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DELHI METRO RAIL CORPORATION LTD.

CONTRACT NO: OEW-2257

“SITC of Local SCADA and RTUs for Traction SCADA in DMRC”

EMPLOYER’S REQUIREMENT & TECHNICAL SPECIFICATION

DELHI METRO RAIL CORPORATION LTD

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Employer's Requirement & Technical Specification

1. OBJECTIVE

The objective of the contract is "**SITC of Local SCADA and RTUs for Traction SCADA in DMRC**" as mentioned in Employer Requirement. In full recognition of this objective, and with full acceptance of the obligations, liabilities and risks which may be involved, the Contractor shall undertake the execution of the works.

2. GENERAL

SITC of Local SCADA and RTUs for Traction SCADA in DMRC shall be done in accordance with Employer's Requirements and the other requirements of the Contract.

The purpose of this work is to supply, installation, testing and commissioning of Local SCADA and RTUs for Traction SCADA in DMRC to support reliable and secure SCADA communication for traction power control.

3. SITE OF WORK:

The work will be carried out at different RSSs, Depots, Sub-stations across various lines of DMRC. However, DMRC may also instruct contractor to carry out the work at any other location in DMRC network if required.

4. SCOPE OF WORK

Contractor shall execute the work "SITC of Local SCADA and RTUs for Traction SCADA in DMRC" as defined in BOQ in the operational network of DMRC. Work shall be carried out as per specified guidelines and as per directions of Engineer in-charge. Work involves supply, installation, testing and commissioning as per BOQ.

4.1. **Supply, Installation, Testing & Commissioning of Hardware & Software for Local SCADA (S.N.1,2,3,4&5 of BOQ) includes Following:**

4.1.1. **HARDWARE requirements:**

Hardware at each RSS shall consist at least following:

- 4.1.1.1. 2 SCADA Servers in Hot Standby configuration with SCADA software installed, configured and tested.
- 4.1.1.2. 1 Monitor (32inch) along with keyboard & mouse for each server
- 4.1.1.3. Associated redundant communication & dual LAN equipment
- 4.1.1.4. Cables, connectors, accessories for cabling and earthing as per site requirement

- 4.1.1.5. Other equipment (such as speakers etc) as necessary to fulfil the specified requirements
- 4.1.1.6. Servers, Network switches and any other communication equipment required will be installed in a U standard suitable Rack with sufficient ventilation and cooling arrangement at RSS with redundant power supply system and protections from UPS distribution board.

4.1.2. Hardware specification of SCADA Server:

- Type: 19" Rack Mountable Industrial Grade Servers
- OS: Latest licensed Windows OS
- Power Supply: Dual Power Supply
- Ram Size: 64bit, 32GB RAM
- Hard Disk: 2X960GB SSD in RAID-1 Configuration
- Monitor: 32" Display Monitor (minimum Full HD) with stand
- Other Accessories: Keyboard, Mouse, Speakers etc
- Warranty- Minimum 5 years on-site OEM Warranty from date of commissioning.

4.1.3. Ethernet Switch specifications:

- Layer-2/Layer-3 Managed Ethernet Switch
- Type: Minimum 16 Cu (RJ-45 Ports) +Minimum 8 SFP ports
- Features: Redundant power input, VLAN, RSTP/MSTP, IEC 61850 compliant
- Speed: Gigabit Ethernet

4.1.4. SAS Server Panel:

4.1.4.1. SAS server panel shall have following specifications:

- Dimensions: 2000(h)x800(w)x800(d) mm or as per server dimensional requirements
- Type: Floor-mounted, powder-coated CRCA Steel enclosure
- Accessories: Dual power supply bus, PDU with surge protection, Earthing busbar, Cooling fans with temperature/humidity control, Cable management accessories, Cable entry from top/bottom, Front/rear lockable doors with toughened glass in front.

- 4.1.4.2. The SAS Server panel which houses SCADA Server hardware mainly consisting of the power supplies, switches etc. Panel shall provide enough space to house main and redundant components and shall be of IP54 protection class or higher for indoor panels. The Panel shall be dust, rodent and vermin proof with doors. The doors shall have proper rubber gaskets & locking arrangement. Separate earth connection (insulated) shall be used between panel and Terminal subjected to EMI/EMC Compatibility.

- 4.1.4.3. All the cables entry into the panels shall be sealed. The cable sealing system shall provide foolproof protection against Fire, Water, Dust, Dirt, Humidity, Vibrations, Temperature Variations, Pull Tension, Noise as well as Rodents.
- 4.1.4.4. Panel shall be provided with an internal maintenance lamp, protection from humidity and proper ventilation.
- 4.1.4.5. There shall be no sharp corners or edges. All edges shall be chamfered to prevent injury.
- 4.1.4.6. Document Holder shall be provided inside the panel to keep test report, drawing, maintenance register etc.
- 4.1.4.7. All materials used in the enclosures including cable insulation or sheathing, wire troughs, terminal blocks, and enclosure trim shall be made of flame-retardant material and shall not produce toxic gases under fire conditions.
- 4.1.4.8. The power supply and communication cables etc. required for the Servers, Network Switches, RTUs etc. shall be in the scope of the Contractor.
- 4.1.4.9. All terminals, cables, and accessories should be properly labeled with engraved/printed markers for traceability.
- 4.1.4.10. Doors should have limit switches to cut off supply when opened for maintenance.

4.1.5. SCADA Software Requirements:

- 4.1.5.1. Detailed technical specifications and requirements of SCADA software has been attached at **Annexure-1**.

4.2. Supply, Installation, Testing & Commissioning of RTUs (S.N.5&6 of BOQ) includes Following:

- 4.2.1. The list of approved Makes of RTU is available on DMRC website <http://www.delhimetrorail.com/> and same will be updated by DMRC on its website from time to time. At the time of submitting the vendor proposal for approval after award of contract by the Contractor, the updated list as available on DMRC website or installed makes in DMRC shall be applicable, however vendor approval shall be taken from Engineer-in-charge.
- 4.2.2. The RTU shall be compatible with and licensed with all open protocols: IEC-60870-101, IEC-60870-5-103, IEC-60870-104, IEC-61850, DNP 3.0 (Serial & TCP/IP), Modbus. It shall be possible for RTU to communicate simultaneously on all communication ports and using multiple concurrent protocols mentioned above. Various Type Tests Report shall be submitted as per Annexure-3.
- 4.2.3. Technical specifications of RTU shall be as per the Annexure-2.

- 4.2.4. Contractor shall submit FAT plan in advance. DMRC may decide to send its inspection official to manufacturer site/Inspection Site for inspection of RTUs to be delivered. Manufacturer/supplier shall have to arrange such inspection at the manufacturer site/Inspection Site. Travelling, lodging & boarding charges of DMRC officials shall be borne by DMRC. Factory Acceptance test (FAT) reports shall be submitted as per Annexure-3.
- 4.2.5. GTP approval, Manufacturing clearance and dispatch clearance for supply of items shall be taken from engineer in-charge.
- 4.2.6. During the entire work period, any Shifting, Transportation, Handling work of Material from one location to other Location shall be under the scope of contractor.
- 4.2.7. At present, ABB make RTUs have been installed inside RTU panel at different sub-stations of DMRC. The RTU to be provided under this contract shall be installed in the same panel in which old ABB make RTU is already functional at various sub-stations of DMRC. Both dismantling of existing RTU as well as installation of new RTU shall be in the scope of contractor.
- 4.2.8. Cables interface with supplied RTU to field cables (terminated at TBs) is in the scope of contractor. Existing hardware inside RTU panel (interposing relays, MCBs, DC-DC converter, field cabling, Ethernet switch etc.) shall be used as it is.
- 4.2.9. After successful installation and commissioning of RTUs, testing shall be carried out to ensure proper data updation and communication link between RTU and OCC/ BCC/ Local SCADA.
- 4.2.10. Contractor shall also submit as built drawing and documents for each site.
- 4.2.11. Site commissioning tests of RTU as per **Annexure-3** shall be done by the contractor and report shall be submitted to DMRC site in charge. All T&P testing equipment's shall be arranged by the contractor.

5. EXECUTION OF WORK

- 5.1. Contractor shall take all necessary safety precautions during execution of the work.
- 5.2. Work shall be done after obtaining power block and permission to work from DMRC representative.
- 5.3. While executing work, if any minor modification/alteration is to be done by the contractor as advised by DMRC Engineer-in-charge then same should be done by contractor without any financial implications to DMRC.
- 5.4. The contractor during the execution of work shall maintain required Electrical clearance between any live and earth parts and jointly check the clearance with DMRC Engineer after completion of the work.

- 5.5. Contractor may also deploy multiple teams on various sites if required, to execute the work within stipulated time on each day for which power block shall be arranged by DMRC.
- 5.6. The work shall be carried out during revenue hours as well as non-revenue hours as per availability of power block. The time for actual work may be less than the power block/permit to work duration. No compensation/extra payment shall be made in this account.
- 5.7. There may be cases when the scheduled permit to work may be cancelled even after contractor manpower reaches the site of work & no work may be performed in that night. No compensation shall be paid for such cases.
- 5.8. Contract period may prolong due to bad weather condition or power Block constraint. Contractor has to negotiate with the prevailing condition. Nothing will be paid extra.
- 5.9. The contractor team shall be equipped with necessary communication facility at site of work. There should be at least one Engineer who will control his man-power & obtain necessary instruction from DMRC's Engineer at site of work.
- 5.10. Any damage/breakage to the DMRC property during the execution of work will be at the risk & cost of the contractor.
- 5.11. DMRC is an ISO-14001 & OHSAS 18001 certified Organization for Environment, Health & safety. The work is to be carried out as per International Norms/Standards and in such a manner that all premises always look Neat & Clean. Similarly, the waste disposal is also carried out in totally sealed manner without affecting the Environment.
- 5.12. DMRC's engineer in-charge / representative shall verify the installation during & after completion of work each day, and prepare joint report in duplicate duly signed by him and contractor's representative. A copy of report shall be handed over to contractor which will be produced along with the bill.
- 5.13. The contractor shall be responsible for shifting of BOQ items from their premises to actual site of installation. Any damages during transportation shall be borne by the contractor without any financial implications to DMRC. Only site access for movement of material at site shall be provided by DMRC. Quantity for each BOQ item shall be thoroughly checked and authenticated by joint report duly signed by DMRC representative and contractor representative.
- 5.14. The work shall be carried out under the guidance of DMRC engineer in-charge and in case of any dispute regarding any matter; decision of DMRC engineer in-charge shall be final and bound to contractor.
- 5.15. Quantity of work may vary up to $\pm 25\%$, for this payment will be made accordingly.
- 5.16. Handling of Servers, Network Switches, RTU assembly and all other sub-components shall be done with due regard to all necessary precautions that must be adhered to during execution of work.

- 5.17. Special precaution must be taken to ensure that Servers, Network Switches, RTU assembly aren't damaged during transportation/installation. In case of any damage(s), then complete lot shall be rejected by DMRC. Nothing shall be paid extra.
- 5.18. After completion of the installation of equipments, contractor shall carry out point to point testing of each commissioned location jointly with DMRC team and handover the same to DMRC after completion of the work. Purpose of point-to-point testing is to ensure that signals (both indication as well as analog values) are getting updated and commands are getting executed properly without any mismatch/delay/ambiguity.

6. SAFETY

- 6.1. Contractor shall adopt the necessary safety procedures to avoid any type of accidents to Employer's personnel, any other personnel & to avoid damages to DMRC assets.
- 6.2. The contractor shall display necessary sign boards/Barricades while carrying out the work. The contractor may visit the site before submitting the offer.
- 6.3. The work is to be carried out as per the recommendations of manufacturers. The contractor during the execution of work shall follow the Indian Electricity act & all other statutory rules, regulations Acts as available & applicable on date during the period of contract.
- 6.4. Indemnity Bond to be filled by contractor supervisor before entering the site.
- 6.5. All contractor staff should be fully equipped with Face Mask, Safety shoes, Luminous jacket, Safety Helmet and other PPEs. The minimum qualification for unskilled manpower, if any, shall be 8th pass to work in DMRC premises so that the workmen can at least read the signages and instructions. Necessary personal protective equipment's (PPE) as per site requirement to be used by the contractor staff working at the site shall be in the scope of the Contractor. Nothing shall be paid extra on this account.
- 6.6. Portable first aid box should be readily available at site during execution of work.
- 6.7. Contractor shall keep close coordination and interface with Traction & Safety department of DMRC O&M as well as CISF official for smooth working and proper execution & completion of work.

7. TOOLS, PLANT AND EQUIPMENT

All such tools, tackles etc. required for work execution shall be arranged by contractor. Nothing shall be paid extra.

8. COMPLETION PERIOD

The work shall be completed within 9 months starting from date of LOA or date of submission of Notice to proceed by contractor to DMRC, whichever is earlier.

9. DEFECT LIABILITY PERIOD (DLP)

- 9.1. In reference to SCC clause no. 9, Defect liability period (DLP) shall be 24 Months from the date of issue of taking over certificate for the whole of the work. Same shall be validated by joint report signed by DMRC site in-charge and contractor representative.
- 9.2. After expiry of DLP, Guarantee/Warranty given by OEM of the parts shall also be extended to DMRC and relevant Guarantee/Warranty document of such parts shall also be submitted to DMRC by the contractor before processing of the final bill.

10. SCHEDULE OF PAYMENT

- 10.1. No mobilization advance is payable to contractor for the said work.
- 10.2. Payment shall be made through running bills in stages as per progress of work on submission Invoices & declarations/documents.
- 10.3. The payment shall be made subjected to submission of verified measurement sheet along with working locations & verified quantity of BOQ items, Annexure-A & Annexure-B of measurement book.
- 10.4. Payment shall be subjected to deduction of all TDS as per applicable law.
- 10.5. DMRC's engineer in-charge / representative after verifying the installation during & after completion of work each day shall prepare joint report in duplicate duly signed by him and contractor's representative. A copy of report shall be handed over to contractor. Bill along with copy of joint report shall be submitted by contractor to DMRC Engineer for verification and processing the bill for payment.
- 10.6. As the work will be performed at different locations in Delhi, UP, Haryana of DMRC Contractor will submit their invoice as per provision of GST law.

11. PENALTY

- 11.1. If the contractor delays the start of work or does not complete the work as per the schedule given by contractor (which is approved by DMRC), then a penalty of Rs 1000/- per day shall be imposed on the contractor. The penalty shall be limited to 15% of contract value.
- 11.2. The contractor shall ensure that the site is made fit and operational at least 30 minutes before scheduled time of cancellation of PTW & power block. Any delay in train services due to contractor's negligence shall lead to penalty to contractor. Penalty in such cases shall be assessed separately but will be limited to 15% of contract value. Contractor shall be liable to pay the penalty @ Rs 10,000/- per incident of delay in scheduled revenue service, if the Permit to Work (PTW) is not cancelled as per scheduled cancellation time mentioned in PTW.

TECHNICAL SPECIFICATIONS OF LOCAL SCADA SOFTWARE

1. Technical Requirements of SCADA System:

- 1.1. The SCADA system shall be a proven system based on MS windows platform and shall have reference installation in India or abroad in Metro/Railway Traction Power Control applications.
- 1.2. The product shall have graphical user interface for windows look & feel and shall support the features listed in the specifications under different points.
- 1.3. The architecture of software shall be modular and it shall be possible to upgrade the software to its newer version on same/upgraded operating system if any upgraded version of software is released.
- 1.4. During the commissioning/DLP, patch updating (security, performance related) and version up gradation (if released by OEM) shall be in the scope of this contract. Contractor shall test new versions and patches in system without any additional cost.
- 1.5. Post DLP, Contractor shall provide software support for minimum 10 years which includes fault diagnosis, installation of patch files/ service packs, software up gradation if required, and corrective action whenever required on chargeable basis. The Contractor shall submit a formal **undertaking** confirming compliance with this requirement.
- 1.6. The SCADA equipment at RSS shall control all the required equipment installed in RSS through the various RTUs installed at RSS.
- 1.7. The SCADA system shall support minimum 1 workstation connection of SCADA server. It shall also be possible to open the minimum 1 workstation of server in RSS for operational purposes.
- 1.8. The capacity of hardware (Servers and Switches) shall be adequate for designed and spare I/O Points.
- 1.9. The local SCADA Servers shall communicate with the RTU's using IEC-60870-5-104 protocol.
- 1.10. The local SCADA Server shall include necessary software such as operating system, antivirus software and any other specific software with licenses. Antivirus software shall be provided with minimum of 3 years subscription. The updating of Antivirus shall be done by the contractor during the DLP period.
- 1.11. Local SCADA System overview picture shall have provision to view the status of each I/O card of RTU at respective RSS. If any problem appears in any module of RTU that should be communicated to Local SCADA so that timely rectification can be done.

- 1.12. It shall be possible to disable a RTU from Local SCADA to allow maintenance or reconfiguring of the RTU without affecting other parts of the SCADA system. When disabled or enabled, a change of status condition shall be recorded as an event.
- 1.13. All recorded events shall be tagged with real time in hours, minutes, seconds and milliseconds, along with the location of the event.

2. Software of the SCADA System:

- 2.1. The SCADA software shall be based on the latest version of a proprietary software package with proven use in similar applications.
- 2.2. SCADA software shall at least comply standards for cyber security (as applicable for SCADA software) as per IEC 62443, IEC 62351, IS 16335, IEEE 1686.
- 2.3. All SCADA software shall be tested and approved by the DMRC prior to deployment.
- 2.4. SCADA software shall be protected from unauthorized access and computer virus infection.
- 2.5. The SCADA software shall be supplied on a non-volatile removable storage medium such as optical disk (magnetic discs or any other type of exposed media shall not be used). Three copies of the SCADA software, including all supporting documentation and manuals etc. shall be provided to the DMRC. Further copies shall be retained and archived to support software maintenance.
- 2.6. The SCADA software shall be developed using a structured "top down" approach and be presented using process diagrams, which shall form part of the software documentation in the operations and maintenance manuals.
- 2.7. The SCADA software proposed shall be capable of handling the large power supply network like that of DMRC and shall be proven at similar traction applications worldwide.
- 2.8. The Contractor shall arrange visit to site where proposed software is installed for inspection/check the performance and features of the software, by DMRC representatives before submitting the vendor proposal. Also, Contractor will simulate the entire required system of DMRC to prove the suitability of the software for DMRC during FAT.
- 2.9. There shall be no limit of Tags that a user can create on one equipment. As and when required, Tags shall be created by the Operator on any equipment and the software shall support this feature.
- 2.10. The software shall give fast response to operator actions and system events. SCADA system stability should be sustained during event bursts. The manufacturer shall ensure no software hanging during operations.
- 2.11. SCADA software shall allow customization of the operator menu bar with specific access rights.

- 2.12. SCADA software shall provide dynamic network colouring based on the energized/de- energized condition of the network. Different colours shall be used to indicate this network colouring.
- 2.13. Facilities shall be provided on servers for time trending of selected analogue parameters. Each point shall be plotted on a graph with the measured variable scaled on the Y-axis and real-time scaled on the X-axis. It shall not require pre-configuration and shall be available on immediate request of the operator by selecting the required parameter.
- 2.14. Creation and/or modification of SCADA databases shall be carried out using standard commercially available database management tools. There shall be a provision for manual update of central database at RSS.
- 2.15. Historical data storage and software backup systems shall be designed and provided to ensure that stored data is retained in an efficient manner and permit rapid searching against selectable criteria. The storage facilities shall also ensure that the historical records can be reconstructed into a form of readable data.
- 2.16. The storage system shall utilize optical disc technology, allowing data to be indexed and shall allow random and sequential searches.
- 2.17. The design of the SCADA software shall be based on a main program structure utilizing sub-program modules or blocks. Additions or modifications to the SCADA software shall be easily achieved and executed by means of simply adding, deleting or replacing software modules or blocks within the main program structure. SCADA software should be independent of MAC address of any hardware installed i.e. Software license shall not be linked with particular hardware.
- 2.18. SCADA application Software shall have minimum following inherent features to check its own sub functions and report status to the operator.
- Online/standby/offline state of SCADA server
 - State of all RTUs
 - State of printers
 - Connection status of all the operator workstations
 - Communication as well as health status of energy meters and numerical relays

3. Software Framework :

As defined in EN-50128, all software produced or supplied for the project shall be subject to a defined quality framework. The Contractor shall use a Quality Assurance System which is compliant with CENELEC specifications, with EN-29000 series and others and meet the requirements as stipulated in the PS. ISO 9000-3 is considered appropriate for safety Integrity Level O or 1 software.

4. SCADA System and Man Machine Interface :

4.1. Description

The following functionalities are to be achieved by the SCADA system proposed to be installed at RSSs:

- **Remote monitoring:** The remote monitoring functions covers the monitoring of equipment status as per the I-O list provided by DMRC.
- **Remote control:** The SCADA system shall provide facility to open/close breakers, interrupters etc. as per the IO list provided by DMRC. In case of an emergency or abnormal situation, the RSS Operator shall be able to control the various items of equipment, typically:
 - Isolation of the faulty sections or circuits
 - Restore the normal configuration after the fault has been remedied.
 - The SCADA system shall provide facility to display the voltage, currents etc. measurements as per IO list provided by DMRC.
 - Logics & interlocking as per requirement for various equipment i.e. Isolators /Interrupters /CBs /LBS etc.
 - Transfer, to handle the opening/closing of switchgears in bridges.
 - Auto re-closure of traction feeder CBs.
 - Auto/Remote operation of the switchgears.
 - Generating & Recording the Status of signals and alarms.
 - Supervision of the action of protections
 - Time stamped Events Logging & archiving
 - Time Synchronization
 - User-friendly GUI including zoom in zoom out, cluttering/de-cluttering features at HMI/workstations.
 - Dual Redundant data transmission
 - User login recording
 - Interlocking & interface with other SCADA systems for operation of equipment at boundary post.
 - SCADA software shall have programmable live simulation feature for open/close status, other indications and analogue measurands through engineering login only.

4.2. Remote Monitoring Requirements :

4.2.1. Process Display & Power Supply Views

- The SCADA software shall be designed with necessary process display screen to provide a graphical depiction of the power supply network for the Rail/Metro Corridor. This shall include the Receiving Substations, Auxiliary Main Substation, Traction Substation and RSS Local Auxiliary power distribution.

- The SCADA software shall support necessary bus bar coloring feature by which the dynamic status of the bus bar can be depicted during charged and uncharged condition.
- SCADA software shall have provision to show the hang status or any non-operational scenario of the Server, Workstation and RTU, which shall be in the form of changed coloration, pop-up and event.
- Healthy Running status of software (in the form of flashing signal/blinking signal etc.) shall be indicated in toolbar.

4.2.2. Network Coloring

- The SCADA software at RSSs proposed shall support necessary bus bar coloring feature by which the dynamic status of the bus bar can be depicted during charged and uncharged condition. The busbar coloring shall be provided for the individual RSS, AMS, TSS, AC, DC screens and RSS overview Screen at applicable servers.
- The busbar coloring shall be provided based on the PT Value as well as from closing/opening status of breakers, isolators/LBS, earth switch etc. by providing AND gate logic.
- Overview diagram shall be provided on Server screen as per site requirement.
- Alarm for reaching low and high voltages shall be configured in SCADA as per DMRC requirement.

4.2.2.1. Equipment other than Battery Charger Coloring

Normally all power equipment reflecting in various screens should be in green color unless and otherwise any alarm, Blocking and communication Fail event is associated with the equipment. Close and Open State should not be considered as an alarm state for a switchgear and in both cases, it should be shown in green color. In case of occurrence of other alarms its color should change to Red.

4.2.2.2. Battery Charger

The status of battery chargers of RSS shall be indicated in RSSs SCADA as per the following conventions:

- **Green** – Healthy and In-service
- **Yellow** – Healthy and Standby
- **Red** – Defective

4.2.2.3. Alarm Status

Normally all devices should show in green color, unless and otherwise any alarm associated with the device appears from field or it is blocked by operator. In case of alarm occurrence color of device should change to red.

4.2.2.4. Blocking Status

In case of operator blocks control of any device or section, color of the blocked device should change to brown.

4.2.2.5. Communication Failure

In case of communication failure of an installation, all equipment (including PT and other installed equipment) of the installation should change to pink color. Bus bar coloration shall also be changed to pink color in the event of communication failure.

4.2.3. Event management

The EMIS (Event Management Information 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 may generate additional events resulting from the processing of the field information and/or operator request. All events processed by the EMIS 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 initialisation. Event logged in SCADA shall neither be erasable nor be editable. The event Logging System of EMIS shall support the following features and options:

- Historical Storage of events with facility to retrieve the same later
- Configurable layout: columns, fonts, toolbars, Coloring, and so on.
- Configurable scrolling behavior
- Configurable presentation modes: log mode /event mode, latest at top/bottom
- Updating/Frozen presentation modes.
- Easy navigation through scrolling, go to date, time filters.
- Any filtering Combinations(s) (such as 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
- All the events shall be accessible to Operator at all times. Event log exportation shall be in non-editable format.
- The deletion of the events in case of exhaustion of system capacity shall be in first in first out (FIFO) basis.
- SCADA server should be able to store events of at least 1 year. There should be a provision of warning to operator when capacity reaches 90% for storing relevant data prior to its deletion.

4.2.4. Alarm management

An Alarm is an important event that the operator needs to be informed of immediately so that prompt corrective action may be implemented to ensure the operational safety and integrity of Power Supply. High priority visual and audible warnings appear on the current operator work station and an acknowledgement request is made to ensure that the operator has received the alarm information. Alarm may result from field information changes or from processing of field information, operator and system actions. Alarms may be configured as major and minor alarms.

The EMIS system shall be able to handle various types of alarms, typically:

- Monitored alarm
- Complex alarm
- Conflicting alarm
- Control failure alarm
- Uncontrolled state change alarm

Monitored alarms: shall be directly linked with the value of a field-monitored alarm, all others shall be processed alarms.

Complex alarm: shall be the result of processing the values of one or more field events (examples: combination of monitored states, comparison of a monitored metering to a threshold).

Conflicting alarm: This apply to a processed status resulting from several distinct field monitored states. When the sources give inconsistent information (examples: power supply availability status from 2 distinct voltage relays, CB open and closed).

Control failure alarm: When performing such remote control, the EMIS system shall check the correct monitored or processed status change. If this event does not occur after a predefined time, the EMIS system shall generate a control failure alarm.

Uncontrolled state change alarm: Similarly, 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.

4.2.4.1. Alarm procedure

The purpose of the alarm procedure is to draw the operator'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.

Alarm procedures may be generated in the following cases:

- Alarm appearance
- Alarm disappearance

Alarm appearance procedure: Any change from "normal" to "alarm" value of an alarm shall be considered as an alarm appearance event and shall generate an alarm procedure.

Alarm disappearance procedure: Any change from "alarm" to "normal" value of an alarm shall be considered as an alarm disappearance.

4.2.4.2. Alarm list

Approval from the DMRC shall be required for the alarm list.

All alarm appearance events shall generate a record in the alarm list. The alarms can be removed from the Alarm List if:

- Alarm is not present any more,
- 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 not be erasable.

Alarm acknowledgement shall be logged as event.

4.2.4.3. Audible warning cancellation

The possibility of implementing an "audible warning cancellation" facility shall be provided. When an alarm procedure has been initiated, this facility shall allow the operator to stop the audible warning prior to alarm acknowledgment. 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 management of the alarm list.

Any new alarm procedure after the audible warning cancellation shall reset the audible warning.

4.2.4.4. Display of Alarms and Events

The digital input signals being monitored by various RTU shall be categorized as P0, P1, P2 categories. The method of configuration for these alarms shall be as below:

- **P0 (events)** P0 category signals are non-severe signals that need not be configured as alarms. These are to be stamped in event list only.
- **P1 (Alarms and events)** P1 category signals are non-severe signals that need not be configured as alarms. These are to be stamped in event list only
- **P2 (Alarms & Events)** P2 alarms are used for major system warnings that require acknowledgement from the operators and shall be attended so that the system can operate/function smoothly. These are to be configured as alarms and events. Audible alarms are required to be configured for this category signals.

- **P3 (Alarms & Events)** P3 alarms are used for critical alarms which if not attended timely can damage the equipment being monitored. These are to be configured as alarms & events. Audible alarms are required to be configured for this category signals.

Alarm window shall be configurable for segregation of alarms into P0, P1, P2, P3 Persisting alarm, Fleeting alarm as required by DMRC.

4.2.4.5. Group Alarm

The system shall have provision for configuration of group alarm as per user requirement.

Irrespective of common server, alarm for same signal shall be configurable to different classes for separate line as per requirement.

4.2.4.6. Alarm Management

When any alarm appears, the concerned station should flicker in red color. When operator click on the navigation link, the equipment having alarm should blink in red color for easy identification. After acknowledgement of alarm, blinking should stop.

In addition to common alarm link in the main menu, Alarm link should also be provided at each station picture to view the unacknowledged fleeting alarm and persisting alarms of that station.

4.3. Remote Control Requirements

4.3.1. Automatic / Manual control

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–Execute–Final status sequence through two-step verification.

4.3.2. Control Command Logging

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

Event shall be logged for:

- Command selection
- Command executed with user name
- 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.

The System ID from which operation is performed shall be logged in the event list.

4.3.3. Permissive for Local Operation

In order to facilitate local maintenance of the equipment and to prevent unauthorized 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.

4.3.4. Remote Control Inhibition Management – Alienation of a Power Supply Equipment

The operator at RSS 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 for equipment as well as individual signal of equipment. 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 that has carried out the blocking action shall also be logged in the Event List in the SCADA system.

4.3.5. Level of Control

The following levels of controls should be possible:

- Centralized Control from main control centre.
- Centralized Control from Backup control centre
- Local control mode from RSS control room for local equipment only.
- Local mode from the equipment

4.3.5.1. Centralized Control from Main or Backup Control Location

The control shall be possible as default design from the Main or Backup Control centre. The control shall also be possible from the Backup control centre under the following two 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 to backup control centre

The Backup Control centre shall be at Shastri Park. It shall be possible for the station operator to select Local mode and operate the equipment under both the above conditions after taking "Permission for Local Operation" from the OCC operator/TPC.

4.3.5.2. Local Control Mode from RSS Control Room for Local Equipment Only

Equipment at RSS can be operated from the local control room through Local SCADA server connected to the RTU network of RSS. Operation of the switchgears from this Local SCADA server shall be possible only if OCC/BCC has granted permission for Local Operation.

4.3.5.3. 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.

4.3.5.4. Control Transfer

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

The Levels of control shall be such that centralized control is from main control centre only. In case of failure of main control centre, control should be automatically transferred to backup control centre. In an event of failure of main as well as backup control centre, control should be transferred to LOCAL SCADA for operation of local equipment.

4.4. Tele Metering and Energy Meter Reading

The SCADA system shall display and log the analogue parameters from the SCADA system as per the IO list for SCADA. Energy values from energy meters of the RSS stations have to be hooked up to in respective Receiving substation.

4.5. Interlocking Scheme

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

- **Breaker–Isolator interlocking** – It should not be possible to operate isolator when consecutive breaker is in Close condition.
- **2/3 interlocking** for TSS incomer, RSS Incomer and AMS Incomer and LT incomer of Local supply.
- If 25kV bus is charged then 25kV incomer should not be closed.
- If 33kV bus is charged, AMS incomer should not be closed.
- Any other additional interlocking that DMRC may require needs to be configured.

If any interlocking condition is active, normally the operation of the device shall be disabled along with a clear pop-up interlocking message showing the interlocking condition but if desired,

the operation of the device shall be possible even in case of interlocked condition only through forced command operation. The event of forced command shall be logged as a forced operation.

Presence of interlocking condition shall not prevent the opening of the device in case of emergency operation. Interlocking text shall be configurable and there shall not be any limitation of text in the interlocking window.

It shall be possible to implement multiple interlocking for a particular device as per the Employer requirement and approved by DMRC.

The interlocking conditions that are not prevailing shall not be visible in the interlocking window. Operator must be able to know due to which interlock condition, operation is not possible.

4.6. Operation Aids

4.6.1. Log-on / Log-off:

Log-on

Before commencing work on a server, operator identification shall be required. Log-on window with password protection shall be provided for the purpose. After suitable display prompts the operator shall enter his name, password and validate them, system access shall be granted to the authorised sessions.

Log-off

The operator shall log off to end a working session on a workstation.

After the current operator has logged off and with no other operator logged on, no Supervisory, control, monitoring or other action on the SCADA system shall be possible from the server.

However, the above, based on system requirements, may be modified by DMRC.

4.6.2. Reports

The 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 reports. 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 support the following time-related reports:

- Hourly report (time resolution: 3 minutes)
- Daily report (time resolution: 15 and 30 minutes)
- Weekly report (time resolution: 1 day)

- Monthly report (time resolution: 1 day)
- Yearly report (time resolution: 1 month)

Printers that are connected to the servers are used for printing of reports. Automatic periodic printing of reports can be configured for the server. Printing of reports is also possible.

Format for all reports shall be as approved by DMRC.

4.6.3. Trends

SCADA shall support trends for performing time-related follow-up of process data. The trends shall be possible for both digital as well as analogue 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 variables in a single display.

The trend display shall support the following features:

- Support of graphical or tabular view modes with zooming facility
- Shall support scrolling with scroll bars and panning
- Configurable axes, line properties and legend
- Update interval options from 30 seconds to 10 minutes
- Trends for calculation formulas: minimum, maximum, direct, mean, sum and difference shall be possible
- Shall have printout option
- Depiction of Update/Frozen modes
- Facility to copy to clipboard and export to CSV and PDF file
- The Contractor shall clearly specify the uncertain condition of trend values in case of server shutdown due to any reason (such as failure/maintenance etc.).

4.7. Man-Machine Interface

The energy supervision shall be carried out by means of the Visual Control Panel.

The Visual Control Panel, which will receive the single line diagram of receiving, traction and auxiliary supply, shall be a monitoring device only. It shall reflect the drawing showing General Feeding arrangement.

4.7.1. MMI Overview

The MMI Display for Local SCADA servers are each composed of 1 or more screens managed with a single keyboard and pointing device. The keyboard/mouse is able to select different views of power equipment for monitoring purposes.

4.7.2. General Concept of the MMI Screens

The display of views, controls and the event resolution shall be possible from the same screen.

The screens shall have provision to be organized into different sections for processing the operator activity information for future requirements. There shall be no overlap between the various sections at any time that may obscure vital information.

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.

Each view shall display the necessary tools and options for the processing or management of events.

Hourly and daily programming tools, which allow the completion of automatic operations according to the option chosen by an operator, shall be provided.

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.

4.7.3. Typical MMI Screen Design

4.7.3.1. Alarm List (AL)

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.

A scrolling facility shall enable the operator to scan the list. Each alarm in the list shall be displayed with different color or shape attributes according to the alarm level and acknowledgement status.

The alarm list shall have various configurable filter facilities to enable the operator to display different formats of events. The operator shall be able to print the alarm list.

4.7.3.2. Logging List (LL)

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.

A scrolling facility shall enable the operator to scan the list.

The logging list shall have various filter configurable facilities to enable the operator to display different formats of events.

The filter keys shall typically include:

- location
- equipment group
- time period
- event category (ordinary event, minor and major alarm)
- other options

Any combination of the filter keys shall be possible.

Each event in the list shall be displayed with different color attributes according to their category.

- event class
- operator or system action

The operator shall be able to print the logging list or the filtered logging list.

4.7.3.3. View Selection

A view selection bar may be permanently displayed on each screen to allow the operator to select various available images.

Some detailed images may not be selectable from the view selection bar but be selected directly from other displays.

4.7.3.4. Graphic Display

The graphic display shall display images as requested by the operator.

4.7.3.5. Control Facilities

Equipment control may be managed by designating the equipment on the screen.

This action may open a dialogue box requiring the operator to select:

- one possible control mode for the equipment
- setting remote control inhibition on the equipment
- cancelling remote control inhibition on the equipment

After selecting the control action, the operator shall either validate or cancel the action.

If validated, the control action shall be performed.

4.7.3.6. Remote Control Inhibition Management – Alienation

Setting or cancelling remote control inhibition from this dialog box only concerns the inhibition with "EMIS controller's request" origin. All other inhibitions currently active on the same item of equipment shall remain unchanged.

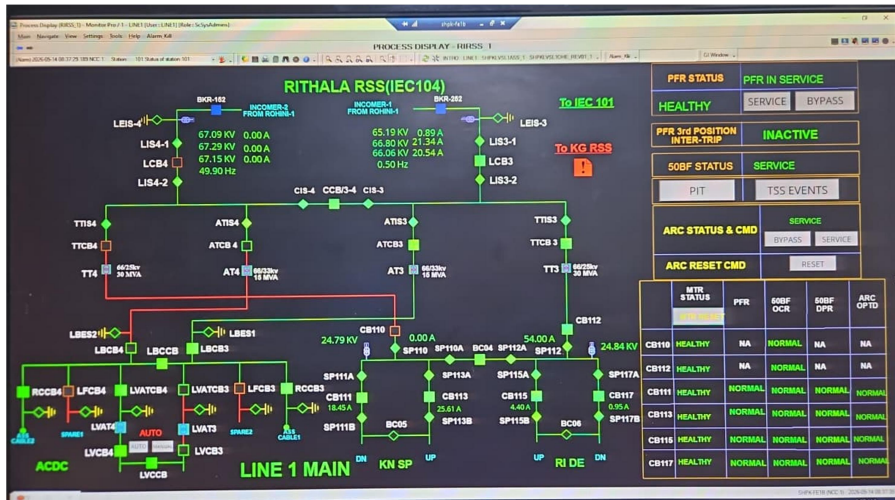
Setting remote control inhibition shall activate an inhibition with "EMIS controller's request" origin, if none of the same origin is already active. This action shall set the control status of the corresponding equipment to "remote control inhibition".

The cancellation of remote control inhibition shall deactivate the inhibition with "EMIS controller's request" origin, if currently active.

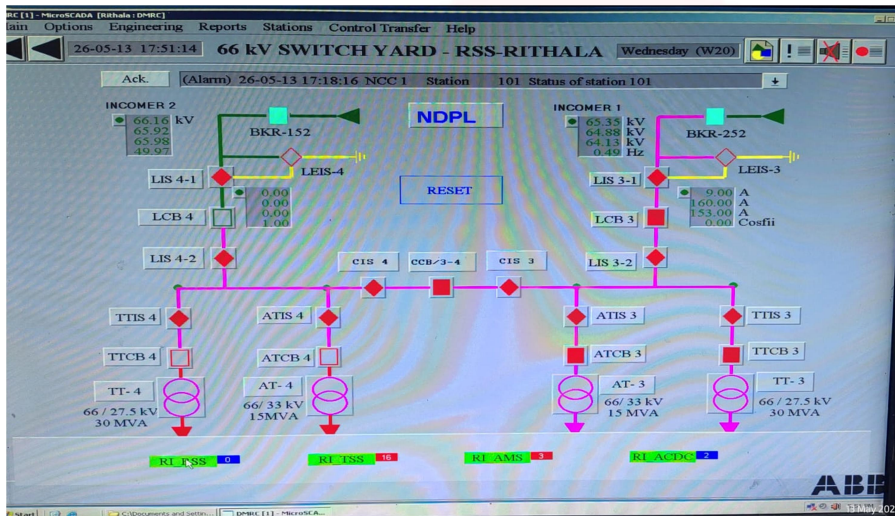
The control dialog box shall also give access to the list of all remote control inhibitions currently active on the corresponding equipment, showing the origin of the inhibition and the identification number (if relevant).

4.7.4. The Various Views of the System

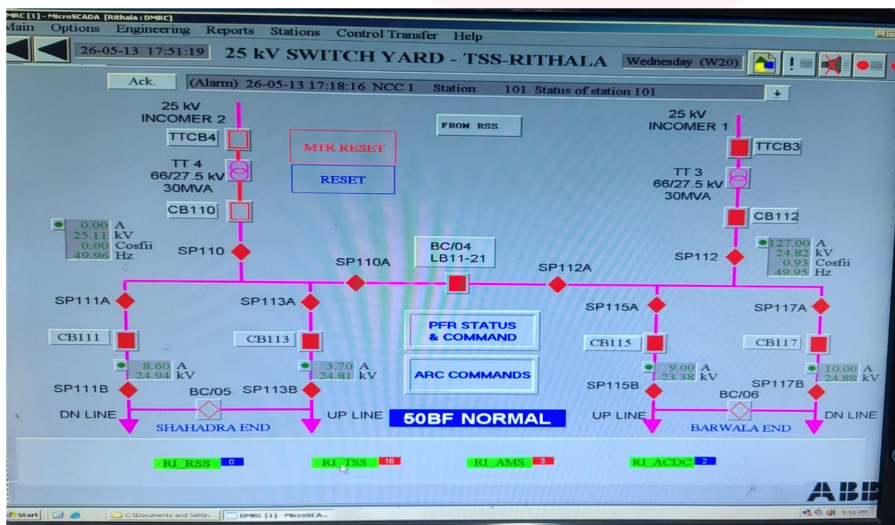
4.7.4.1. Typical Receiving Sub-station Overview



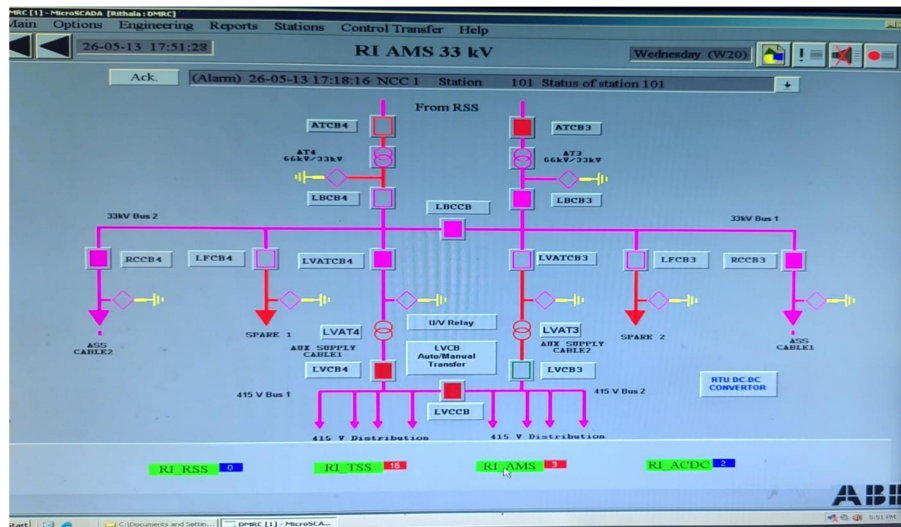
4.7.4.2. Typical Receiving Sub-station View (66kV)



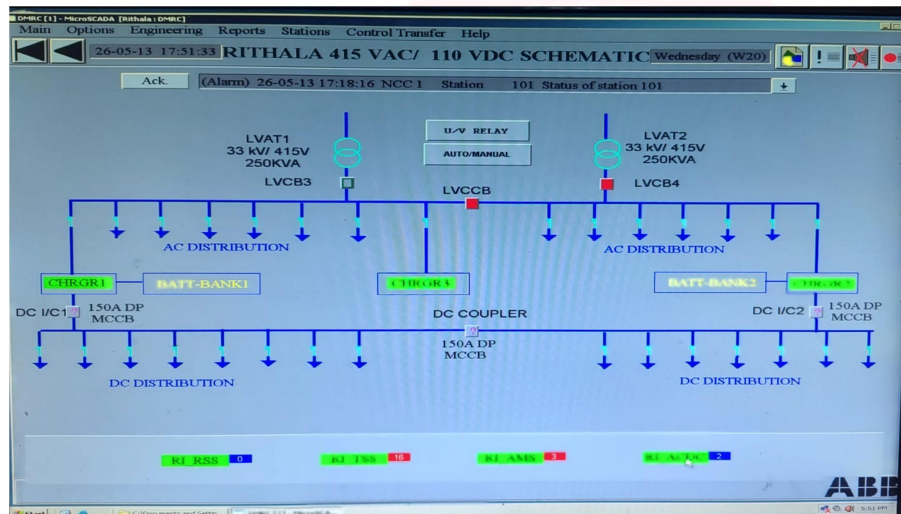
4.7.4.3. Typical Traction Sub-station View(25kV)



4.7.4.4. Typical Auxiliary Main Sub-station View(33kV)



4.7.4.5. Typical AC&DC Supply Arrangement View



4.7.4.6. Local SCADA Network Scheme and any other picture as per requirement

5. SCADA System Network

The SCADA system acquires data from the RTU installed at RSSs via data transmission network.

5.1. Data Transmission Network

It picks up data also called the Remote Monitoring on site, i.e. RSS RTUs, and brings them to RSSs Data Processing system. On the other direction, all the operator's instructions are sent to the Remote terminal units by means of Remote Controls.

5.2. Data Processing System

The RTUs at RSS will act as the data processing equipment. These RTUs acquire the process information and transmit the same to the Local SCADA Server.

5.3. Standards / Communication Protocol

In general, following reference, latest standards and specifications apply to work included in this Section or as approved by Engineer-in-charge (DMRC Engineer shall have final say on selection and switchover to any of the communication protocol without any additional license fees by the contractor):

- **EN 60529** – Specification for degrees of protection provided by enclosures (IP code)
- **EN 60950** – Information technology equipment Safety
- **IEC 60870-5-1** – Transmission Frame Formats
- **IEC 60870-5-2** – Data Link Transmission Services
- **IEC 60870-5-3** – General Structure of Application Data
- **IEC 60870-5-4** – Definition and coding of Information Elements
- **IEC 60870-5-5** – Basic Application Functions
- **IEC 60870-5-101**- Transmission protocols, Companion standard for basic telecontrol tasks using serial communication links
- **IEC 60870-5-102** – Companion standard for the transmission of integrated totals in electric power systems
- **IEC 60870-5-103** – Transmission protocols, Companion standard for the informative interface of protection equipment
- **IEC 60870-5-104** – Transmission Protocols, Network access for IEC 60870-5-101 using standard transport profiles
- **UL 1950, CSA 950** – Safety / IEC 60950
- **IEC 61850** - Substation automation communication standard using Ethernet and object-oriented data models
- Server will communicate with RTUs on IEC 60870-5-104 communication protocol.
- **Modbus protocol** may be used for energy meters.

Self-certification of above protocols/standards from the OEM is required to be submitted during vendor approval.

5.4. Synchronization Process

The SCADA servers at RSS will acquire the time synch messages from the RTU at RSS through the ports configured in the RTU.

5.5. Communications

5.5.1. LAN Network at Control Centres

The SCADA servers and RTUs at RSS will be interconnected using managed Ethernet switches on Dual LAN. In case of loss of communication of RTUS, LAN devices, an event shall be generated.

5.5.2. Performance Requirements

The performance of the system must enable the operators to operate the equipment under satisfactory conditions. More precisely, the following targets must be reached:

Transfer time

The time required to transmit the status information and alarms at the SCADA system is no more than 1 second in normal conditions and no more than 2 seconds in avalanche conditions. The sequence of events information which are mainly for analysis purpose & is stored in RTU memory can be polled at a lower priority.

6. Future Additions of Electrical Equipment

Provision should be available for addition of new equipments. In case of such additions which may be required in future, support would be required from the contractor.

7. Minimum Indicative I-O Requirements

1. Operation counter for CB/Interrupter/Isolator/Lightning Arrestor shall be configured at RSS SCADA. It shall work in case of Close/Open operations and Relay-generated tripping and shall be shown on SCADA screen.
2. Existing I/O signals to be integrated under each RSS are as mentioned below:

S. No.	Line	RSS	RTU	No. of Signals	Total Signals
1	Line-1	Rithala RSS	RI RSS	270	690
2			RI TSS	150	
3			RI AMS	150	
4			RI ACDC	120	
5		Kashmere Gate RSS	KG RSS	250	800
6			KG TSS	200	
7			KG AMS	200	
8			KG ACDC	150	
9	Line-3	Dwarka RSS	DW RSS	400	1040
10			DW TSS	300	
11			DW AMS	240	
12			DW ACDC	100	
13		Subhash Nagar RSS	SN RSS	350	900
14			SN TSS	250	
15			SN AMS	150	

S. No.	Line	RSS	RTU	No. of Signals	Total Signals
16		Indraprastha RSS	SN ACDC	150	800
17			IP RSS	350	
18			IP TSS	250	
19			IP AMS	200	

3. During Factory Acceptance Test, arrangement for testing of SCADA I/O signals shall be done to check incorporation of all I/O signals.
4. Data of all Equipment which are configured in the RSS RTUs, shall be configured in RSS Server. However, DMRC may decide the signal requirements at RSSs.
5. Monitoring and control of any other system or equipment shall be integrated in SCADA as per detailed design requirement or as approved by the Engineer-In-Charge.
6. Any logic required for operational requirement, as approved by DMRC, shall be configured and implemented at RSS.

I/O requirements in this clause are minimum but not limited to. However, DMRC may take final decision based on the requirements.

8. Expandability:

The size of the system shall be sufficient to allow the addition of new equipment to be supervised. The SCADA software shall be scalable and upgradable and pre-programmed and licensed to accommodate additional 100% of the installed capacity (RTUs and other subsystems).

9. Playback Option:

The SCADA Software shall have a feature of playback option which can be used to check the sequence of operations performed, if required. Playback function shall involve recording of data into the history and play it back, starting from some given time. It shall be possible to playback the stored data of last one week.

This permits post mortem analysis of the information that was available to the operators (and their responses). It is also useful for capturing "scenarios" for training and analysis purposes.

10. Cybersecurity

10.1. System security and access levels

- 10.1.1. A biometric authentication system shall also be incorporated. Biometric terminals shall be provided with each operator server/workstation. Whenever, a user performs login action on an operator server/workstation, in addition to username and password,

the biometrics shall also be validated from the biometric terminal connected to that operator server/workstation. Validation of both methods, i.e., password and biometrics shall allow successful login into the workstation.

- 10.1.2.** Separate logs shall be provided for the User logins in SCADA.
- 10.1.3.** There shall be different User authorization levels for the accessing logs and data.
- 10.1.4.** Implementation of Application White listing shall be considered in SCADA servers/workstations so as to prohibit the use of unauthorized software if any.
- 10.1.5.** In addition to above backup and recovery procedures shall also be well defined by SCADA vendor and purchaser shall be trained about the security threats and vulnerabilities involved in the systems.
- 10.2.** To restrict access to the SCADA system, each person accessing the system shall be required to initially log in using some form of security access code. Such access codes shall be assigned to individual persons based upon, as a minimum, the following access levels:
 - Monitoring only;
 - Monitoring and control, where the control authority is limited by the area of responsibility assigned to the operator /user.
 - Monitoring, control and access to modify certain SCADA parameters
 - Full SCADA system access
- 10.3.** It shall be possible to modify the access security features only from dedicated servers in the RSS by a systems administrator with the appropriate login privileges.
- 10.4.** The action of all log-in and log-out operations of the SCADA system, as well as any configuration changes to the system, shall be recorded by date, time and the user's security access code as an event record.
- 10.5.** Log-off-The operator shall log off to end a working session on a workstation. After the current operator has logged off and with no other operator logged on, no supervisory, control, monitoring or other action on the SCADA system shall be possible from that workstation.
- 10.6.** Individual events and alarms shall be stored and monitored separately by the SCADA system. However, the operator shall have the capability to use a group alarm feature in order to minimize alarm clutter at the display panel.

11. Training:

- 11.1.** The Contractor shall train DMRC staffs. Any other training requirement shall be specifically mentioned by Contractor. The training shall tentatively cover following aspects:
 - 11.1.1.** Training in operation of Local SCADA software and MMI display functions.
 - 11.1.2.** Training in configuration of SCADA software, changing the setting of the software, generating various reports, adding new signals/bays/RTUs.

- 11.1.3.** Formatting of hard disk loading of the operating system, loading of the basic SCADA application, software and taking backup of files.
- 11.1.4.** Operation and maintenance instructions recommended by OEMs of SCADA sub-systems.
- 11.1.5.** Specialized training of networking of Ethernet communication.



TECHNICAL SPECIFICATIONS OF RTU

1. Remote Terminal Unit (RTU)

Remote terminal units shall be intelligent, fully autonomous in operation and modular in construction and scalable up to maximum of 2000 data points. The RTU shall support distributed processing intelligence with decentralised structuring with the task of pre-processing of inputs distributed to the I/O modules. RTU's will monitor and control equipment installed at DMRC sites.

The remote terminal units shall be configured to enable logical and sequential functions to be carried out locally, without reference to the central SCADA system or any SCADA workstations.

Remote terminal units shall have flash card memory to store RTU parameterization data & up to 7 days event storage (minimum 2000 events) in the event of a SCADA communications failure. These stored events could be retrieved from RTU whenever required for analysis. Provision of Software required for retrieving is included in scope of SCADA contractor. Remote Terminal Units shall be IP-55 with proper ventilation arrangement.

Remote terminal units shall have the feature of Remote parameterization from the OCC using SCADA Workstation over the OFC Communication Network.

Remote terminal units shall have I/O Modules, redundant Power Supply unit (PSU), redundant Central Processing Unit (CPU) & redundant communications modules. In case of failure of any modules like PSU, CPU etc. PSU/CPU modules the redundant module will take care without interrupting full functionality of SCADA and Alarm of the failed module shall be generated in the OCC and stored as event in Event List. Communication module shall have the feature of adding additional communications port for future expansion.

It shall be possible to disable a remote terminal unit locally or from a SCADA workstation to allow maintenance or reconfiguring of the remote terminal unit without affecting other parts of the SCADA system. When disabled or enabled, a change of status condition shall be recorded as an event.

All recorded events shall be tagged with real time in hours, minutes, seconds and milliseconds, along with the location of the event. The data shall be stored on non-volatile read-write memory, in a first in first out (FIFO) manner, such that the data shall overwrite the earlier recorded data.

Access to stored data in any remote terminal unit for maintenance purposes shall be password protected to allow access by appropriately qualified personnel only. Portable computer based plug-in devices shall be provided to read and evaluate stored data. Such reading process shall not erase or corrupt stored data.

Space to install additional modules in racks of remote terminal unit shall also be available to cater additional 25% signals of designed capacity for future expansion.

All cards of RTU shall have following minimum requirements: -

- Operational temperature ranges from -0.6° C to 55° C,
- As per IEC 60571, all printed board assemblies shall be protected on both sides with a protective transparent coating, in order to prevent deterioration or damage due to such causes as moisture and atmospheric contaminants. The coating shall not have any adverse reaction with any other materials or components used on Delhi/NCR environmental condition
- Dry heat run test as per IEC 60571 standards.
- In addition, the details of configuration in the card, block diagram of the card and waveform signature for each card shall also be submitted by Contractor.

Software configuration of Hardwired DI/DO/AI signals in RTU should be user friendly and not to be configured through any PLC Logic or functional blocks.

The RTU shall have self-monitoring/diagnostic for fault conditions. This shall provide various details such as defective I/O cards, host lines, device status, supervision etc. The RTU support the test procedure as per standard protocols.

1.1 Central Processing Unit

The central processing unit shall have minimum 32 bit microprocessor or as approved by engineer in-charge with at least 256 MB RAM, Internal watchdog, Reset switch, internal real time clock with ≤ 50 ppm accuracy and shall have a dedicated peripheral bus controller for handling I/O functions. The CPU module shall have at least 256 MB non-volatile memory and capable to store minimum 2000 events, so that these events can be transferred to OCC even for the period of communication failure with RTU after normalizing.

The CPU module shall support the communication protocols. The CPU shall have minimum following ports for communications:

- It shall have Minimum 3 Nos Ethernet Ports for communication with different control centers

- It shall have Serial ports.
- It shall support data acquisition from energy meters on MODBUS protocol through 2 Nos. of RS485/RJ-45
- It shall have provision of communication with numerical relay on IEC 870-5-103 protocol/ IEC 61850 protocol via 2 Nos. of ports.
- It shall support for addition of COM ports for communication with OCC.

The RTU shall have one dedicated MMI port which can be used for RTU configuration purpose. Time accuracy of RTU time stamp shall be 1ms.

RTU firmware shall be capable of being configured (under password control) locally through laptop and from the OCC by using RTU maintenance software tool. SCADA Manufacturer shall furnish licensed copies of RTU firmware in CD/DVD to the DMRC.

Port level redundancy in CPU card shall be provided.

1.2 Power Supply Unit

The RTU shall be capable to operate on 48V DC (with +10% to -20% Variation). The deferent voltage levels require for operation of various cards/modules of RTU shall be provided by PSU. The design of PSU shall enable easy trouble shooting and replacement in case of failure. Alternatively, redundant power supplies shall be provided i.e. each I/O modules, CPU, line driver to operate directly on DC.

The failure of PSU may lead to total shutdown of RTU hence the design and selection of components shall be such as to achieve zero failure under extreme service conditions. In no case the required output voltage level of PSU should drop below the designed value while taking on load. Overloading by any module due to its internal failure should not cause the total failure of PSU.

The PSU shall have suitable Surge Protection device (SPD), EMI filters capable of filtering all switching surges, electrical noise and high frequency transients.

The output voltage regulation from no load to 120% of full load shall not exceed 1% of rated voltage for each class of the voltages. The ripple factor shall also be less than 1%.

The PSU shall be designed for 120% of the full load shall not exceed 1% of rated voltage. Similarly for each class of the voltages, the ripple factor shall also be less than 1%.

The PSL shall be designed for 120% of full load rating for 15 min. The PSU shall have fold back characteristics beyond this condition

The power supply should be able to withstand momentary short circuit (not longer than 20ms) and recover automatically once the short circuit condition is eliminated. Particular

output voltage level should be able to withstand overloading /short circuit condition caused by any card/module. It should keep off the particular output voltage level circuit condition and thus not leading the total failure of PSU.

The power supply unit/DC-DC convertor of RTU shall have provision of protections against voltage, overload and short circuits in addition to adequate protection against surges and lightening in compliance of IEC-61643-12, 61312 & 61024 and VDE-0100-534 as applicable.

1.3 RTU Internal Clock

The accuracy and resolution of the time stamping is very critical for analyzing the events that occurs across various stations. To achieve this, RTU shall be provided with clock with ≤ 50 ppm accuracy which shall support time synchronization from master station via periodically initiated synchronization messages of communication protocol. The SCADA system shall also initiate Time Synchronization messages when the communication with the RTU is restored after a communication failure. RTU shall be provided with dedicated back-up power for clock, which shall update the time even in case of complete failure of power supply of RTU.

1.4 I/O Module Specification :

1.4.1 Digital Input Module

The Digital input module shall have 16 optically isolated channels per modules and shall support time stamping with time resolution of 1ms. The digital input module shall support configuration of inputs for the following options:

- Single Indications
- Double Indications
- Digital Measurands

The digital input module shall support the following features:

Programmable parameters like

- Bounce Filter (Suppression Time)
- Settling time for reliable digital measured value
- Chatter suppression (for avoiding constant changes in the digital input)
- Suppression of intermediate position
- With / Without time tagging shall be a configurable feature
- Configurability of message transmission priority
- Indication processing

- Group or Common alarms shall be configurable from Individual alarms by Boolean operations
- Acquisition of events in chronological order with a time resolution of 1ms
- Buffering up to 3 changes per input

1.4.2 Analog Input Module

The Analog inputs module shall have 8 channels per module and shall support Dual Slope integration A/D conversion. The Analog module shall support the following features:

- Unipolar Measured values
- Bipolar measured Values

Programmable parameters like

- Live zero conversion coefficients
- Cyclic Transmission or threshold value
- Forced zero point conversion coefficient
- Limit Values
- Smoothing factor
- Threshold values
- Cyclic duration
- Priority of Transmission

Other parameters:

- Inputs shall be configurable for 4 to 20 mA / bipolar or live zero
- Accuracy - $\leq 0.1\%$
- Common Mode Voltage: ± 8 V DC
- Line Interference suppression: > 100 d for $f_n = 50$ or 60 Hz

1.4.3 Digital Output Module

The Digital Output module shall support 16 digital output channels per module. The output module shall support the following features.

Programmable Parameters shall include:

- Duration of Output Pulse
- Release disconnection delay time at response indications

- Select before execute
- Cyclic duration
- Priority of Transmission
- The command relays shall be provided with visual indication for relay status.

1.5 Redundancy

The RTU offered shall have duplicated CPU, communication units (provided for control center communication and Relay communication), power supply card and duplicate Powers supply system (Power Convertors). Both communications cards shall have three Ethernet ports to communicate with three Operational Control Centre. Only one set of I/O cards will be provided.

1.6 PLC Programming Facility

The RTU has to program for several logic functions which are required for the metro power supply distribution application. Hence, the RTUs offered shall support PLC programming facility as per IEC 61131-3 standards. Necessary programming tool shall be offered with license.

1.7 Environmental Conditions

The RTU hardware shall meet the following environmental requirements:

- EMC Immunity: As per IEC 60870-2-1 Level 3 or 4, As per EN 61000
- EMC Emission: As per IEC 60870-2-1 Class A
- Temperature: -10 to 55 deg C as per IEC 60870-2-2
- Humidity: 5 to 95% as per IEC 60870-2-2.
- Vibration: IEC 60068-2-6

1.8 Other Requirements for RTU

- i. RTU shall also have the capability of starting up from OCC/BCC and automatic start-up and initialization following restoration of power after an outage without need of manual intervention. All restarts shall be reported to the connected OCCs.
- ii. The RTU accuracy, for analog input measurement, shall be 99.8% or better. Mean accuracy shall drift no more than 0.002%perdegree C within the temperature range of -0.6 to 47.2 degree C.
- iii. Self-diagnostic capabilities within each RTU which can be initiated at the RTU site. The diagnostic software shall check for memory, processor, and input/output ports errors and failures of other functional areas.

- iv. A non-volatile event buffer (minimum 250 events) that shall record all fatal errors/restarts/ faults of RTU.

1.9 Cybersecurity

RTU shall have provision of RBAC (Role base access control) according to IEC 62351-8.

- 1.9.1** Provision of Proper Encryption in the field data (data from RTU) as per IEC62351 Standards as applicable.
- 1.9.2** Proper security measures and policies for handling unused communication port shall be taken.
- 1.9.3** The firmware integrity verification (digitally signed firmware) shall be carried out prior to the firmware update.
- 1.9.4** Multi-level authorization shall be implemented for the firmware update operation as patch management policy.
- 1.9.5** RTU shall communicate with white listed SCADA servers only. Requests from unauthorized systems/IP shall be rejected and logged by the RTU.
- 1.9.6** All connection requests received by the RTU shall be logged including connection acceptance and rejection.
- 1.9.7** Access to RTU via its configuration software shall be protected using username/password combination. Facility to have multiple users with different access rights shall be possible.
- 1.9.8** Access to RTU via its configuration software shall be archived and shall be stored in RTU as an event.
- 1.9.9** It shall be possible to enforce configuration software access, only after appropriate access from SCADA software.
- 1.9.10** RTU shall prevent execution of unauthorized third-party application.

Functional Test for RTU**1) Type Test**

S.N.	Description of Test	Type Test
1	Surge Immunity Test as per IEC 61000-4-5	√
2	Electrical Fast Transient Burst Test as per IEC-61000-4-4	√
3	Damped Oscillatory Wave Test as per IEC 61000-4-18	√
4	Electrostatic Discharge test as per IEC 61000-4-2	√
5	Radiated Electromagnetic Field Test as per IEC 61000-4-3	√
6	Damped Oscillatory magnetic Field Test as per IEC-61000-4-10	√
7	Power Frequency magnetic Field Test as per IEC-61000-4-8	√
8	Power frequency voltage with stand Test as per IEC 60255-27	√
9	Impulse voltage with stand Test as per IEC-60255-27	√
10	Insulation resistance test as per IEC-60255-27	√

2) FAT & SAT Test

S.N.	Description of Test	Factory Acceptance test	Site Acceptance test
1.	Check for BOQ, Technical details, Construction & Wiring as per RTU drawings	√	√
2.	Check for RTU database & configuration settings	√	√
3.	Check the operation of all Analog inputs, Status input & Control output points of RTU	√	√
4.	Check operation of all communication ports of RTU	√	√
5.	Check for communication with OCCs or simulator for RTU	√	√
6.	Test for downloading of RTU database from OCCs.	√	
7.	Test for RTU time synchronization from OCC	√	

8.	Test Power Supply Voltage Margin, Ripple Levels and Short Circuit Protection	√	
9.	Test for RTU operation with DC power supply voltage variation	√	
10.	Check for auto restoration of RTU on DC power recovery after its failure and for manual command from OCCs.	√	√
11.	Test for RTU diagnostic feature	√	
12.	Test for RTU SOE (Standing operating environment) feature	√	
13.	RTU Analog accuracy test for analog input	√	
14.	Test for IEC 60870-5 -104, 61850/IEC 60870-5-103 & Modbus protocol implemented	√	
15.	Test for RTU internal Clock stability	√	
16.	Test for RTU Noise level measurement	√	
17.	Test for Control Security and Safety for Control outputs	√	
18.	Other functional tests as per technical specification requirements	√	
19.	End to end test (between RTU & operational control centre) for all I/O points		√