindly refer for technical specifications of RTU.

12.15.4 System Design

- 12.15.4.1 The Local SCADA system shall be suitable for operation and monitoring of the Bay level intelligent electronic devices (IED) for protection and control and shall be provided in the RSS Control Room. Each IED shall be directly connected to the pc/workstation of the Local SCADA

system through a dual managed Ethernet Switches on fiber optic medium and shall communicate as per the IEC 61850 standard. The RTU supporting IEC 61850 protocol for communication with IEDs shall also communicate the RSS data to OCC/BCC over IEC 60870-5-104 protocol on dedicated managed ethernet network.

- 12.15.4.2 Redundant local SCADA server in hot standby mode shall be installed in the RSS for control and monitoring of all substation equipment.
- 12.15.4.3 The systems shall be of the state-of-the art based on IEC 61850 for operation under electrical conditions present in high-voltage substations and follow the latest engineering practice, ensure long-term compatibility requirements and continuity of equipment supply and the safety of the operating staff.
- 12.15.4.4 The offered Local SCADA shall support remote control and monitoring from Operation Control centers (OCC/BCC) via RTU.
- 12.15.4.5 Local workstation shall be used for control and monitoring of sub-station equipment, in case of Local control transfer from OCC/BCC or failure of communication between OCC/BCC with Local SCADA at RSS. To achieve this, necessary control transfer logic shall be implemented at both RSS and OCC SCADA system.
- 12.15.4.6 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 so that operating personnel shall be able to operate the system easily after having received some basic training.
- 12.15.4.7 Disturbance recorder workstation: 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.
- 12.15.4.8 Maintenance, modification or extension of components may not cause a shutdown of the whole Local SCADA. Self-monitoring of components, modules and communication shall be incorporated to increase the availability and the reliability of the equipment and minimize maintenance.
- 12.15.4.9 Ethernet Topology: The Ethernet communication infrastructure to ensure a certain level of quality, performance and availability at least the following described criteria's have to be fulfilled concerning the Ethernet switches and the topology.
- 12.15.4.10 Ethernet Switches: Ethernet switches that fulfill the hardened requirements concerning temperature, EMC and power supply (110V DC from the station battery) suitable to be installed in substations shall be provided.

12.15.5 System architecture

- 12.15.5.1 The system architecture shall be based on completely distributed approach also concerning the connection of any device to the system. Meaning any device, protection as well as control and station level devices shall directly be connected to the Ethernet backbone.
- 12.15.5.2 The Local SCADA system shall be based on a decentralized architecture and on a concept of bay-oriented, distributed intelligence.

- 12.15.5.3 Functions shall be decentralized, object-oriented and located as close as possible to the process.
- 12.15.5.4 The main process information of the station shall be stored in local SCADA server. The typical Local SCADA architecture shall be structured in two levels, i.e. in a station and a bay level.
- 12.15.5.5 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.
- 12.15.5.6 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. The fiber optic cables shall be run in GI conduit pipes. Data exchange is to be realized using IEC 61850 Communication standard with a redundant managed switched Ethernet communication infrastructure which shall be supplied by EPC contractor. EPC contractor shall also supply fiber optic patch cables inside GI flexible conduit from CRP panels to Local SCADA Ethernet Switches forestablishing dual LAN over IEC 61850.
- 12.15.5.7 The communication shall be made in 1+1 mode, excluding the links between individual bay IEDs to switch, such that failure of one set of fiber shall not affect the normal operation of the local SCADA. However it shall be alarmed in Local SCADA. Each fibre optic cable shall have four (4) nos. of spare fibers.
- 12.15.5.8 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.
- 12.15.5.9 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. OCC, station HMI, bay level or apparatus level.
- 12.15.5.10 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, RTU.
- 12.15.5.11 The GPS receiver with time synchronizing signal as per IEC 61850 standard SNTP (Simple network time protocol) for the synchronization of the entire system shall be provided. When communication between OCC and local SCADA system is failed the GPS clock shall synchronize with local SCADA system as well as Relays for time synchronization.

12.15.6 Functional Requirements

- 12.15.6.1 The high-voltage apparatus within the station shall be possible to be operated from different places:
- a) Operation Control Centers (OCC)
 - b) Backup Control Center (BCC)
 - c) Local SCADA Station HMI
 - d) Local Bay controller IED (in the bays)
 - e) Apparatus Level

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.

12.15.7 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.

12.15.8 Self-supervision

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

12.15.9 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 drive 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).

12.15.10 System level functions

12.15.10.1 Status supervision

12.15.10.1.1 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.

12.15.10.1.2 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.

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

12.15.10.2 Measurements

12.15.10.2.1 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 (V) and current (I) shall be calculated.

12.15.10.2.2 The measured values shall be displayed locally on the station HMI and in the control centre. The abnormal values must be discarded. The analogue values shall be updated cyclically in every 2 seconds.

12.15.10.2.3 Threshold limit values shall be selectable for alarm indications.

12.15.10.3 Event and alarm handling

12.15.10.3.1 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.

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12.15.11 Station HMI

12.15.11.1 Substation HMI Operation

12.15.11.1.1 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.

12.15.11.1.2 Control operation from other places (e.g. REMOTE) shall not be possible in this operating mode.

12.15.11.2 Presentation and dialogues

12.15.11.2.1 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 (or touch screens).

12.15.11.2.2 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.

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

12.15.11.2.4 The following standard pictures shall be available from the HMI:

- a) Single-line diagram showing the switchgear status and measured values.
- b) Control dialogues with interlocking and blocking details. This control dialogue shall tell the operator whether the device operation is permitted or blocked.
- c) Measurement dialogues
- d) Alarm list, station / bay-oriented
- e) Event list, station / bay-oriented

- f) System status
- 12.15.11.3 HMI design principles
- 12.15.11.3.1 Consistent design principles shall be adopted with the HMI concerning labels, colors, dialogues and fonts. Non-valid selections shall be dimmed out.
- 12.15.11.3.2 The object status shall be indicated using different status colors for:
 - a) Selected object under command
 - b) Selected on the screen
 - c) Not updated, obsolete values, not in use or not sampled
 - d) Alarm or faulty state
 - e) Warning or blocked
 - f) Update blocked or manually updated
 - g) Control blocked
 - h) Normal state, faulty state
- 12.15.11.4 Process status displays and command procedures
- 12.15.11.4.1 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.
- 12.15.11.4.2 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.
- 12.15.11.4.3 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.
- 12.15.11.4.4 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.
- 12.15.11.5 System supervision & display
- 12.15.11.5.1 The local SCADA system shall be comprehensively self-monitored such that faults are immediately indicated to the operator, possibly before they develop into serious

situations. Such faults are recorded as a faulty status in a system supervision display. This display shall cover the status of the entire substation including all switchgear, IEDs, communication infrastructure and remote communication links, and printers at the station level, etc.

12.15.11.6 Object picture

12.15.11.6.1 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:

- a) Type of blocking
- b) Authority
- c) Local / remote control
- d) ALDC/Local SCADA control
- e) Errors etc. shall be displayed

12.15.11.7 Control dialogues

12.15.11.7.1 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:

12.15.11.8 User-authority levels

12.15.11.8.1 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.:

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

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

- a) No engineering allowed
- b) Engineering/configuration allowed
- c) Entire system management allowed

- 12.15.11.8.3 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.

12.15.12 Event list

- 12.15.12.1 The event list shall contain events that are important for the control and monitoring of the substation.
- 12.15.12.2 The event and associated time (with 1 ms resolution) of its occurrence has to be displayed for each event.
- 12.15.12.3 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.
- 12.15.12.4 A printout of each display shall be possible on the hard copy printer.
- 12.15.12.5 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.
- 12.15.12.6 The chronological event list shall contain:
- a) Position changes of circuit breakers, isolators and earthing device
 - b) Indication of protective relay operations
 - c) Fault signals from the switchgear
 - d) 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.
 - e) Loss of communication
- 12.15.12.7 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:
- a) Date and time
 - b) Bay
 - c) Device
 - d) Function e.g. trips, protection operations etc.
 - e) Alarm class

12.15.13 Alarm list

- 12.15.13.1 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 table, 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:

- a) The date and time of the alarm
- b) The name of the alarming object
- c) A descriptive text
- d) The acknowledgement states

12.15.13.2 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).

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

12.15.14 Reports

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

Trend reports:

- a) Day (mean, peak)
- b) Month (mean, peak)
- c) Semi-annual (mean, peak)
- d) Year (mean, peak)

Historical reports of selected analogue Values:

- a) Day (at 15 minutes interval)
- b) Week
- c) Month
- d) Year

12.15.14.2 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.

- a) Following printouts shall essentially be available from the printer and shall be printed on demand (List is not exclusive): 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.
- b) Weekly trend curves for real and derived analogue values.
- c) 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.
- d) Provision shall be made for logging information about breaker status like number of operations with date and time indications.
- e) Equipment operation details shift wise and for 24 hours.
- f) Printout on adjustable time period as well as on demand for MW, MVAR, Current, Voltage on each

feeder and transformer as well as Tap Positions, temperature and status of pumps and fans for transformers.

g) Printout on adjustable time period as well as on demand system frequency and average frequency.

h) Reports in specified formats which shall be handed over to successful bidder.

12.15.15 Trend display (historical data)

12.15.15.1 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.

12.15.15.2 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

12.15.16 Automatic disturbance file transfer

12.15.16.1 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.

12.15.17 Disturbance analysis

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

12.15.18 IED parameter setting

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

12.15.19 Automatic sequences

12.15.19.1 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.

12.15.20 Local SCADA RTU

12.15.20.1 Communication Interface: The Local SCADA RTU shall have the capability to support simultaneous communications with multiple independent remote master stations.

12.15.20.2 Communication Protocol: The communication protocol between IED's and station HMI shall be on the global Automation standard IEC 61850 at inter bay level and shall be on IEC 60870-5-104 protocol for communication from RSS to the OCC/BCC.

12.15.21 System hardware

12.15.21.1 Station HMI, and Disturbance Recorder Work station

12.15.21.1.1 The Contractor shall provide station HMI. It shall be capable to perform all functions for entire substation including future requirements as indicated in the SLD.

12.15.21.2 HMI (Human Machine Interface)

12.15.21.2.1 The HMI platform should be based on the latest technologies such that the HMIs have the ease of usage and configuration. 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.

12.15.21.2.2 HMI shall support various user-defined views of system data and shall support Role based user access based on the permissions. The HMI shall support password complexities while creating user passwords.

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

12.15.21.3.1 The Contractor shall provide three LED display units, one for Local workstation HMI, one for redundant Server HMI and one for DR cum Engineering workstation. 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 24" diagonally in size and capable of colour graphic displays.

12.15.21.3.2 **DELETED**

12.15.21.3.3 The HMI shall be able to switch the keyboard and cursor positioning device, as unit among all the monitors at a consol vis push button or other controls.

12.15.21.4 Printer

12.15.21.4.1 It shall be robust & suitable for operation with a minimum of 132 characters per line. The printing operation shall be quiet with a noise level of less than 45 dB suitable for location in the control room. Printer shall accept and print all ASCII characters via master control computer unit interface.

12.15.21.4.2 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.

12.15.21.4.3 All reports and graphics prints shall be printed on laser printer.

12.15.21.4.4 All printers shall be continuously online.

12.15.21.5 Mass Storage Unit

12.15.21.5.1 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 4 GB or more capacity. The unit should support at least Read (48X), Write (24X), and Re-Write (1 OX) 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.

12.15.21.6 Switched Ethernet Communication Infrastructure

12.15.21.6.1 The Contractor shall provide the redundant switched optical Ethernet communication infrastructure for Local SCADA. The Contractor shall keep provision of 100% spare capacity for Employer use. One switch shall be provided to connect all IEDs for two bays of Bangalore Metro Receiving Substation to communication infrastructure. The switches shall be equipped with fully integrated redundant power supply. It shall support priority tagging and SNMP for supervision. The switching time shall be as low as 5 ms per switch. The switch shall be of industrial grade hardware with EMC to meet SA environment.

12.15.22 Extensibility in future

12.15.22.1 General

12.15.22.1.1 The Offered LOCAL SCADA shall be based on the latest global automation standard IEC 61850 which as part of it supports future seamless extension and integration of additional fully complaint IEC 61850 IED's of other suppliers.

12.15.22.1.2 Offered Local SCADA shall be suitable for extension in future for additional bays. During such requirement, all the drawings and configurations, alarm/event list etc. displayed shall be designed in such a manner that its extension shall be easily performed by the Employer. During such event, normal operation of the existing substation shall be unaffected and system shall not require a shutdown. The Contractor shall provide all necessary software tools along with source codes to perform addition of bays in future and complete integration with Local SCADA by the user.

12.15.22.1.3 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 with IEDs of same manufacture/different manufacture.

12.15.23 Software Structure

The software package shall be structured according to the Local SCADA architecture and strictly divided in various levels. Necessary firewall shall be provided at suitable points in software to protect the system. An extension of the station shall be possible with lowest possible efforts. Maintenance, modification or an extension of components of any feeder may not force a shutdown of the parts of the system which are not affected by the system adaptation.

12.15.23.1 Station level software

Human-machine interface (HMI): The base HMI software package for the operator station shall include the main Local SCADA 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.

12.15.23.2 Application software

In order to ensure robust quality and reliable software functions, the main part of the application software shall be on Linux / Windows Operating System at Servers, which 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.

The SCADA system shall support monitoring of servers (CPU usage and memory), network switches, routers and other IT devices through SNMP V3 protocol.

The SCADA system shall be compliant with Cyber Security industry Standards such as NERC, CIP, CERT-In, IEC 62443. Bidders shall provide detailed description of Cyber Security features supported by their offered system and what has been considered for delivery based on the specification.

12.15.23.3 Network Management System

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

- a. Configuration Management
- b. Fault Management
- c. Performance Monitoring
- d. Play back feature

12.15.23.3.2 This system shall be used for management of communication devices and other IEDs in the system. This NMS can be loaded in work-station and shall be easy to use, user friendly and menu based. The NMS shall monitor all the devices in the Local SCADA 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 Local SCADA connectivity and device status.
- c. Issue alarms when error conditions occur.
- d. Provide facility to add and delete addresses and links.
- e. The Contractor shall provide each software in two copies in CD to load into the system in case of any problem related with Hardware/Communication etc.

12.15.24 Tests

12.15.24.1 Factory Acceptance Tests

12.15.24.1.1 The manufacturing phase of the Local SCADA 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.

- 12.15.24.1.2 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).
- 12.15.24.2 Integrated Testing
 - 12.15.24.2.1 The integrated system tests shall be performed as detailed in subsequent clauses as per following configuration:
Station HMI, work station, switches along with all IEDs and printers.
 - 12.15.24.3 All other switches for complete sub-station as detailed in section project shall be simulated as needed

12.16 USER INTERFACE

12.16.1 General concept of the workstation screens

- 12.16.1.1 The display of views, controls and the event resolution shall be possible from the same screen.
- 12.16.1.2 The screens shall be organized into different sections for processing the Power Controller activity information. There shall be no overlap between the various sections at any time that may obscure vital information.
- 12.16.1.3 The active sections shall have dynamic information displayed. Each active section shall manage and update the alarms, processing and controls that shall be displayed in it. Every status change shall be shown within the active sections and the relevant display updated.
- 12.16.1.4 Each view shall display the necessary tools and options for the processing or management of events.
- 12.16.1.5 Any section of the screens displaying text shall have scrolling abilities. The management of any overflows of alarms and various data, i.e. when the number of alarms exceeds the capacity of the section on the screen, shall use these scrolling facilities.

12.16.2 Typical Workstation Screen Design

- 12.16.2.1 Alarm List (AL)
 - 12.16.2.1.1 The alarm list may show detailed alarms in comprehensible text format with the date and time of their occurrence. They shall be displayed in chronological order, commencing with the most recent.
 - 12.16.2.1.2 A scrolling facility shall enable the Power Controller to scan the list.
 - 12.16.2.1.3 Each alarm in the list shall be displayed with different colour or shape attributes according to the alarm level and acknowledgement status.
 - 12.16.2.1.4 The alarm list shall have various filter facilities to enable the Power Controller to display different format of events.
 - 12.16.2.1.5 The Power Controller shall be able to print the alarm list.
- 12.16.2.2 Logging List (LL)
 - 12.16.2.2.1 The logging list shall show detailed events in comprehensible text format with the date and time of their occurrence. They shall be displayed in chronological order.
 - 12.16.2.2.2 A scrolling facility shall enable the Power Controller to scan the list.

- 12.16.2.2.3 The logging list shall have various filter facilities to enable the Power Controller to display different format of events.
- 12.16.2.2.4 The filter keys shall typically include location, equipment group, time period, event category (ordinary event, minor and major alarm ...) and other options.
- 12.16.2.2.5 Any combination of the filter keys shall be possible.
- 12.16.2.2.6 Each event in the list shall be displayed with different colour attributes according to their category
- 12.16.2.2.7 The Power Controller shall be able to print the logging list or the filtered logging list.
- 12.16.2.3 View Selection
- 12.16.2.3.1 A view selection bar may be permanently displayed on each screen to allow the Power Controller to select various available images.
- 12.16.2.3.2 Some detailed images may not be selectable from the view selection bar but be selected directly from other displays.
- 12.16.2.4 Graphic Display
- 12.16.2.4.1 The graphic display shall display images as requested by the Power Controller.
- 12.16.2.5 Control facilities
 - 12.16.2.5.1 Equipment control may be managed by designating the equipment on the screen.
 - 12.16.2.5.2 This action may open a dialogue box requiring the Power Controller to select one possible control mode for the equipment, setting remote control inhibition on the equipment and cancelling remote control inhibition on the equipment.
 - 12.16.2.5.3 After selecting the control action, the Power Controller shall either validate or cancel the action. If validated, the control action shall be performed.

12.16.3 SCADA Views

- 12.16.3.1 The Contractor shall design specific views which shall be designed in such a manner that it gives an easy control and accessibility to the relevant operators. The views related to RSS, ASS, Depot, 25 kV Traction system etc. shall be designed as per the single line diagram of each location showing the equipment status and measured values. One common alarm HMI screen of all equipments of a location shall be designed for each RSS, ASS, Depot, 25 kV Traction system views.
- 12.16.3.2 The auxiliary overview and traction overview of corridor 1 and corridor 2 shall be designed to be display on the Large Video Display Screen.

- 12.16.3.3 The contractor shall design the HMIs as required by the client and shall submit the HMI design to the Engineer in charge for the approval. Any other HMIs if required by the client for operational requirement shall be designed by the contractor.

12.17 PERFORMANCE REQUIREMENT

The performance of the system must enable the Power Controllers to operate the line under satisfactory conditions. More precisely, the following targets must be reached.

12.17.1 Transfer time

- 12.17.1.1 The display of each critical system shall require rapid updates of the workstation displays of the status and event data, together with a rapid response by the SCADA System to control inputs. The status of any circuit breaker trip, protecting any Safety Critical equipment etc., shall also be identified on the workstations at OCC and BCC and recorded in the event record, within 1 second in normal condition and within 2 seconds in avalanche conditions of its occurrence.
- 12.17.1.2 The SCADA systems shall continue to be able to function without degradation of performance of system, should there be a mass tripping of equipment at multiple RSS, ASS or avalanche breakdown of power supply network. The OCC/BCC SCADA system shall continue to function normally in such an event without any software hanging and system restart.

12.17.2 System Capacity

- 12.17.2.1 The processing power of the servers, workstations, remote terminal units, and all the relevant peripherals of the system should be designed to guarantee that SCADA System will cope with all situations and allow the operator to manage all the events he is in charge to supervise.
- 12.17.2.2 SCADA server and SCADA software shall be scalable & upgradeable and shall be sized & suitably licensed for the control & monitoring requirement of corridor 2 and corridor 4 and its future expansion shall be included. The SCADA software shall be supplied with the license (RTUs and other Subsystems) complete in all respect with 100% installed capacity + 20% installed spares + additional 20% of the total installed capacity (RTU and other Subsystems) shall be included.
- 12.17.2.3 The selected SCADA hardware and software shall be expandable & capable to accommodate additional 75% of the total installed capacity for future expansion if required

12.17.3 Hot-Standby Changeover Time

- 12.17.3.1 In case of failure of Main system, the complete SCADA system shall switch to standby system with full communication with all RTU's and HMI on Workstations within not more than 30 Seconds without requirement by Power Controller to re-login into the standby system.

12.17.4 Chronological analysis

- 12.17.4.1 In order to analyse afterwards a sequence of events with an acceptable accuracy the number of data samples must be sufficient. Therefore, every alarm or event is dated with a precision of 0.001s i.e. 01 (one) ms (day and time: hours, minutes, seconds, tenths of second) by the RTU that

receives it from an equipment, or by the computer that generates it if no RTU is involved in this alarm or event: this date is called the « origin » date of the alarm or event. Each alarm or event existing in the whole system is designed to be sent to the OCC and the BCC.

- 12.17.4.2 The sequence of events shall be logged and presented in event list or alarm list strictly in chronological order.

12.17.5 Usable Service Life

- 12.17.5.1 The SCADA software shall be supplied with perpetual license, and the usable service life of SCADA software and it's enabling IT environment (OS, Database Software and any other software required for installation of SCADA software) shall be minimum 15 years from date of supply.

12.17.6 Interoperability

- 12.17.6.1 The SCADA System selected shall support integration of RTU of other make and model over IEC 608705-104. It shall also be capable to exchange information with other SCADA system over IEC 60870-5-104, OPC DA/UA and other standard communication protocols.

12.18 INTERFACE REQUIREMENT

It shall be the responsibility of Traction Contractor to interface with all the agencies involved in the project for the successful completion of all activities assigned to the Contractor. SCADA contractor shall be required to do the necessary interface with the following contractors but not limited to.

12.18.1 Interface with Depot Civil contractor

12.18.2 Interface with Depot E&M contractor

12.18.3 Interface with RSS contractor

12.18.4 Interface with Signalling contractor

12.18.5 Interface with Telecom contractor

12.18.6 Interface with Station E&M contractor

Kindly refer Chapter 3 of Tender Specifications for detailed SCADA Interface Requirements.

12.19 Testing & Acceptance

12.19.1 General Requirements

- 12.19.1.1 The Contractor shall carry out all the tests and checks required for guaranteeing the engineer in charge of the satisfactory construction and the satisfactory operation of all SCADA installations.
- 12.19.1.2 The Contractor shall put in place a full testing program to demonstrate that all the requirements of the specification are met.
- 12.19.1.3 The Contractor shall develop an Integrated Testing & Commissioning Plan including details of all testing activities as specified, to verify the system in all modes of operation and with all necessary interfacing requirements. Test programs, methods and results shall be documented and submitted to the Engineer in charge for necessary approval.

12.19.2 Tests

All the tests shall be carried out by the Contractor and will be witnessed by the Engineer in charge.

12.19.2.1 Type Test

- 12.19.2.1.1 Type Tests shall be performed prior to full production and before FAT.

- 12.19.2.1.2 Type Tests shall be used to confirm that the proposed equipment is fit for purpose in the environmental conditions specified, design and meets the requirements of the Specification.

- 12.19.2.1.3 The Contractor shall provide detailed Type Test specifications in respect of tests to be performed for the equipment.

- 12.19.2.1.4 Type tests shall be carried out on the prototype in accordance with provisions contained in governing specifications. If type test conforming to this specification has already been conducted and a valid type test certificate is available, fresh type test shall not be required if it had passed the type tests and no change in design or material used have been made. Certified copies of type test report shall be furnished along with the Tender submission or at the time of vendor approval.

- 12.19.2.1.5 For any item that the Engineer does not agree to waive Type testing for, the Contractor shall propose the body who will undertake the Type Testing (which may in certain circumstances be the Contractor). The Engineer may specify which authority will witness and approve the results of the Type Testing.

12.19.2.2 Factory Acceptance Test

- 12.19.2.2.1 The manufacturing phase of the SCADA system equipments shall be concluded by the Factory acceptance test (FAT) at supplier's premises. 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.
- 12.19.2.3 Acceptance Test
- 12.19.2.3.1 Tests shall be carried out during erection/commissioning of the equipment at site on the complete system in the presence of the employer's representative to check the proper erection and successful commissioning of the equipment. These tests shall be carried out to check the compliance of the SCADA system with the stipulations made in the specification/drawings.
- 12.19.2.4 Integrated Testing & Commissioning
- 12.19.2.4.1 Integrated Testing of SCADA system shall be carried out from OCC and BCC on fully interconnected SCADA system with power supply equipment and SCADA Dedicated FO network. In Integrated Testing, both functional and performance test shall be conducted. Additionally, point to point testing of each I/O signals shall be also carried out.
- 12.19.2.4.2 All the defects and shortfalls in the Contractor's system discovered in the course of integrated testing and commissioning shall be made good and retested to the satisfaction of the Engineer.

12.20 INPUT / OUTPUT REQUIREMENT**12.20.1 Description**

12.20.1.1 This Specification defines the Input/output requirements for the SCADA system. The list is indicative and not exhaustive. The contractor shall consider all I/O signals for the equipments at all RSS/ASS/Depot/25 kV Traction posts. The Contractor shall prepare a comprehensive list of Input/output for each of the monitored/controlled equipment and submit for approval by the Engineer.

12.20.2 Input Output Signal List

12.20.2.1 The typical requirement for the various equipments have been indicated below:

12.20.2.1.1 Auxiliary Substations (Elevated ASS)

S. No	Device	Event Description	Signal Type				Event Text		Signal Type
			Digital Input	Digital Output	Analog Input	Alarm Class	Normal State	Alarm State	
1	Incomer/Outgoing Breaker	Local/Remote Status	DI			P 1	Remote	Local	Hardwired
2		110V DC Control Supply Status	DI			P 2	Normal	Fail	Hardwired
3		CB Position Indication Close	DI			P 0	Close		Hardwired
4		CB Position Indication Open	DI			P 0	Open		Hardwired
5		CB SCADA Permissive Indication	DI			P 1	Banned	Permitted	Hardwired
6		Earth Switch Position Indication Close	DI			P 0	Close		Hardwired
7		Earth Switch Position Indication Open	DI			P 0	Open		Hardwired
8		CB Test/Service Status	DI			P 2	Service	Test	Hardwired
9		CB Trip Circuit Status	DI			P 2	Healthy	Unhealthy	Hardwired
10		CB Spring Status	DI			P 1	Charged	Discharged	Hardwired
11		CB Close Command		DO		P 0			Hardwired
12		CB Open Command		DO		P			Hardwired

		Command				0			d
13		CB SCADA Permissive Command		DO		P 0			Hardwired
14		MTR Reset Command		DO		P 0			Soft signal
15		Line Differential Relay Status	DI			P 3	Normal	Faulty	Soft signal
16		Line Differential Comm. Status	DI			P 2	Normal	Fail	Soft signal
17		Line Differential SOTF	DI			P 2	Normal	Fail	Soft signal
18		Fuse Failure Monitoring	DI			P 2	Normal	Fail	Soft signal
19		Master Trip Relay Status	DI			P 3	Normal	Faulty	Soft signal
20		Line Differential Prot. Status	DI			P 2	Normal	Operated	Soft signal
21		O/C IDMT Prot. Status	DI			P 2	Normal	Operated	Soft signal
22		O/C DMT Prot. Status (2 stages)	DI			P 2	Normal	Operated	Soft signal
23		E/F IDMT Prot. Status	DI			P 2	Normal	Operated	Soft signal
24		E/F DMT Prot. Status (2 stages)	DI			P 2	Normal	Operated	Soft signal
25		Over Voltage Protection Status	DI			P 2	Normal	Operated	Soft signal
26		Under Voltage Protection Status	DI			P 2	Normal	Operated	Soft signal
27		O/C & E/F Relay status	DI			P 3	Normal	Faulty	Soft signal
28		Any Other Protection Signals from Relay as per protection scheme through Relay communication link	DI			P 2	Normal	Operated	Soft signal
29	PT	R-Y Voltage			AI				Soft signal
30		Y-B Voltage			AI				Soft Signal
31		B-R Voltage			AI				Soft signal

32	R-Current			AI				Soft signal
33	Y- Current			AI				Soft signal
34	B- Current			AI				Soft signal
35	Local/Remote Status	DI			P 1	Remote	Local	Hardwired
36	110V DC Control Supply Status	DI			P 2	Normal	Fail	Hardwired
37	CB Position Indication Close	DI			P 0	Close		Hardwired
38	CB Position Indication Open	DI			P 0	Open		Hardwired
39	CB SCADA Permissive Indication	DI			P 1	Banned	Permitted	Hardwired
40	Earth Switch Position Indication Close	DI			P 0	Close		Hardwired
41	Earth Switch Position Indication Open	DI			P 0	Open		Hardwired
42	CB Test/Service Status	DI			P 2	Service	Test	Hardwired
43	CB Trip Circuit Status	DI			P 2	Healthy	Unhealthy	Soft signal
44	CB Spring Status	DI			P 1	Charge d	Discharged	Hardwired
45	CB Close Command		DO		P 0			Hardwired
46	CB Open Command		DO		P 0			Hardwired
47	CB SCADA Permissive Command		DO		P 0			Hardwired
48	MTR Reset Command		DO		P 0			Soft signal
49	Master Trip Relay Status	DI			P 3	Normal	Faulty	Soft signal
50	O/C IDMT Prot. Status	DI			P 2	Normal	Operated	Soft signal
51	O/C DMT Prot. Status (2 stages)	DI			P 2	Normal	Operated	Soft signal
52	E/F IDMT Prot. Status	DI			P 2	Normal	Operated	Soft signal

53	E/F DMT Prot. Status (2 stages)	DI			P 2	Normal	Operated	Soft signal
54	Breaker Failure Protection Status (50BF)	DI			P 2	Normal	Operated	Soft signal
55	O/C & E/F Relay Status	DI			P 3	Normal	Faulty	Soft signal
56	Any Other Protection Signals from Relay as per protection scheme through Relay communication link	DI			P 2	Normal	Operated	Soft signal
57	R-Current			AI				Soft signal
58	Y- Current			AI				Soft signal
59	B- Current			AI				Soft signal
60	Local/Remote Status	DI			P 1	Remote	Local	Hardwired
61	110V DC Control Supply Status	DI			P 2	Normal	Fail	Hardwired
62	CB Position Indication Close	DI			P 0	Close		Hardwired
63	CB Position Indication Open	DI			P 0	Open		Hardwired
64	CB SCADA Permissive Indication	DI			P 1	Banned	Permitted	Hardwired
65	CB Test/Service Status	DI			P 2	Service	Test	Hardwired
66	CB Trip Circuit Status	DI			P 2	Healthy	Unhealthy	Hardwired
67	CB Spring Status	DI			P 1	Charged	Discharged	Hardwired
68	CB Close Command		DO		P 0			Hardwired
69	CB Open Command		DO		P 0			Hardwired
70	CB SCADA Permissive Command		DO		P 0			Hardwired
71	R-Y Voltage			AI				Soft signal

72	Y-B Voltage			AI				Soft signal
73	B-R Voltage			AI				Soft signal
74	Winding Temp High Alarm Status	DI			P 2	Normal	Alarm	Soft signal
75	Winding Temp High Auto Trip Alarm	DI			P 2	Normal	Trip	Soft signal
76	T/F Door Status	DI			P 2	Close	Open	Soft signal
77	Local/Remote Status	DI			P 1	Remote	Local	Hardwired
78	110V DC Control Supply Status	DI			P 2	Normal	Fail	Hardwired
79	CB Position Indication Close	DI			P 0	Close		Hardwired
80	CB Position Indication Open	DI			P 0	Open		Hardwired
81	CB SCADA Permissive Indication	DI			P 1	Banned	Permitted	Hardwired
82	CB Test/Service Status	DI			P 2	Service	Test	Hardwired
83	CB Trip Circuit Status	DI			P 2	Healthy	Unhealthy	Hardwired
84	CB Spring Status	DI			P 1	Charge d	Discharge d	Hardwired
85	U/V Trip Relay Status	DI			P 2	Normal	Operated	Hardwired
86	Thermal O/L Relay Prot. Status	DI			P 2	Normal	Operated	Hardwired
87	CB Close Command		DO		P 0			Hardwired
88	CB Open Command		DO		P 0			Hardwired
89	CB SCADA Permissive Command		DO		P 0			Hardwired
90	Charger Position	DI			P 3	Main	Standby	Hardwired
91	Charger Status	DI			P 3	Healthy	Unhealthy	Hardwired

92	Charger Mode	DI			P 1	Float	Boost	Hardwired
93	AC Mains Status	DI			P 3	Normal	Fail	Hardwired
94	Input MCB Trip Status	DI			P 3	Normal	Trip	Hardwired
95	Output MCB Trip Status	DI			P 3	Normal	Trip	Hardwired
96	DC Under Voltage	DI			P 3	Normal	Alarm	Hardwired
97	DC Over Voltage	DI			P 3	Normal	Alarm	Hardwired
98	Battery Voltage			AI				Hardwired
99	Lack of 415V AC Supply	DI			P 1	Normal	Fail	Hardwired
100	Lack of 110V DC Supply	DI			P 2	Normal	Fail	Hardwired
101	RTU Power Supply 1 Status	DI			P 2	Normal	Fail	Hardwired
102	RTU Power Supply 2 Status	DI			P 2	Normal	Fail	Hardwired
103	RTU SCADA Permissive Switch Status	DI			P 2	Remote	Local	Hardwired
104	RTU Panel Door Status	DI			P 1	Close	Open	Hardwired
105	RTU CPU Module, Communication Module, I/O Module Status	DI			P 2	Normal	Faulty	Internal
106	RTU Time Synch Status	DI			P 2	Synch	Not Synch	Internal
107	RTU Reset / Restart Command	DO						Internal
108	Wind Speed			AI				Hardwired

12.20.2.1.2 Traction Switching Station Elevated (For SS, SSP, SP, FP and Depot FP)

Sr. no	Device	Event Description	Signal Type	M Class	Event Text	
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			Digital Input	Digital Output	Analog Input		Normal State	Alarm State	Signal Type
1	Feeding Breaker	Local/Remote Status	DI			P1	Remote	Local	Hardwired
2		110V DC Control Supply Status	DI			P2	Normal	Fail	Hardwired
3		CB Position Indication Close	DI			P0	Open	Closed	Hardwired
4		CB Position Indication Open	DI			P0	Closed	Open	Hardwired
5		CB SCADA Permissive Indication	DI			P1	Banned	Permitted	Hardwired
6		CB Trip Circuit Status	DI			P2	Healthy	Unhealthy	Hardwired
7		CB Close Command		DO		P0			Hardwired
8		CB Open Command		DO		P0			Hardwired
9		CB SCADA Permissive Command		DO		P0			Hardwired
10		MTR Reset Command		DO		P0			Soft signal
11		Unit Healthy	DI			P2	Healthy	Unhealthy	Hardwired
12		DMT Overcurrent Protection Status	DI			P2	Normal	Operated	Soft signal
13		IDMT Overcurrent Protection Status	DI			P2	Normal	Operated	Soft signal
14		DMT Earth Fault Protection Status	DI			P2	Normal	Operated	Soft signal
15		IDMT Earth Fault Protection Status	DI			P2	Normal	Operated	Soft signal
16		Breaker Failure Protection Status	DI			P2	Normal	Operated	Soft signal
17		Distance Protection Status	DI			P3	Normal	Operated	Soft signal
18		Fuse Failure Monitoring for Dist. Prot.	DI			P3	Normal	Fail	Soft signal
19		Auto Reclosure Status	DI			P2	Normal	Alarm	Soft signal
20		Master Trip Relay Status	DI			P3	Normal	Faulty	Soft signal
21		Under Voltage Protection Status	DI			P2	Normal	Operated	Soft signal
22		Over Voltage Protection Status	DI			P2	Normal	Operated	Soft signal
23		O/C & E/F Relay Status	DI			P3	Normal	Faulty	Soft signal
24	Interrupter	Local/Remote Status	DI			P1	Remote	Local	Hardwired
25		110V DC Control Supply Status	DI			P2	Normal	Fail	Hardwired
26		Interrupter Position Indication Close	DI			P0	Close		Hardwired
27		Interrupter Position Indication Open	DI			P0	Open		Hardwired
28		Interrupter SCADA Permissive Indication	DI			P1	Banned	Permitted	Hardwired
29		Spring Status	DI			P1	Charged	Discharged	Hardwired
30		Trip Circuit Status	DI			P2	Healthy	Unhealthy	Hardwired

31	Control Unit Status	DI			P2	Healthy	Unhealthy	Hardwired
32	Breaker Failure Status	DI			P2	Normal	Fail	Hardwired
33	Capacitive Voltage Status	DI			P2	Ready	Low	Hardwired
34	Interrupter Close Command		DO		P0			Hardwired
35	Interrupter Open Command		DO		P0			Hardwired
36	Interrupter SCADA Permissive Command		DO		P0			Hardwired
37	Local/Remote Status	DI			P1	Remote	Local	Hardwired
38	110V DC Control Supply Status	DI			P2	Normal	Fail	Hardwired
39	Isolator Position Indication Close	DI			P0	Close		Hardwired
40	Isolator Position Indication Open	DI			P0	Open		Hardwired
41	Isolator SCADA Permissive Indication	DI			P1	Banned	Permitted	Hardwired
42	Isolator Close Command		DO		P0			Hardwired
43	Isolator Open Command		DO		P0			Hardwired
44	Isolator SCADA Permissive Command		DO		P0			Hardwired
45	Voltage			AI				Hardwired
46	Charger Position	DI			P3	Main	Standby	Hardwired
47	Charger Status	DI			P3	Healthy	Unhealthy	Hardwired
48	Charger Mode	DI			P1	Float	Boost	Hardwired
49	AC Mains Status	DI			P3	Normal	Fail	Hardwired
50	Input MCB Trip Status	DI			P3	Normal	Trip	Hardwired
51	Output MCB Trip Status	DI			P3	Normal	Trip	Hardwired
52	DC Under Voltage	DI			P3	Normal	Alarm	Hardwired
53	DC Over Voltage	DI			P3	Normal	Alarm	Hardwired
54	Battery Voltage			AI				Hardwired
55	Lack of 415V AC Supply	DI			P1	Normal	Fail	Hardwired
56	Lack of 110V DC Supply	DI			P2	Normal	Fail	Hardwired
57	RTU Power Supply 1 Status	DI			P2	Normal	Fail	Hardwired
58	RTU Power Supply 2 Status	DI			P2	Normal	Fail	Hardwired
59	RTU SCADA Permissive Switch Status	DI			P2	Remote	Local	Hardwired
60	RTU Panel Door Status	DI			P1	Close	Open	Hardwired
61	RTU CPU Module, Communication Module, I/O Module Status	DI			P2	Normal	Faulty	Internal
62	RTU Time Synch Status	DI			P2	Synch	Not Synch	Internal
63	RTU Reset / Restart Command	DO						Internal

			Signal Type	↔	Event Text	
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S.No	Device	Event Description	Digital Input	Digital Output	Analog Input		Normal State	Alarm State	Signal Type
1	Interrupter	Local/Remote Status	DI			P1	Remote	Local	Hardwired
2		110V DC Control Supply Status	DI			P2	Normal	Fail	Hardwired
3		Interrupter Position Indication Close	DI			P0	Close		Hardwired
4		Interrupter Position Indication Open	DI			P0	Open		Hardwired
5		Interrupter SCADA Permissive Indication	DI			P1	Banned	Permitted	Hardwired
6		Earth Switch Position Indication Close	DI			P0	Close		Hardwired
7		Earth Switch Position Indication Open	DI			P0	Open		Hardwired
8		Disconnecter Switch Position Indication Close	DI			P0	Close		Hardwired
9		Disconnecter Switch Position Indication Open	DI			P0	Open		Hardwired
10		SF6 Gas Pressure Low Alarm	DI			P2	Normal	Low	Hardwired
11		SF6 Gas Pressure Low Trip	DI			P2	Normal	Trip	Hardwired
12		Spring Status	DI			P1	Charged	Discharged	Hardwired
13		Trip Circuit Status	DI			P2	Healthy	Unhealthy	Hardwired
14		Control Unit Status	DI			P2	Healthy	Unhealthy	Hardwired
15		Breaker Failure Status	DI			P2	Normal	Fail	Hardwired
16		Disconnecter Switch Close Command		DO		P0			Hardwired
17		Disconnecter Switch Open Command		DO		P0			Hardwired
18		Interrupter Close Command		DO		P0			Hardwired
19		Interrupter Open Command		DO		P0			Hardwired
20		Interrupter SCADA Permissive Command		DO		P0			Hardwired
21	Isolator	Local/Remote Status	DI			P1	Remote	Local	Hardwired
22		110V DC Control Supply Status	DI			P2	Normal	Fail	Hardwired

23		Isolator Position Indication Close	DI			P0	Close		Hardwired
24		Isolator Position Indication Open	DI			P0	Open		Hardwired
25		Isolator SCADA Permissive Indication	DI			P1	Banned	Permitted	Hardwired
26		Isolator Close Command		DO		P0			Hardwired

27		Isolator Open Command		DO		P0			Hardwired
28		Isolator SCADA Permissive Command		DO		P0			Hardwired
29	PT	Voltage			AI				Hardwired
30	Battery Chargers	Charger Position	DI			P3	Main	Standby	Hardwired
31		Charger Status	DI			P3	Healthy	Unhealthy	Hardwired
32		Charger Mode	DI			P1	Float	Boost	Hardwired
33		AC Mains Status	DI			P3	Normal	Fail	Hardwired
34		Input MCB Trip Status	DI			P3	Normal	Trip	Hardwired
35		Output MCB Trip Status	DI			P3	Normal	Trip	Hardwired
36		DC Under Voltage	DI			P3	Normal	Alarm	Hardwired
37		DC Over Voltage	DI			P3	Normal	Alarm	Hardwired
38		Battery Voltage			AI				Hardwired
39	ACDB	Lack of 415V AC Supply	DI			P1	Normal	Fail	Hardwired
40	DCDB	Lack of 110V DC Supply	DI			P2	Normal	Fail	Hardwired
41	RTU	RTU Power Supply 1 Status	DI			P2	Normal	Fail	Hardwired
42		RTU Power Supply 2 Status	DI			P2	Normal	Fail	Hardwired
43		RTU SCADA Permissive Switch Status	DI			P2	Remote	Local	Hardwired
44		RTU Panel Door Status	DI			P1	Close	Open	Hardwired
45		RTU CPU Module, Communication Module, I/O Module Status	DI			P2	Normal	Faulty	Internal
46		RTU Time Synch Status	DI			P2	Synch	Not Synch	Internal
47		RTU Reset / Restart Command	DO						Internal