



SECTION – 2.06

SUBSTATION AUTOMATION SYSTEM (SAS)

1.0.0 INTRODUCTION

This section covers the requirements of Substation Automation System (SAS) for 132 kV Substation.

2.0.0 SCOPE OF WORK

2.1.0 The scope of work shall include the following equipment:

2.2.0 The substation automation system shall be selected in a manner that it has been designed, manufactured, tested, installed, commissioned and in satisfactory operation in 132kV or higher system as per the Qualification criteria mentioned elsewhere in the specification.

2.3.0 The effects of wind, storms, floods, lightning, elevation, temperature range, contamination, pollution, earthquakes etc., shall be considered in the design and operation of the connected facilities.

2.4.0 Substation Automation System for Substation covering 132kV Substation, LT switchgears – ACDB, UPSDB, DCDB, Lighting DB, UPS, Battery Chargers, Fire Protection System with SAS, etc. EPC of Substation Automation System shall be in scope of bidder. It shall be designed for maximum safety, efficiency, reliability, cyber security and CEA / Electricity Regulatory Commission / Transmission Utility / POSOCO/ RLDC or similar competent statutory authorities' latest guidelines in India. The specification covers all technical requirement with all accessories, tools and tackles of Design, Engineering, Testing at manufacture's work, supply, packing, forwarding, transportations, insurance, delivery at site, unloading at site, installation, erection, commissioning, testing of SAS, Warranty, Training to owners' representative, support/services and integration with all IED, meters, etc.

2.5.0 All the software functionally completes to cater to all control / operation / protection/ communication with relays / data acquisition of the electrical system shall be provided along with all software licenses. The license shall be valid for the life cycle. In any case if license is required to be re-entered in the system, then license code/key generation and implementation of license in system shall be done by EPC contractor or O.E.M at no cost to Owner / GIPCL. The license shall not be hardware. In case of anti-virus software, the license shall include regular updates until the end of warranty and annual maintenance contract (AMC) period. Any defect in the software, which may arise during lifetime of the system shall be fixed at no cost to the Owner. During warranty period for any fault in entire Substation Automation System package, the fault shall be rectified within 24 hours from time of intimation given to bidder/O.E.M and system should function with all functionality at time of commissioning.

2.6.0 The Bidder shall provide training for operation, maintenance and programming of SAS and shall provide all necessary training material to Owner / GIPCL at no cost.

2.7.0 Mandatory spares

2.8.0 Furniture for all workstations and printers.

2.9.0 All equipment under this SAS shall work with redundant 110V DC power supply and redundant communication system with hot standby. Failure of communication link or power supply shall be alarmed, and event should be generated in SCADA / SAS HMI as applicable.

2.10.0 SAS and CRP panels shall be of reputed make.



- 2.11.0 SAS shall support redundant OFC communication from CRP panel to Control room server panel. Communication between BCU and Ethernet switch shall be redundant OFC communication. OFC communication shall be fault tolerant ring architecture. The SAS shall contain following main functional parts:
- Bay control Intelligent Electronic Device (IED) for control and monitoring
 - Station Human Machine Interface (HMI)
 - Redundant managed Ethernet Local Area Network (LAN) Communication infrastructure with hot stand by Gateway for remote supervisory control to remote control via industrial grade hardware through IEC60870-5-104 protocol.
- 2.12.0 SAS shall be designed such that it all equipment shall be controlled and monitored from local and remote-control center (Regulatory and GIPCL control room). The communication gateway shall facilitate the information flow with remote control centers.
- 2.13.0 Peripheral equipment like printers, display units, keyboards, Mouse etc. It shall enable local station control via a PC by means of human machine interface (HMI) and control software package, which shall contain an extensive range of supervisory control and data acquisition (SCADA) functions. It shall include communication gateway, intelligent electronic devices (IED) for bay control and inter IED communication infrastructure.
- 2.14.0 The communication gateway shall facilitate the information flow with remote control center. The bay IED for protection and control shall provide the direct connection to the switchgear without the need of interposing components and performance control, protection and monitoring functions.
- 2.15.0 SAS shall be designed to be immune against Electromagnetic Interference (EMI).
- 2.16.0 The technical details, designs, drawings, write up are minimum requirements, bidder to understand the system completely and shall be bound to supply, commission the additional items or, services required for complete satisfactorily as EPC and operation of SAS within their quoted price.
- 2.17.0 Communication equipment installed shall be interoperable, so as to allow seamless integration between different vendors.
- 2.18.0 Communication equipment for all the nodes shall be provided with at least Two hours battery backup and extended backup shall be provided depending upon the requirement.

3.0.0 CODES AND STANDARDS

The equipment to be furnished under this specification shall be in accordance with the applicable section of the latest version of the relevant IS / IEC / ANSI standards including amendments, if any, except where modified and / or supplemented by this specification. Some of the applicable standards are listed below:

IEC 61850	Communication network and systems in substations
IEC 60359	Expression of the performance of electrical & electronic measuring equipment
IEC 60447	Basic and safety principles for man machine interface (MMI) – Actuating principles
ANSI C37.2	Manual and automatic station control, supervisory and associated telemetering equipment



IEC 61000-4-5/ IEC 62305	Communication system lightning and electrical surge protection
IEEE-1100 / IEEE-80/ IS: 3043	Earthing of communication system/equipment
IEEE 802.3 / IEEE 802.3u	Ethernet (Interface with electrical system)
IEEE 802.1 P/Q	Ethernet (VLAN)
ITU-T G.957, G.958	Optical Interface
IEEE C37.94	Standard for N times 64 kbps Optical Fiber Interfaces between Teleprotection and Multiplexer Equipment
ITU-T G.703	Physical/electrical characteristics of hierarchical digital interfaces
ITU P.1010	VoIP
ITU-T G.821/G.826	SDH
RFC 2702, RFC 4379, RFC 4090 & RFC 4553 Circuit Emulation	IP - Packet Switched Networks (Layer 2.5 OSI)
IEEE 802.11s, IEEE 802.15.4, ETSI EN 300 220-1, ETSI EN 300 440	RF
MD5 Authentication, 3.SNMPv3, Radius/TACS+	Cyber Security
H.323	Video
G.8110,8112,8113.1,8113.2,8121, 8121.1,8121.2,8131,8151,8152	MPLS-TP
IEC 60870-5-104	Real time status of switchyard and other accessories in the sub station

4.0.0 GENERAL REQUIREMENTS

- 4.1.0 The systems shall be state-of-the art suitable for operation under electrical environment present in Extra High Voltage (EHV) substations, shall follow the latest engineering practice, ensure long-term compatibility requirements and continuity of equipment supply and the safety of the operating staff of Owner / GIPCL.
- 4.2.0 SAS system shall be capable of transmitting all operational data as required by appropriate control center.
- 4.3.0 The design shall provide high reliability by ensuring high mean time between failures (MTBF) and low mean time to repair (MTTR). The availability shall be more than 99.95% per year. The formula for availability is: $\text{Availability} = (1 - (\text{MTTR}/\text{MTBF})) \times 100\%$. The guaranteed annual system availability shall be not less than 99.95% percent. To ensure availability, adequate redundancy in system design shall be provided at hardware and software level.



- 4.4.0 Bidder shall be responsible for planning, design, implementation, secured operation and maintenance of SAS communication infrastructure to be interfaced with the communication system.
- 4.5.0 Protection against lightning and electric surge shall be provided as per International Electro-Technical Commission (IEC) 61000-4-5 and compliant to relevant parts of IS/IEC 62305, as per the applicability.
- 4.6.0 Earth connection of communication equipment (indoor and outdoor) shall be done in accordance with the norms of the IEEE-1100, IEEE-80 or IS: 3043.
- 4.7.0 The resistibility of communication equipment installed against over voltage and over current shall be as per ITU-T K 20 recommendations.
- 4.8.0 All users and control centers connected to the communication system shall have robust programs in place to adequately and continuously manage cyber security risks that could have adversely impact power system communications infrastructure.
- 4.9.0 The cyber security program shall address the following:
Cyber Security Compliance

The SAS / SCADA system for the GIPCL – Gujarat Project shall be designed, supplied, installed, tested, and commissioned in compliance with applicable cyber-security guidelines and regulations issued by statutory and regulatory authorities, including but not limited to the following:

- CEA Cyber Security in Power Sector Guidelines (latest revision)
- Applicable provisions of the Indian Electricity Grid Code (IEGC)
- CERT-In cyber-security advisories, directions, and notifications, as applicable
- Relevant IEC / ISO cyber-security standards, such as IEC 62443 and ISO/IEC 27001, wherever applicable to the scope of the system

The system architecture shall incorporate appropriate cyber-security controls, including but not limited to:

- Network segmentation and zoning
- Role-based access control
- Secure authentication mechanisms
- System logging and event monitoring
- Patch and vulnerability management
- Secure local and remote access mechanisms

Method of Certification / Compliance Declaration

Compliance with the above cyber-security requirements shall be demonstrated through one or more of the following methods, as applicable to the supplied system and as required by GIPCL:

1) OEM / System Integrator Self-Certification

The OEM and/or System Integrator shall submit a formal self-certification declaring compliance with the applicable cyber-security guidelines, standards, and best practices.



- 2) **Third-Party Certification / Assessment (Where Applicable)**
Where specified by GIPCL or mandated by applicable regulations, certification or assessment reports from recognized and accredited agencies (such as ISO/IEC 27001 or IEC 62443 certification bodies) shall be provided.
- 3) **Cyber-Security Audit and Compliance Report**
A cyber-security audit and compliance report covering system architecture, network design, access control, incident handling, patch management, and system hardening shall be submitted prior to commissioning or as required by GIPCL.
- 4) **Authority-Specific Submissions**
Any cyber-security compliance documentation, declarations, or data required by statutory or regulatory authorities applicable to the GIPCL – Gujarat Project shall be submitted by the Contractor, including but not limited to:
 - Central Electricity Authority (CEA)
 - Gujarat Energy Transmission Corporation Limited (GETCO)
 - Gujarat State Load Dispatch Centre (SLDC)

However, if regulatory requirements or grid connectivity change in future, the Contractor shall comply with the applicable authority requirements accordingly.

Final Acceptance

Final acceptance of the SAS / SCADA system by GIPCL shall be subject to submission and approval of the applicable cyber-security compliance documents and certifications, in accordance with project requirements and prevailing regulations.

- a) All systems, equipment, communication networks, and control architecture shall comply with the provisions of the Information Technology Act, 2000, and the National Cyber Security Policy, 2013, as amended from time to time. The design shall also fully adhere to the Central Electricity Authority (Cyber Security in Power Sector) Guidelines, 2021, and the latest Central Electricity Authority (Cyber Security in Power Sector) Regulations, including the forthcoming 2025 Regulations coming into force on April 6, 2026. These requirements ensure protection of critical infrastructure, secure data handling, implementation of security controls, OT-IT segregation, cyber-incident response mechanisms, and adherence to Trusted Telecom procurement norms for all IT equipment used in the power sector.
- b) Implementation of the National Critical Information Infrastructure Protection Centre (NCIIPC) Guidelines.
- c) Implementation of guidelines and advisories issued by Computer Emergency Response Team (CERT India) and applicable Sectoral Computer Emergency Response Team (CERT).
- d) Compliance to the Central Electricity Authority (Cyber Security) Regulations, as and when they come into force.
- e) The architecture for control system shall be designed with security such that it is important that the selection process ensures that the level of protection is commensurate with the business risk and the system security shall not rely on one single security measure for its defense. (*Reference IEC/TR62351-10 Edition 1.0 2012-10 Power systems management and associated information exchange – Data and communications security – Part 10: Security architecture guidelines*).



- f) There is hard isolation of OT (Operational Technology) system from any internet facing IT system.
- g) .
- h) internet/broadband shall be used. Communication channel security configuration shall be done.
- i) Downloading/Uploading of any data/information from internet facing IT system shall be done only through an identifiable whitelisted device followed by scanning of both for any vulnerability/malware as per the SOP laid down by GIPCL/Owner IT policy team. And for all such activities digital logs shall be maintained and retained, under the custody of GIPCL/Owner IT team, for at least 6 months. The log shall be readily available to carry out any forensic analysis, if requested by law enforcing/ investigation agency.
- j) List of whitelisted IP addresses for each firewall shall be provided, and each firewall shall be configured for allowing communication with the whitelisted IP addresses only.
- k) Bidder shall leverage state-of-the-art cyber security technologies and relevant processes at multiple layers to mitigate the cyber securities risks.
- l) The bidder shall identify and document the Electronic Security Perimeter(s) and all Access Points to the perimeter(s) as per IEC 62443 / IS16335 (as amended from time to time).
- m) Bidder shall ensure that every Critical System resides within an Electronic Security Perimeter.
- n) Bidder shall perform a cyber-Vulnerability Assessment of each electronic Access Points to the Electronic Security Perimeter(s). Bidder shall ensure that all vulnerabilities identified as a result of cyber-Vulnerability Assessment shall be closed. If a Cyber Asset is found vulnerable to any exploits or upon any patch updates or major configuration changes, then further Penetration Testing may be carried out offline or in a suitably configured laboratory testbed to determine other vulnerabilities that may have not been identified so far. Bidder shall submit the report to Owner.
- o) System supplied by bidder shall be provided with Intrusion Detection feature and Intrusion Prevention facility, capable of identifying behavioral anomaly in both IT as well as OT Systems. Bidder shall share reports on incident response and targeted malware samples Owner.
- p) All Firmware/Software with digital sign of O.E.M shall only be updated in the system.
- q) The system shall have 6 (six) month firewall log. Firewall log shall be analyzed and all critical high severity comments shall be closed immediately.
- r) System shall maintain all cyber logs and cyber forensic records of any incident at least 90 days from the date of the commissioning of the system/recovery from any incident, whichever is later.
- s) Bidder shall ensure that all the Communicable Intelligent Equipment and the Service Level Agreements (SLAs) for their Critical Systems shall be sourced from the list of the "Trusted Sources" as and when drawn by MoP/CEA.
- t) Bidder shall ensure that, in case, for any Communicable Intelligent Devices, if no Trusted Source has been identified, then it shall have compliance with the provisions made in MoP order dated 2.7.2020 and any other relevant MoP order has got the product cyber



tested for any kind of embedded malware/Trojan/cyber threat and for adherence to Indian Standards at the designated lab.

- u) Bidder shall ensure that all Cyber Assets being procured shall conform to the type tests as mentioned in the specification for type testing listed in the bid document. Type test reports of tests conducted in NABL accredited Labs or internationally accredited labs (with in last 5 years from the date of bid opening) shall be mandated to be submitted along with bid. In case the submitted Type Test reports are not as per specification, the re-tests shall be conducted without any cost implication to the Owner.
- v) Bidder shall ensure that all Critical Systems designed with Open-Source Software are adequately cyber secured.
- w) FAT, SAT must include comprehensive cyber security tests of the communicable component/equipment/system to be delivered/delivered at site. Bidder shall ensure that the essential cyber security tests are carried out successfully during FAT and SAT. The equipment/System besides functionality shall also be tested in the factory for vulnerabilities, design flaws, parts being counterfeit or tainted, so as to minimize problems during on-site testing and installation.

4.10.0 The Responsible Entity shall ensure that Cyber Security training program designed for Owner must include following topics and as per their functional requirements and security concerns additional topics shall be added:

- 1) User authentication and authorization.
- 2) Cyber Security and Protection mechanisms of IT/OT/ICS Systems.
- 3) Introduction to various standards i.e. ISO/IEC:15408, ISO/IEC:24748-1, ISO: 27001, ISO: 27002, ISO 27019, IS 16335, IEC/ISO:62443.
- 5) Training on implementation of ISO/IEC 27001 and awareness on IEC 62443.
- 6) Vulnerability Assessment in the Critical System.
- 7) Monitoring and preserving of electronic logs of access of Critical Assets.
- 8) Detecting cyber-attacks on SCADA and ICS systems
- 9) The handling of Critical System during cyber crisis.
- 10) Action plans and procedures to recover or re-establish normal functioning of
- 11) Critical Assets and access thereto following a Cyber Security Incident.
- 12) Hands on SCADA operation at any of the Regional Load Dispatch Centre.
- 13) Handling of risks involved in the procurement of COTS Products.

4.11.0 SAS data access and data retention shall be as mentioned below:

- a) Confidentiality of data and information of the power system shall be maintained.
- b) Protecting data and information from unauthorized, incorrect or accidental access, use, modification, destruction or disclosure shall be the responsibility and obligation of the concerned user and control center.
- c) Communication system access shall be designed, developed, built, configured and maintained in such a way that only authorized person has access.
- d) Bidder shall keep evidence of compliance on availability for the previous two calendar years plus the current year for all the interfaces which are in operation.
- e) Historical data of ninety (90) days shall be kept.



4.12.0 SAS shall be used for automation of local operations, data collection, evaluation and forwarding data on power system status and substation condition for display and storage. SAS shall be provided covering the following systems/equipment:

- 132 kV Substation
- 132/11kV Power Transformers
- Station Service Transformers
- 11 kV Switchgears
- LV Auxiliary system

The bidder shall refer to the project Single Line Diagram and SAS architecture drawing attached as annexures to the tender specification for detailed SAS requirements.

4.13.0 Any system (Hardware and Software) considered under this turnkey package for fulfilling the functional requirement of the SAS shall be from the same OEM. No Hardware and Software shall be manufactured, delivered, customized exclusively for this Project/Contract.

4.14.0 The offered SAS shall support remote control and monitoring from Remote Control center via gateways.

4.15.0 The SAS shall comprise full station and bay control (CRP Panel), monitoring and communication functions and shall provide all functions required for the safe and reliable operation of the substation. SAS shall be based on a decentralized architecture and on a concept of bay oriented, distributed intelligence. The SAS shall conform to IEC 61850 standards. The SAS layout shall be structured in station level and bay level.

4.16.0 The SAS shall be state-of-the-art and shall follow the latest engineering practice. It shall be scalable modular system. It shall ensure long term compatibility requirements and continuity of equipment supply and safety of the operating staff. Bidder shall guarantee hardware and software support for 15 years to guard against obsolescence.

4.17.0 The SAS architecture shall be flexible to allow for future extension of Substation bays. During such extension, normal operation of the existing Substation shall be unaffected, and system shall not require a shutdown.

4.18.0 The SAS shall be designed so that the failure of any single component, processor, Power Supply, Communication link, or device shall not render the system unavailable.

4.19.0 Self-monitoring of single components, modules and communication shall be incorporated to increase the availability and the reliability of the equipment and minimize maintenance, and any failures shall be alarmed to the operator. Online testing routines for various subsystems shall be provided. All the modules shall be hot swappable.

4.20.0 Bidder shall offer the BCU (a bay comprises of on circuit breaker and associated disconnectors, earth switches and instrument transformers), bay mimic along with relay and protection panels and SAS HMI housed in air-conditioned substation CRP & SAS panel room suitably located in 132kV Substation control room for overall optimization in respect of cabling and control room building.

4.21.0 System self-supervision shall be used for supervising and monitoring the system. It shall provide status information of hardware and software, as well as picture functions for the supervision of system objects.

4.22.0 All software versions shall be the latest official releases as on the day of shipment from works and shall include all software updates released up to that date. The Vendor shall inform the Owner about software updates / new releases that would be taking place after the system is commissioned.



- 4.23.0 The offered SAS system concept shall be adaptable to various system requirements depending on the actual Substation, size, voltage levels, importance and configuration complexity.
- 4.24.0 Maintenance, modification or extension of components shall not cause a shut-off of the whole SAS system.
- 4.25.0 The SAS shall be designed so that personnel without any background in micro-processor-based technology shall be able to operate it easily after they have been provided with some basic training.
- 4.26.0 The detailed design of the SAS to meet the requirements of this specification is within the manufacturer's and bidder's responsibility but subject to approval by the Owner.
- 4.27.0 Redundant power supply shall be provided for SAS. Power for the SAS shall be derived from Substation 48/110V DC system. 240V uninterrupted power supply (UPS) for human machine interface (HMI) and its peripheral devices e.g. printer etc. shall be derived from UPS system.
- 4.28.0 Finalization of Functional Design Specifications, Substation-wise Automation System Architecture, GTP, I/O List, Schematic Diagrams of Panel, Cable Requirement, Auxiliary Power System requirement shall be in scope of EPC contractor subject to approval from GIPCL / Owner.
- 4.29.0 Layout for installation of Panels, Cable route etc. shall be prepared by bidder / EPC contractor and finalization of the same shall be based on requirement & approval of Owner / GIPCL.
- 4.30.0 Appropriate IP class shall be considered for all the equipment planned to be installed in open space. For indoor application bidder shall consider panel enclosure with IP55, for outdoor application bidder shall consider IP65 or, better (IP-66/67) as per the site requirement.
- 4.31.0 All Indoor equipment, panels and cabinets shall be pre-treated as per IS 6005 before being factory-painted with epoxy-based paint shade of paint shall be RAL 7035. Corrosivity grade C4 as per ISO 12944 shall be considered for equipment. Painting shall be carried out by approved process. Enough touch-up paint shall be furnished for application at site.

5.0.0 Control Aspects

- 5.1.0 The entire substation shall be controlled and supervised from SAS. Operation of any equipment can be typically initiated from various control levels. However, clear control priorities shall prevent initiation of operation from more than one control level. The priority shall always on the lowest enabled control level.
- 5.2.0 All transducer, actuator and other field devices shall be terminated in it. Local Control Panel shall be hardwired with BCU (Bay Control Unit) panel. BCU shall be connected to HMI/Server in Control room. There shall be emergency trip button for circuit breaker on Local Control Panel. The bay level intelligent electronic devices (IED) for protection and control shall provide the direct connection without the need of interposing components and perform control, protection, and monitoring functions.
- 5.3.0 For circuit breaker, local operation shall be carried out from CB operating box, for which local / remote selector switch located in the CB operating box shall be selected in 'local'. This operation is envisaged only for maintenance and testing of circuit breaker.
- 5.4.0 For isolators, local operation shall be carried out from isolator operating box, for which local / remote selector switch located in the isolator operating box shall be selected in 'local'. This operation is envisaged only for maintenance and testing of isolator.
- 5.5.0



5.6.0 For earth switches both electrical and manual operation from field is envisaged. Electrical operation shall be performed from Local control panel.

5.7.0

5.8.0 Synchronizing of line feeders and transformer feeders shall be carried out from SAS. Live line / dead bus and deadline / live bus closing facility shall be provided. The closing schemes of the CB shall be wired in such a way that only one CB is selected at a time for synchronizing.

6.0.0 Disturbance Recorder

6.1.0 Disturbance recorder shall record analogue values of currents and voltages as well as open / closed positions of relay contacts and breakers during system disturbances. The disturbance recorder shall comprise of distributed individual acquisition units, one for each feeder and an evaluation unit common for the whole Substation. The acquisition units shall acquire the disturbance data for the pre-fault, fault and post-fault periods and transfer them to the evaluation unit automatically. Necessary hardware and software shall be supplied for the on-line transfer of data from acquisition unit to the evaluation unit. The acquisition units shall have the following features: This is the minimum feature, however during detailed Engineering if more feature or functionality is required the same shall be complied by bidder at no cost to Owner.

- Microprocessor based
- Minimum number of analogue channels – 8
- Minimum number of digital channels – 16
- Minimum pre-fault memory >200ms
- Minimum post-fault memory >2s
- Storage of up to 100 disturbance records in non-volatile memory
- Event resolution of 1ms or less
- Time display
- Data output in COMTRADE format (IEEE standard – common format for transient data exchange)
- Communication through IEC 61850 standard protocol
- Software for transferring the data automatically from local evaluation unit to a remote station and receiving the same at remote station through OPGW / leased line / wireless.

6.2.0 The evaluation unit shall consist of the latest desktop PC including a large high resolution color monitor, mouse, keyboard and high-speed color printer. Evaluation software for the analysis and evaluation of recorded data shall be provided and shall be run on the operating platform of the PC.

6.3.0 The disturbance recorder shall have stable software, reliable hardware, simplicity of maintenance and immunity from the effects of the hostile environment of 132 kV Substation prone to numerous interference signals.

6.4.0 In case of failure of AC supply, the evaluation unit and printer shall be automatically switched to DC supply through an inverter of adequate capacity which shall form a part of the disturbance recorder system.

7.0.0 Time Synchronization Equipment (Simple Network Time protocol)



- 7.1.0 The time synchronization equipment shall receive the co-coordinated universal time (UTC) transmitted through global positioning system (GPS) and synchronize equipment to the Indian standards time in a substation.
- 7.2.0 Time synchronization equipment shall include antenna, special cables, processing equipment etc. It shall be compatible for synchronization of event loggers, disturbance recorders and SAS at a substation through individual port or through ethernet realized through optic fiber bus. The synchronization equipment shall have 2 microsecond accuracy. It shall also have redundant communication system.
- 7.3.0 Time synchronization equipment shall be suitable for redundant power supply of 110V DC supply available at substation. Equipment shall have real time digital display in hour, minute, second (24-hour mode) and have a separate time display unit to be mounted on the top of control panels having display size of approximately. 100mm height. The equipment offered shall have minimum six (6) output ports of various combinations.

8.0.0 Gateway

- 8.1.0 Gateway shall be scalable, and secure solution with Next Generation Firewall (NGFW) capabilities, protects against cyber threats. Security-Driven Networking approach provides tight integration of the network to the new generation of security. Shall have the redundant power supply for critical networks

9.0.0 Communication Interface

The SAS shall have minimum Four (04) ports for RLDC, however the quantity & type shall be finalized during detail engineering based on the requirements.

10.0.0 Communication Protocol

The communication protocol for gateway to RLDC / CTU GSS must be open protocol and shall support IEC 60870-5-101, 60870-5-104 and IEC 61850 for all levels of communication for SAS such as Bay to station HMI, gateway to remote station etc.

11.0.0 SYSTEM REQUIREMENTS

- 11.1.0 The control hierarchy level shall be as follows:

Level 0 : Substation equipment
Level 1 : Bay control unit
Level 2 : SAS
Level 3 : Client's Remote Monitoring

- 11.2.0 Proposed SAS configuration diagram is attached with this specification.
- 11.3.0 At substation level, the entire substation shall be controlled and supervised from the SAS HMI. At bay level, the IEDs shall provide all bay level functions like control, monitoring etc. Each bay control IED shall be independent of the others, and its functioning is not affected by any fault occurring in any of the other bay control units of the station. The main process information of the substation shall be stored in distributed database.
- 11.4.0 It shall be possible to control and monitor the bay from the bay level equipment, whenever required. The decentralized architecture shall ensure that station-wide interlocking is available even when the station computer fails.



- 11.5.0 The operation of each equipment shall depend on the status of other functions like interlocking, synchro check etc., as applicable. Operation logics, interlock, protection etc. shall be submitted by bidder during detailed Engineering to Owner / GIPCL for approval.
- 11.6.0 The data exchange among bay level IEDs, and between bay level and station level take place via the redundant dual fiber optic inter-bay bus according to IEC 61850-8-1 standard. Optical system details shall be submitted by bidder during detailed Engineering to Owner / GIPCL for approval.
- 11.7.0 One Ethernet switch is provided for each bay. The connection from each IED to the switch is by a dual fiber optic link. Ethernet switch shall be powered by redundant DC power supply.
- 11.8.0 The ethernet switches shall be connected in a dual redundant fault tolerant ring.
- 11.9.0 The connections from the bay level to the process shall be hardwired.
- 11.10.0 Bidder shall submit the comprehensive functions (Logical nodes, or LN, as defined in IEC 61850) for Substation bays. The owner shall review the function and will add additional function if required. Bidder shall comply without any cost implication to Owner. The following minimum functions (logical nodes, or LN, as defined in IEC 61850) shall be required for Substation bays:
- Synchronizing and energizing check
 - Trip circuit supervision
 - Fault locator
 - Disturbance recording, bay level acquisition, with 8 analog and 16 digital
 - Sequential event recorder with time resolution of 1ms
 - Breaker and isolator control
 - Bay level and inter-bay interlocks
 - Measurement of voltages, currents, active and reactive power
 - Local HMI (on the BCU)
 - Transformer protection and control
- 11.11.0 All intra-bay interlocks are software based and performed by the BCU. The complete bay can be monitored and controlled from the local HMI on the BCU.
- 11.12.0 Bidder shall submit the comprehensive functions (Logical nodes, or LN, as defined in IEC 61850) for station level. The owner shall review the function and will add additional function if required. Bidder shall comply without any cost implication to Owner. The following minimum functions (LN, as defined in IEC 61850) shall be required at station level:
- Operator interface (HMI)
 - Archiving (IARC) for long term historical data
 - Disturbance data evaluation (RDRS)
 - Time master (STIM)
 - System supervision (SSYS)
- 11.13.0 Substation level HMI shall include graphic screens, special user functions such as station single line diagram, system wise single line diagram for each system (132kV, 11kV, 415V LV System, DC system, UPS system etc.) overviews, control of circuit breakers and isolators, alarm lists and event lists, logging of historical data for trends and reports. 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.

11.14.0 The system shall be controlled with the help of a mouse and keyboard.. All alarm and event logs shall be printed out on the dot matrix printer. The reports and graphics will be printed on the color laser printer. 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.

11.15.0 The main features of the managed Ethernet Switches shall include as mentioned below, these are minimum features, if during Engineering design addition features is required it shall be provided by bidder at no extra cost to Owner:

- High speed (100 Mbps) operation
- Glass fiber optic cables with MTRJ connectors
- Dual redundant power supplies for increased network availability
- Designed for harsh environment (IEC 61850-3 requirements for use in electrical substations)
- Operates up to a temperature of 85°C without the use of fans
- Full compliance with IEEE 802.3 and IEEE 802.3u Ethernet standards for universal interoperability
- Enhanced rapid spanning tree (IEEE 802.1w) for fault tolerance with fast recovery times (<5ms)
- Virtual LAN (IEEE 802.1Q) for traffic segregation
- SNMP for network management
- SNTP for time synchronization of the Ethernet switches
- Dual redundant Communication card and Communication link

11.16.0 The GPS receiver shall be connected to the Ethernet LAN and it shall synchronize all the IEDs, the redundant HMIs and the remote communication gateways directly. In conformance with the IEC 61850 standards, SNTP protocol shall be used for time synchronization function.

11.17.0 A desktop PC running Windows operating system (latest version) along with the disturbance evaluation software shall be provided as the DR workstation. The application server shall automatically download the DR data from the IEDs. The downloading of DR data can also be done manually on operator's request. The operator or protection engineer can access these DR files and analyze them using the DR evaluation software. The disturbance waveforms shall be printed on the color laser printer.

12.0.0 FUNCTIONAL REQUIREMENTS

12.1.0 It shall be possible to operate the Substation equipment subject to interlocking, synchronization etc. from the following:

- Station HMI located in Substation control room
- Bay control unit for 132kV AIS Bays
- Local operations with MIMIC of 132kV AIS Bays, 11kV Switchgear, LT auxiliary System



The functional aspects are described below:

- 12.2.0 For security reasons, the command is always to be given in two stages: selection of the object and command operation under all modes of operation except emergency operation. Final execution shall take place only when selection and command are activated. After the "execution" of the command the operated switching symbol shall flash until the switch has reached its new position. The operator shall be in a position to execute a command only, if the switch is not blocked and if no interlocking condition is going to be violated. The interlocking statements shall be checked by the interlocking scheme implemented at bay and station level. After command execution the operator shall receive 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.
- 12.3.0 Software interlocking shall be provided to ensure that inadvertent incorrect operation of equipment causing damage and accidents in case of false operation does not take place. In addition to software interlocking, hardwired interlocking is to be provided for bus earth switch interlocking and transfer bus interlocking (if applicable). An override function shall be provided which can be enabled to bypass the interlocking function via a key / password.
- 12.4.0 Configurable command execution timer must be available for each control level. If the control action is not completed within a specified time, the command shall get cancelled.
- 12.5.0 The SAS system shall be comprehensively self-monitored such that faults are immediately indicated to the operator, possibly before they develop into serious situations. Such faults are recorded as faulty status in a system supervision display. This display cover the status of the entire substation including all switchgear, IEDs, communication infrastructure and remote communication links, and printers at the station level, etc. Continuous self-supervision function with self-diagnostic feature shall be included.
- 12.6.0 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.
- 12.7.0 Functional requirements shall be divided into (a) bay level functions and (b) system level functions.
- 12.8.0 Bay level functions are subdivided further into bay control functions and bay protection functions. Separate IEDs shall be provided for bay control function and bay protection function. IED's shall be connected to the communication infrastructure for data sharing and meeting real time communication requirements for automatic functions. The data presentation and the configuration of the various IEDs shall be compatible with the overall system communication and data exchange requirements.
- 12.9.0 Bay control shall have the following functions as a minimum. During Engineering design if additional functions are required it shall be provided by bidder at no extra cost to Owner:
- Control mode selection (bay level operation / emergency operation / remote operation)
 - Select before execute
 - Command supervision for interlocking / blocking and double command
 - Synchronizing and energizing check (i) with settable voltage, phase angle and frequency difference (ii) for deadline / live bus and live line / dead bus conditions and (iii) for live line / live bus condition with synchro check function.



- Automatic selection of correct voltages for synchronizing and energizing through auxiliary switches of circuit breakers, isolators and earth switches
- Run time command cancellation
- Raise and lower operation of OLTC for power transformer bays
- Operation counters for circuit breakers and pumps
- Operating pressure supervision through digital contacts
- Breaker position indication per phase
- Alarm annunciation
- Measurement display
- Local HMI
- Interface to station HMI
- Data storage for minimum 200 events
- Facilities for future expansion with additional I/O's, fiber optic communication etc.

12.10.0 The bay protection functions, independent of bay control functions, shall be provided separately by numerical relays and other protection devices as described in section on Relay Panel.

12.11.0 Analogue inputs for voltage and current measurements shall be connected directly to VTs and CTs without intermediate transducers. Values of active power, reactive power, frequency and RMS values of voltage and current shall be calculated in the bay control unit.

13.0.0 System Local Functions

13.1.0 The positions of circuit breaker, isolator, earth switch, transformer tap change etc. shall be supervised continuously. Every change of position shall be immediately displayed in the SLD on the station HMI screen, recorded in the event list. Alarms shall be initiated in case of spontaneous changes in position.

The equipment positions shall be indicated by two auxiliary switches; one normally closed and one normally open. An alarm shall be initiated if these position indications are inconsistent or indicate an excessive running time of the operating mechanism to change position.

The Substation auxiliaries shall be controlled and their status monitored by the SAS through a separate common BCU.

13.2.0 The analog values acquired / calculated by BCU shall be displayed in the station HMI as well as remote HMI. These values shall be updated every 1 second but shall be finalized during detailed engineering. Threshold limit values shall be selectable for alarm indications.

13.3.0 Events and alarms generated by the switchgear / control IEDs / station level unit 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. The events and alarms shall be time-tagged with a time resolution of 1ms.

13.4.0 It shall be possible to specify user authority levels with respect to categories such as display only, normal operation, restricted operation, system administrator etc. Similarly, for maintenance and engineering purposes, authorization levels such as 'no engineering allowed', 'engineering / configuration allowed', 'entire system management allowed' etc. shall be specified. The access rights shall be defined by passwords assigned during log-in procedure. Only the system administrator shall be able to add / remove users and access rights.



- 13.5.0 The reports shall provide time-related follow-ups of measured and calculated values, and it shall be possible to get required printouts on demand. Historical data shall be displayed in graphical form as columns or curves with adjustable time span and scaling ranges. It shall be possible to change the type of value logging, change the update intervals as well as the selection of threshold values for alarming purposes on-line.
- 13.6.0 All recorded data from disturbance recorders shall be automatically uploaded (event triggered or once per day) to a dedicated computer and stored on hard disc. Necessary software to evaluate all the data for proper fault analysis shall be provided.
- 13.7.0 Setting of parameters or the activation of parameter sets for IEDs shall be password protected.

14.0.0 SYSTEM HARDWARE

- 14.1.0 The station level hardware shall consist of main and redundant servers, workstations, printers and switched ethernet communication infrastructure etc. They shall be powered by redundant power supply and have redundant communication card and links. RAID 5 or, higher configuration hard disk shall be supplied for Server and workstation. Redundant communication link shall be between switch -switch, switch-server, server-server, server- workstation.
- 14.2.0 Server main and standby servers as well as workstation servers shall be of industrial grade and state of the art. The main server and standby server shall be hot redundant standby. The server shall be capable of performing all functions of the entire Substation including future requirements. Processor and RAM shall be selected in such a manner that during normal operation not more than 30% of the capacity of processing and memory are used. The capacity of hard disk shall be selected such that the following requirements will occupy less than 50% of disk space:
- Storage of all analogue data (at every 1 second interval which shall be finalized at time of detailed Engineering) and digital data including alarm, event and trend data for three (03) years. Also, Station level server shall be configured and provided with all necessary hardware and software for sending data with Historian.
 - Storage of all necessary software
 - 20GB space for Owner's use
 - Bidder shall demonstrate that capacity of hard disk is sufficient to meet the above requirement.

Main standby servers and Ethernet switches shall be rack mounted.

- 14.3.0 The Visual Display Unit (VDU) for all workstations shall be 32" LED monitor. Minimum viewing angle shall be 85 deg. The unit shall have a minimum resolution of 1280X1024 pixels, and the screen shall be reflection protected.
- 14.4.0 The user interface shall be based on WINDOWS concepts with graphics and facility for panning, scrolling, zooming, decluttering etc. Operation shall be by a user-friendly function keyboard and optical mouse.
- 14.5.0 Printers
- Dot matrix printer shall be robust and suitable for operation with a minimum of 132 characters per line. The printing operation shall be quite with a noise level of less than 45 dB suitable for location in control room. Printer shall accept and print all ASCII character via master control computer unit interface. One dot matrix printer shall be exclusively used for hourly log printing.

Laser printer shall serve as a color hard copy device to copy diagrams from color monitor for documentation and graphic diagram development functions. Minimum seven colors shall be provided. All reports and graphics shall be printed on laser printer.



All printers shall be continuously online. Failure of any printer shall be indicated on the station HMI. The printer shall have in built testing facility. The printer shall have an offline mode selector switch to enable safe maintenance. The maintenance should be simple with provisions for ease of change of print head, ribbon changing, paper insertion, etc.

14.6.0 Switched Ethernet Communication Infrastructure

The Bidder shall provide the redundant switched optical ethernet communication infrastructure for SAS. One Switch shall be provided to connect all IEDs for two bays of 132kV to communication infrastructure. Each switch shall have at least two spare ports for connecting bay level IEDs and one spare port connecting station bus.

14.7.0 Mass Storage Unit

The mass storage unit shall be built- into Station HMI. All operational measured values and indications shall be stored in a mass-storage unit in form of DVD RW. The mass storage unit should support at least Read (48X), Write (24X), and Re-Write (10X) operations, with Multi-Session capability. It should support ISO 9660, Rock ridge 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.

15.0.0 Bay Control Unit (BCU)

15.1.0 BCUs shall be of modular construction and equipped for the delivered inputs / outputs plus 20% spare capacity. Each BCU shall include two redundant interfaces to interface with substations. BCUs shall provide control and protection functions, each function being a separate independent element within the unit. BCUs shall include logic function and sequences. Alteration of logic sequence program shall be possible. Following power interruption and / or communication failure, the BCU shall be arranged to restart automatically. BCUs shall receive regular synchronizing signals from the station controller to maintain the accuracy of time tagging not exceeding 2ms with a resolution of 1ms. The healthiness of BCU shall be monitored.

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

One number Bay level unit shall be provided for supervision and control of each 132/11 kV bay (where a bay comprises of one circuit breaker and associated disconnecter, earth switches, instrument transformers etc.). The Bay level unit shall be equipped with analogue and binary inputs/outputs for handling the control, status monitoring and analogue measurement functions. All bay level interlocks are to be incorporated in the Bay level unit so as to permit control from the Bay level unit/ local bay mimic panel, with all bay interlocks in place, during maintenance and commissioning or in case of contingencies when the Station HMI is out of service.

The bay control unit to be provided for the bays shall be preferably installed in the CB relay panel/feeder protection panel for respective bay. The bay control unit for future bay shall be installed in a separate panel if required during detailed engineering at no cost to Owner / GIPCL. The Bay level unit shall meet the requirements for withstanding electromagnetic interference



according to relevant parts of IEC 61850. Failure of any single component within the equipment shall neither cause unwanted operation nor lead to a complete system breakdown.

- 15.3.0 The I/O modules shall form part of the BCU and shall provide coupling to the substation equipment. The I/O modules shall acquire all switch-gear information (i.e. data coming directly from the switchgear or from the switchgear interlocking devices) and transmit commands for operation of the switchgear. The measured values of voltage and current shall be from the secondaries of instrument transformers.
- 15.4.0 BCU shall be located in relay panels of respective bays. It shall have redundant DC power supply and redundant OFC communication link. OFC cable termination shall be as per SAS architecture drawing which shall be finalized during detailed Engineering.
- 15.5.0 The substation CRP & SAS panel room shall be constructed to house bay level units, bay mimic, relay and protection panels, etc. The layout of equipment/panel shall be subject to Owner's approval. The substation CRP & SAS panel room shall be provided with necessary illuminations, fire alarm system with sufficient multi-criteria detectors with necessary power supply if required it shall be wired to SAS. The detailed constructional requirement of substation CRP & SAS panel room shall be as per GIPCLs' technical specification. The air conditioner provided in substation CRP & SAS panel room shall be monitored from SAS.

16.0.0 CB Control Unit

- 16.1.0 CB Control Units shall be of modular construction and equipped for the delivered inputs / outputs plus 20% spare capacity. CB Control Units shall provide control and protection functions, each function being a separate independent element within the single unit or multiple units. CB Control Units shall include logic function and sequences. Alteration of logic sequence program shall be possible. Following power interruption and / or communication failure, the CB Control Unit shall be arranged to restart automatically. CB Control Units shall receive regular synchronizing signals from the GPS time master to maintain the accuracy of time tagging not exceeding 2ms with a resolution of 1ms. The healthiness of CB Control Unit shall be monitored.
- 16.2.0 The CB Control Unit shall use industrial grade components. The CB Control Unit, based on microprocessor technology, shall use numerical techniques for the calculation and evaluation of externally input analogue signals. They shall incorporate select-before operate control principles as safety measures for operation via the HMI. They shall perform all circuit breaker bay related functions, such as control commands, bay interlocking, data acquisition, data storage, event recording and provide inputs for status indication and outputs for commands. They shall be directly connected as a part of the switchgear. The bay unit shall acquire and process all data for the bay (Equipment status, fault indications, measured values, alarms etc.) and transmit these to the other devices in SAS. In addition, this shall receive operation commands from substation HMI and Client's remote monitoring. The bay unit shall have the capability to store all the data for at least 24 hours.

One number CB Control Unit shall be provided for supervision and control of each 11 kV Switchgear feeder. The CB Control Unit shall be equipped with analogue and binary inputs/outputs for handling the control, status monitoring and analogue measurement functions. All 11kV circuit breaker bay level interlocks are to be incorporated in the CB Control Unit so as to permit control from the SAS panel, with all bay interlocks in place, during maintenance and commissioning or in case of contingencies when the Substation HMI is out of service.

The CB Control Unit provided for the 11kV feeders shall be preferably installed in the 11kV Switchgear relay panel/feeder protection panel for respective feeder. The CB Control Unit shall meet the requirements for withstanding electromagnetic interference according to relevant parts of IEC 61850. Failure of any single component within the equipment shall neither cause unwanted operation nor lead to a complete system breakdown.



16.3.0 The I/O modules shall form part of the CB Control Unit and shall provide coupling to the substation equipment. The I/O modules shall acquire all switch-gear information (i.e. data coming directly from the switchgear or from the switchgear interlocking devices) and transmit commands for operation of the switchgear. The measured values of voltage and current shall be from the secondaries of instrument transformers.

16.4.0 CB Control Unit shall be located in 11kV HT Switchgear panels of respective bays / feeder. It shall have redundant DC power supply and redundant OFC communication link. OFC cable termination shall be finalized during detailed Engineering.

16.5.0 Extendibility in Future:

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

16.6.0 Software Structure

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

16.7.0 Station Level Software

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

16.8.0 Bay Level Software

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

16.9.0 Application Software

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

16.10.0 Network Management System (NMS):



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

- Configuration Management
- Fault Management
- Performance Monitoring

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

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

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

16.12.0 System Operation

Substation Operation (Normal Operation)

Operation of the system by the operator from the remote RCC or at the substation shall take place via industry standard HMI (Human Machine interface) subsystem consisting of graphic colour VDU, a standard keyboard and a cursor positioning device (mouse).

The coloured screen shall be divided into 3 fields:

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

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

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

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

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

Each operational sequence shall be divided into single operation steps which are initiated by means of the function keys/WINDOW command by mouse. Operator prompting shall be designed in such a manner that only the permissible keys are available in the command field related to the specific operation step. Only those switching elements shall be accessed for which control actions are possible. If the operation step is rejected by the system, the operator prompting shall be supported by additional comments in the message field. The operation status shall be reset to the



corresponding preceding step in the operation sequence by pressing one of the function keys. All operations shall be verified. Incorrect operations shall be indicated by comments in the message field and must not be executed.

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

17.0.0 Substation HMI

17.1.0 Substation HMI Operation:

On the HMI the object has to be selected first. In case of a blocking or interlocking conditions are not met, the selection shall not be possible, and an appropriate alarm annunciation shall occur. If a selection is valid the position indication will show the possible direction, and the appropriate control execution button shall be pressed in order to close or open the corresponding object.

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

17.2.0 Presentation and Dialogues

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

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

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

The following standard pictures shall be available from the HMI:

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

17.3.0 HMI design principles

Consistent design principles shall be adopted with the HMI concerning labels, colours, dialogues and fonts. Non-valid selections shall be dimmed out.

The object status shall be indicated using different status colours for:

- Selected object under command
- Selected on the screen
- Not updated, obsolete values, not in use or not sampled
- Alarm or faulty state
- Warning or blocked
- Update blocked or manually updated



- Control blocked
- Normal state

17.4.0 Process status displays and command procedures

The process status of the substation in terms of actual values of currents, voltages, frequency, active and reactive powers as well as the positions of circuit breakers, isolators and transformer tap-changers shall be displayed in the station single-line diagram.

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

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

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

17.5.0 System supervision & display

The SAS system shall be comprehensively self-monitored such that faults are immediately indicated to the operator, possibly before they develop into serious situations. Such faults are recorded as a faulty status in a system supervision display. This display shall cover the status of the entire substation including all switchgear, IEDs, communication infrastructure and remote communication links, and printers at the station level, etc.

17.6.0 Event list

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

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

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

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

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

The chronological event list shall contain:

- Position changes of circuit breakers, disconnectors and earthing switches
- Indication of protective relay operations
- Fault signals from the switchgear



- Indication when analogue measured values exceed upper and lower limits.
- Suitable provision shall be made in the system to define two level of alarm on either side of the value, or which shall be user defined for each measurands.
- Loss of communication.

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

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

17.7.0 Alarm list

Faults and errors occurring in the substation shall be listed in an alarm list and shall be immediately transmitted to the control centre. The alarm list shall substitute a conventional alarm tableau, and shall constitute an evaluation of all station alarms. It shall contain unacknowledged alarms and persisting faults. The date and time of occurrence shall be indicated.

The alarm list shall consist of a summary display of the present alarm situation. Each alarm shall be reported on one line that contains:

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

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

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

17.8.0 Object picture

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

- Type of blocking
- Authority
- Local / remote control
- SAS control
- Errors etc. shall be displayed.

17.9.0 Control dialogues



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

- Breaker and disconnecter
- Transformer tap-changer

17.10.0 User-authority levels

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

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

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

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

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

17.11.0 Reports

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

Trend reports:

- Day (mean, peak)
- Month (mean, peak)
- Semi-annual (mean, peak)
- Year (mean, peak)

Historical reports of selected analogue Values:

- Day (at 15 minutes interval)
- Week
- Month
- Year



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

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

- i. Daily voltage and frequency curves depicting time on X-axis and the appropriate parameters on the Y-axis. The time duration of the curve is 24 hours.
- ii. Weekly trend curves for real and derived analogue values.
- iii. Printouts of the maximum and minimum values and frequency of occurrence and duration of maximum and minimum values for each analogue parameter for each circuit in 24 hr period.
- iv. Provision shall be made for logging information about breaker status like number of operations with date and time indications along with the current value it interrupts (in both conditions i.e. manual opening and fault tripping)
- v. Equipment operation details shift wise and for 24 hours.
- vi. Printout on adjustable time period as well as on demand for MW, MVA_r, Current, Voltage on each feeder and transformer as well as Tap Positions, temperature and status of pumps and fans for transformers.
- vii. Printout on adjustable time period as well as on demand system frequency and average frequency.
- viii. Reports in specified formats which shall be handed over to successful bidder. The bidder has to develop these reports. The reports are limited to the formats for which data is available in the SAS database.
- ix. Report on availability of Communication system.

17.12.0 Trend display (Historical data)

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

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

17.13.0 Automatic disturbance file transfer

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

17.14.0 Disturbance analysis

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



17.15.0 IED parameter setting

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

17.16.0 Automatic sequences

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

18.0.0 CONSTRUCTIONAL FEATURES OF PANEL

Station controller and Ethernet switches shall be located in a separate panel.

- 18.1.0 Panel shall be of simplex type design. It shall consist of CRCA sheet steel with thickness not less than 3mm for weight bearing elements and 2mm for others and shall provide a degree of protection not less than IP-31. Panels shall be free standing, floor-mounting type. All doors, removable covers and panels shall be gasketed all around. Anti-vibration pads shall be placed between panel and base frame. Cable entries to the panels shall be from the bottom.
- 18.2.0 All wiring shall be carried out with 1100V grade, single core, stranded copper conductor wires with PVC insulation. The minimum size of the multi-stranded copper conductor used for internal wiring shall be 1.5 sq.mm. The power cable size shall be 2.5 sq.mm
- 18.3.0 Terminal blocks shall be 650V grade and have 10A continuous rating, moulded piece, complete with insulated barriers, stud type terminals, washers, nuts and lock nuts. Markings on the terminal blocks shall correspond to wire number and terminal numbers on the wiring diagrams. All terminal blocks shall have shrouding with transparent unbreakable material.
- 18.4.0 At least 20% of the spare terminals shall be provided on each panel and these spare terminals shall be uniformly distributed on all terminal blocks.
- 18.5.0 All equipment mounted on front and rear side as well as equipment mounted inside the panels shall be provided with individual nameplates with equipment designation engraved. Also, on the top of each panel on front as well as rear side, large and bold nameplates shall be provided for circuit / feeder designation.
- 18.6.0 All front mounted equipment shall also be provided at the rear with individual name plates engraved with tag numbers corresponding to the one shown in the panel internal wiring to facilitate easy tracing of the wiring.
- 18.7.0 Nameplates shall be made of SS-304 with blue colour engraving lettering.
- 18.8.0 240V, single phase AC socket with switch suitable to accept 5A and 15A pin round standard Indian plug, shall be provided in the interior of each cubicle with ON-OFF switch.
- 18.9.0 Each panel shall be provided with a LED lighting fixture rated for 240V, single phase, supply for the interior illumination of the panel controlled by the respective panel door switch.
- 18.10.0 Each panel shall be provided with necessary arrangements for receiving, distributing and isolating DC and AC supplies for various control, signaling, lighting and space heater circuits. The incoming and sub-circuits shall be separately provided with miniature circuit breakers (MCB) for AC circuits and DC circuits. Each MCB shall be provided with one potential free contact and the same shall be wired for annunciation purpose.



18.11.0 Each panel shall be provided with a thermostatically controlled space heater rated for 240V, single phase AC supply for the internal heating of the panel to prevent condensation of moisture. The fittings shall be complete with switch unit.

18.12.0 All panels shall be equipped with an earth bus of at least 25 x 6sq. mm. All metallic cases of panel mounted equipment including gland plate shall be connected to the earth bus by copper wires of size not less than 2.5sq.mm. The color code of earthing wires shall be green. An electrostatic discharge point shall be provided in each panel connected to earth bus via 1 mega ohm resistor.

19.0.0 SIGNAL LIST

Bidder shall submit the comprehensive Signal list. The owner shall review the Signal List and will add additional signal (for which new transducer, if required shall be supplied and installed by bidder) if required. The final signal list/IO list shall comprise of IO of existing plant and IO for future equipment/machine/plant as per satisfaction of Owner. Bidder shall provide 20% spare IO above final IO list. Bidder shall comply without any cost implication to Owner / GIPCL.

19.1.0 Tentative List of Analogue and Digital Signals for Substation Automation system are as follows:

a) Basic Monitoring requirements are:

- Switchyard/Switchgear status indication
- Measurements (U, I, P, Q, f)
- Event
- Alarm
- Winding temperature of transformer and reactors & Tap-position of Transformer
- Ambient temperature
- Status and display of 11kV Switchgear, 415V LT system, 230V UPS system 110V DC system
- Status of display of Fire protection system and Air conditioning system.
- Acquisition of all counters in FOTE panels through potential free contacts from FOTE or independently by counting the receive/send commands.
- Acquisition of alarm and fault record from protection relays
- Disturbance records
- Monitoring the state of batteries by displaying DC voltage, charging current and load current etc.

b) The list of Soft signals is as below:

- i. For typical Transmission line bay
 - Current R phase, Y phase, B phase
 - Voltage -R-Y phase, Y-B phase, B-R phase
 - Active, Reactive and Apparent Power
- ii. For typical transformer/ reactor bay
 - Current R phase, Y phase, B phase



- WTI (for transformer and reactor)
 - Tap position (for transformer)
 - Active, Reactive and Apparent Power
- iii. For bus coupler bay
- Current R phase, Y phase, B phase
 - Active, Reactive and Apparent Power
- iv. For main Bus-I
- Voltage R-Y phase, Y-B phase, B-R phase
 - Frequency
- v. For main Bus-II
- Voltage R-Y phase, Y-B phase, B-R phase
 - Frequency
- vi. Switchyard Ambient temperature
- vii. Substation Control room Ambient temperature
- viii. 11 kV system
- Voltage R-Y, Y-B, B-R of each 11 kV Switchgear
 - Current R phase, Y phase, B phase
 - Active, Reactive and Apparent Power
- ix. 415V system
- Voltage R-Y, Y-B, B-R of AC Distribution Boards section
 - Current from Auxiliary transformer
 - Active power for Switch boards
 - Active power for DG set
 - Active power for Station Service Transformer
- x. 110 V DC system
- Voltage of 110V DCDB-I
 - Voltage of 110V DCDB-II
 - Current of DCDB-I
 - Current of DCDB-II



- Current of DCDB tie
 - Current from 110V Battery set-I
 - Current from 110V Battery set-II
 - Current from 110V Battery charger-I
 - Current from 110V Battery charger-II
 - Battery Voltage (Analog)
 - Boost Voltage (Analog)
 - Float Voltage (Analog)
 - Load Voltage (Analog)
 - Battery Current (Analog)
 - Boost Current (Analog)
 - Float Current (Analog)
 - Load Current (Analog)
 - Battery Room Temperature (Analog)
- xi. UPS system
- Input Voltage
 - Input Current
 - Output Voltage
 - Output Current
 - Temperature of Inverter IGBT stack and compartment temperature

c) The list of Digital signals for various bays/system is as follows:

i. Typical 132 kV Line bays

- Status of each pole of CB.
- Status of Isolator, Earth switch
- CB trouble
- CB operation/closing lockout
- Pole discrepancy operated
- Trip coil faulty
- Bus bar protection trip relay operated
- Main breaker auto recloser operated
- Tie/transfer auto recloser operated
- Auto reclosure lockout
- Tie/transfer breaker Auto reclosure lockout
- Direct trip-I/II sent



- Direct trip-I/II received
- Main blocking
- Main Inter trip send
- Main Inter trip received
- O/V STAGE – I operated
- O/V STAGE – II operated
- FAULT LOCATOR FAULTY
- MAIN-I/II CVT FUSE FAIL
- MAIN PROTECTION TRIP
- MAIN PROTECTION TRIP
- MAIN PSB ALARM
- MAIN SOTF TRIP
- MAIN R-PH TRIP
- MAIN Y-PH TRIP
- MAIN B-PH TRIP
- MAIN START
- MAIN Carrier aided trip
- MAIN fault in reverse direction
- MAIN ZONE-2 TRIP
- MAIN ZONE-3 TRIP
- MAIN weak end infeed operated
- MAIN PSB alarm
- MAIN SOTF TRIP
- MAIN R-PH TRIP
- MAIN Y-PH TRIP
- MAIN B-PH TRIP
- MAIN start
- MAIN aided trip
- MAIN fault in reverse direction
- Back-up O/C operated
- Back-up E/F operated
- 220V DC-I/II source fail
- SPEECH CHANNEL FAIL
- FOTE FAIL signals
- Tariff Meter Auxiliary Supply-1 Fail
- Tariff Meter Auxiliary Supply-2 Fail
- Bus VT MCB Trip for each core



ii. Transformer bays

- Status of each pole of CB, Isolator, Earth switch
- CB trouble
- CB operation/closing lockout
- Pole discrepancy operated
- Trip coil faulty
- LBB operated
- Bus bar protection trip relay operated
- REF OPERATED
- DIF OPERATED
- OVERFLUX ALARM (MV)
- OVERFLUX TRIP (MV)
- OVERFLUX ALARM (HV)
- OVERFLUX TRIP (HV)
- HV BUS EMVT FUSE FAIL
- MV BUS EMVT FUSE FAIL
- OTI ALARM/TRIP
- PRD OPERATED (2 Nos)
- Conservator Protection Relay Status
- OVERLOAD ALARM
- BUCHOLZ TRIP
- BUCHOLZ ALARM
- OLTC BUCHOLZ ALARM
- OLTC BUCHOLZ TRIP
- OLTC Surge Relay status
- OIL LOW ALARM
- WTI ALARM / TRIP (3 Nos)
- MOG status
- Back-up O/C (HV) operated
- Back-up E/F (HV) operated
- 110V DC-I/II source fail
- TAP MISMATCH
- GR-A PROTECTION OPERATED
- GR-B PROTECTION OPERATED
- Back-up O/C (MV) operated
- Back-up E/F (MV) operated



- Optical winding temperature sensing system
- Online DGA system
- Online Drying System
- Maintenance Free Dehydrating Breather System
- Tariff Meter Auxiliary Supply-1 Fail
- Tariff Meter Auxiliary Supply-2 Fail
- Auxiliary Transformer WTI Alarm & trip
- Auxiliary Transformer OTI Alarm & trip

iii. RTCC Panel

- Over-Voltage alarm
- Under-Voltage alarm
- OLTC auxiliary power failure
- OLTC fail
- OLTC control
- Master or follower parallel mode
- Circulating Current based on MVA rating of transformer
- Temperature abnormalities
- Top Oil or, winding hot spot temperature exceeds alarm settings
- Top Oil or, winding hot spot temperature exceeds trip or stage to alarm settings
- Cooler auxiliary power failure
- Cooler fail

iv. DC Battery Charger System (All FC+FCBC)

- AC Mains Fail
- Load Bus Over Voltage
- Load Bus Under Voltage
- Float Charger Fail
- Float Charger ON / OFF
- Float Charger on Auto Mode
- Float Charger on Manual Mode
- Boost Charger ON/OFF
- Boost Charger on CV / CC mode
- Charger on Local mode
- Charger on Remote mode



v. 11 kV capacitor Bank signals

- Supervisory Control Enabled
- Supervisory Control Disabled
- Neutral Unbalance Alarm
- Neutral Unbalance Trip
- Over-Voltage Alarm
- Over-Voltage Trip
- Over-Current Trip
- Three Phase Voltage
- Average Voltage
- L-L Voltage
- Phase Currents
- Voltage Unbalance
- Current Unbalance
- Line Frequency
- Phase KW, Total KW
- Phase KVA, Total KVA
- Phase KVA, Total KVA
- Phase Power Factor
- KW Thermal Demand, KVA Thermal Demand, KVA Thermal Demand
- Maximum KW Thermal Demand
- Maximum KVA Thermal Demand
- Maximum KVA Thermal Demand
- Maximum Total kW
- Maximum Total KVA
- Maximum Total KVA
- Minimum Average Current
- Total kVArh, Net kVArh, Total kVArh
- Max Phase Voltage THD, Maximum Phase Current THD

vi. Bus bar Protection

- Bus bar main-I trip
- Bus bar main-II trip
- Bus bar zone-I CT open
- Bus bar zone-II CT open
- Bus protection relay fail
- Tariff Meter Auxiliary Supply-1 Fail



- Tariff Meter Auxiliary Supply-2 Fail
- Bus VT MCB Trip for each core.

vii. Typical 11 kV feeder

- Status of CB.
- CB trouble
- CB operation/closing lockout
- Trip coil faulty
- Back-up O/C operated
- Back-up E/F operated
- 110V DC-I/II source fail
- Annunciator Alarms
- Tariff Meter Auxiliary Supply-1 Fail
- Tariff Meter Auxiliary Supply-2 Fail

viii. 415 V System

- Status (ON/OFF) monitoring of all incomer and outgoing circuit breakers of the 415 V station auxiliary distribution system fed from the 11/0.433 kV auxiliary transformer(s)
- 415V Bus-I/II U/V
- 415V bus coupler breaker on/off

ix. Auxiliary system

- 400 V Bus-I/II U/V
- 400 V bus coupler breaker On/Off
- Time sync. Signal absent
- Alarm/trip signals of 110 V Battery and Battery charger
- 110 V DC-I earth fault
- 110 V DC-II earth fault
- Alarm/trip signals of DG Set
- Alarm/trip signals of Fire protection system
- Switchyard Panel Room Temperature High Alarm

x. Substation CRP & SAS Panel Room

- AC Compressor 1 On/Off
- AC Compressor 2 On/Off
- Fire Detection 1 On/Off
- Fire Detection 2 On/off



- CRP & SAS panel room temperature high alarm

xi. NIFPS System

- System operated
- System out of service
- PNRV/TCIV closed
- Fire detector trip
- N₂ cylinder pressure low
- Visual/audio alarm for system
- Visual/audio alarm for DC supply fail

xii. UPS System Signal list (All UPS)

- Inverter On/Off
- Load on Inverter
- Synchronization
- By pass switch ON/OFF
- Output Frequency
- Output Power
- Output Energy
- Output PF

All other AI/DI parameter as per MODBUS mapping list

xiii. HT Transformer Breaker (DO)

- HT transformer remote open command
- HT transformer remote close command

d) The list of Soft signals for various systems are as follows:

- UPS/Inverter on MODBUS
- Fire monitoring system on MODBUS Protocol
- Breaker Numeric Relay on applicable Protocol
- Panels Annunciator, MFM on MODBUS
- Disturbance Recorder on applicable Protocol
- ABT meter on MODBUS/applicable Protocol
- PQ meter on MODBUS/applicable Protocol



- 19.2.0 The exact number and description of Analogue & digital inputs will be firmed up during detail engineering. Apart from the above-mentioned digital inputs, minimum of 200 inputs shall be kept for Owner's use in future.
- 19.3.0 List of Analogue & digital inputs for Grid substation and Load Dispatch Centre will be firmed up during detail engineering. The minimum required list is
- a) MW and MVAR for all Lines, Transformers, Reactors and Capacitors
 - b) Voltage of all buses
 - c) Frequency of 132kV Bus
 - d) All Breakers
 - e) All disconnectors
 - f) Tap Position for all transformers
 - g) Master protection signal for all feeders, transformers and Bus Bar
 - h) Loss of Voltage signal for Bus bar
 - i) All the points identified in point (d), (g) and (h) above as GPS Time stamped.
 - j) Temperature value per substation.
 - k) Any other point decided during detailed engineering



20.0.0 DRAWINGS, DATA AND MANUAL

To Be Submitted after Award of Contract:

- System architecture drawing
- Hardware specification
- Guaranteed technical parameters,
- Functional design specification
- Clear procedure describing how to add an IED/bay/diameter in future covering all major supplier
- List of drawings
- Substation Automation System Architecture
- Block diagram
- Calculation for power supply dimensioning
- Substation CRP & SAS panel room layout drawing
- Control room layout drawing
- Assembly drawing
- Complete documentation of implemented protocols between various elements
- Guaranteed availability and reliability
- I/O signal lists
- Schematic diagrams
- Logic diagram (hardware & software)
- Test specification for factory acceptance test (FAT)
- Test specification for field tests
- Product manuals
- Operator's manual
- Listing of software and loadable in CD ROM
- List of apparatus
- List of labels
- Calculation for uninterrupted power supply (UPS) dimensioning
- Test specification for site acceptance test (SAT)
- Training Manual/documents
- Bill of Material
- Mandatory spare list supplied with SAS
- IEC and other certificates as required by Owner
- Warranty certificate
- Installation Manual
- Other documents may be required during detailed engineering



- Details of Cyber Assets which uses a routable protocol to communicate outside the Electronic Security Perimeter drawn by the Responsible Entity or a routable protocol within a control centre and dial-up accessible Cyber Assets.
- Details of Critical Business Processes and underlying information infrastructure along with mapped impact and Risk Profile.
- Document Format for FAT, SAT test results and report/ certificate of cyber tests carried out for compliance of Government Orders and Cyber Security Audit. FAT, SAT must include comprehensive cyber security tests of the component/equipment/system to be delivered at site.
- Bidder shall submit Equipment/System certificate obtained by OEM from a certification body accredited to assess devices and process for conformance to IEC 62443-4 standards during design and manufacture and ISO/IEC 15408. This certificate shall be in line with the Testing Protocol as notified by Ministry of Power, Government of India, from time to time.

Note:

- 1) The above-mentioned documentation to be provided for the system in the course of the project shall be consistent, CAD supported, and of similar look/feel. All CAD drawing to be provided in ".dxf" format.
- 2) Two sets of hard copy and four sets of CD ROM/pen drive containing all the as built documents/drawing shall be provided.

21.0.0 TESTS

The substation automation system offered by the bidder shall be subjected to following tests to establish compliance with IEC 61850 for EHV sub-station equipment installed in sheltered area in the outdoor switchyard and specified ambient conditions Type tests, Factory Acceptance Test and Site Acceptance Test final decision shall be taken once the SAS equipment and its functionality is finalized during Engineering design by the Owner. Below is only minimum testing required.

- 21.1.0** Bidder shall ensure that the essential cyber security tests are carried out successfully during FAT and SAT as mentioned below. The equipment/System besides functionality shall also be tested in the factory for vulnerabilities, design flaws, parts being counterfeit or tainted, so as to minimize problems during on-site testing and installation. Cyber Security Conformance Testing are to be carried out in the designated Lab as listed in **Annexure-I of MoP Order No. 12/13/2020-T&R dt. 8th June, 2021.**

FAT & SAT

1. During FAT stage, Owner shall verify all types test reports / certificates including Communication protocol and security conformance tests of the devices offered for FAT.
2. FAT of SCADA involves testing as a whole system in the integrated scale down set up. For SCADA, Indian standard IS 15953: 2011 "SCADA System for Power System Applications" provides definition and guidelines for the specification, performance analysis and application of SCADA systems for use in electrical utilities (for transmission & Distribution) including guidance on Tests and inspections.
3. The SAT will be done at Owner site as per the SAT document mutually agreed by Owner and Bidder. For SAT also, guidance from IS 15953: 2011 need to be applied.
4. IEC 61850-10-3 Communication Networks and Systems for Power Utility Automation- Functional testing of IEC 61850 systems (in draft stage - CDTR) covers testing of applications within substations covering.



- a. A methodical approach to the verification and validation of a substation solution
- b. The use of IEC 61850 resources for testing in Edition 2.1
- c. Recommended testing practices for different use cases
- d. Definition of the process for testing of IEC 61850 based devices and systems using communications instead of hard-wired system interfaces (ex. GOOSE and SV instead of hardwired interfaces)
- e. Use cases related to protection and control functions verification and testing.

21.2.0 Equipment offered shall be of type tested and proven type. Type test reports shall be submitted for approval. All routine tests in accordance with the latest version of applicable standard shall be conducted.

Type Tests

The following are the major type tests to be carried out:

- Power Input
 - i) Auxiliary Voltage
 - ii) Current Circuits
 - iii) Voltage Circuits
 - iv) Indications

- Accuracy tests
 - i) Operational Measured Values
 - ii) Currents
 - iii) Voltages
 - iv) Time resolution

- Insulation tests
 - i) Dielectric Tests
 - ii) impulse Voltage withstand Test

- Influencing Quantities
 - i) Limits of operation
 - ii) Permissible ripples
 - iii) Interruption of input voltage

- Electromagnetic compatibility tests
 - i) 1 MHZ. burst disturbance test
 - ii) Electrostatic Discharge Test
 - iii) Radiated Electromagnetic Field Disturbance Test
 - iv) Electrical Fast transient Disturbance Test
 - v) Conducted Disturbances Tests induced by Radio Frequency Field



- vi) Magnetic Field Test
- vii) Emission (Radio interference level) Test.
- viii) Conducted Interference Test

- Function tests
 - i) Indication
 - ii) Commands
 - iii) Measured value Acquisition
 - iv) Display Indications

- Environmental tests
 - i) Cold Temperature
 - ii) Dry Heat
 - iii) Wet heat
 - iv) Humidity (Damp heat Cycle)
 - v) Vibration
 - vi) Bump
 - vii) Shock

21.3.0 **Factory Acceptance Tests**

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

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

The following are the major factory acceptance tests to be carried out:

- Hardware integration tests
The hardware integration test shall be performed on the specified systems to be used for Factory tests when the hardware has been installed in the factory. The operation of each item shall be verified as an integral part of system. Applicable hardware diagnostics shall be used to verify that each hardware component is completely operational and assembled into a configuration capable of supporting software integration and factory testing of the system. The equipment expansion capability shall also be verified during the hardware integration tests. The Bidder specifically demonstrates how to add a device in future in SAS during FAT. The device shall be from a different manufacturer than the SAS supplier.



- Integrated system tests
Integrated system tests shall verify the stability of the hardware and the software. During the tests all functions shall run concurrently, and all equipment shall operate a continuous 100 Hour period. The integrated system test shall ensure the SAS is free of improper interactions between software and hardware while the system is operating as a whole.
 - Pre power on checks.
 - Power on checks.
 - Functional tests.
 - Parametric tests.
 - Power failure auto-restart tests.
 - Interlocking tests.
- Bidder shall ensure that the essential cyber security tests are carried out successfully during FAT, SAT. The equipment/System besides functionality shall also be tested in the factory for vulnerabilities, design flaws, parts being counterfeit or tainted, so as to minimize problems during on-site testing and installation. Cyber Security Conformance Testing are to be carried out in the designated Lab.
- Bidder shall ensure that the essential cyber security tests are carried out successfully during FAT and SAT as detailed below. The equipment/System besides functionality shall also be tested in the factory for vulnerabilities, design flaws, parts being counterfeit or tainted, so as to minimize problems during on-site testing and installation. Cyber Security Conformance Testing are to be carried out in the designated Lab as listed in Annexure-I of MoP Order No. 12/13/2020-T&R dt. 8th June, 2021(As per provisions of Annexure-B).
- During FAT stage, Owner shall verify all types test reports / certificates including Communication protocol and security conformance tests of the devices offered for FAT.
- FAT of SAS involves testing as a whole system in the integrated scale down set up. For SAS, Indian standard IS 15953: 2011 "SCADA System for Power System Applications" provides definition and guidelines for the specification, performance analysis and application of SCADA systems for use in electrical utilities (for transmission & Distribution) including guidance on Tests and inspections.
- The SAT will be done at Owner site as per the SAT document mutually agreed by Owner and Bidder. For SAT also, guidance from IS 15953: 2011 need to be applied.
- IEC 61850-10-3 Communication Networks and Systems For Power Utility Automation- Functional testing of IEC 61850 systems (in draft stage - CDTR) covers testing of applications within substations covering
 - a. A methodical approach to the verification and validation of a substation solution
 - b. The use of IEC 61850 resources for testing in Edition 2.1
 - c. Recommended testing practices for different use cases



- d. Definition of the process for testing of IEC 61850 based devices and systems using communications instead of hard-wired system interfaces (ex. GOOSE and SV instead of hardwired interfaces)
- e. Use cases related to protection and control functions verification and testing

21.4.0 Site Acceptance Tests

The Site Acceptance Test (SAT) shall completely verify all the features of SAS hardware and software. Detailed site acceptance test procedure shall be submitted for approval. The following are the major factory acceptance tests to be carried out:

- Startup tests
- Calibration and configuration tests
- Pre-commissioning tests
- Trial operation
- Availability tests

22.0.0 TRAINING

22.1.0 Training

Contractor personnel who are experienced instructors and who speak understandable English shall conduct training. The contractor shall arrange on its own cost all hardware training platform required for successful training and understanding. The Contractor shall provide all necessary training material. Each trainee shall receive individual copies of all technical manuals and all other documents used for training. These materials shall be sent to Owner at least two months before the scheduled commencement of the particular training course. Class materials, including the documents sent before the training courses as well as class hand-outs, shall become the property of Owner. Owner reserves the right to copy such materials, but for in-house training and use only. Hands-on training shall utilize equipment identical to that being supplied to Owner.

The Contractor shall quote training prices in the price schedule.

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

22.2.0 Computer System Hardware Course

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

- System Hardware Overview: Configuration of the system hardware.
- Equipment Maintenance: Basic theory of operation, maintenance techniques and diagnostic procedures for each element of the computer system, e.g., processors, auxiliary memories, LANs, routers and printers. Configuration of all the hardware equipment's.
- System Expansion: Techniques and procedures to expand and add equipment such as loggers, monitors, and communication channels.



- **System Maintenance:** Theory of operation and maintenance of the redundant hardware configuration, failover hardware, configuration control panels, and failover switches. Maintenance of protective devices and power supplies.
- **Subsystem Maintenance:** Theory of design and operation, maintenance techniques and practices, diagnostic procedures, and (where applicable) expansion techniques and procedures. Classes shall include hands-on training for the specific subsystems that are part of Owner equipment or part of similarly designed and configured subsystems. All interfaces to the computing equipment shall be taught in detail.
- **Operational Training:** Practical training on preventive and corrective maintenance of all equipment, including use of special tools and instruments. This training shall be provided on Owner equipment, or on similarly configured systems.

22.3.0 Computer System Software Course

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

- **System Programming:** Including all applicable programming languages and all stand-alone service and utility packages provided with the system. An introduction to software architecture, Effect of tuning parameters (OS software, Network software, database software etc.) on the performance of the system.
- **Operating System:** Including the user aspects of the operating system, such as program loading and integrating procedures; scheduling, management, service, and utility functions; and system expansion techniques and procedures.
- **System Initialization and Failover:** Including design, theory of operation, and practice.
- **Diagnostics:** Including the execution of diagnostic procedures and the interpretation of diagnostic outputs.
- **Software Documentation:** Orientation in the organization and use of system software documentation.
- **Hands-on Training:** One week, with allocated computer time for trainee performance of unstructured exercises and with the course instructor available for assistance as necessary.

22.4.0 Application Software Course

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

- **Overview:** Block diagrams of the application software and data flows. Programming standards and program interface conventions.
- **Application Functions:** Functional capabilities, design, and major algorithms. Associated maintenance and expansion techniques.
- **Software Development:** Techniques and conventions to be used for the preparation and integration of new software functions.
- **Software Generation:** Generation of application software from source code and associated software configuration control procedures.
- **Software Documentation:** Orientation in the organization and use of functional and detailed design documentation and of programmer and user manuals.



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

22.5.0 Requirement of training:

The contractor shall provide training for GIPCLs' personnel comprehensively covering following courses:

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

22.6.0 Cyber Security Training

The bidder shall ensure that Cyber Security training program designed for GIPCL/Owner must include following topics and as per SAS functional requirements and security concerns additional topics shall be added:

- User authentication and authorization.
- Cyber Security and Protection mechanisms of IT/OT Systems.
- Introduction to various standards i.e. ISO/IEC:15408, ISO/IEC:24748-1, ISO: 27001, ISO: 27002, ISO 27019, IS 16335, IEC/ISO:62443.
- Training on implementation of ISO/IEC 27001 and awareness on IEC 62443.
- Vulnerability Assessment in the Critical System.
- Monitoring and preserving of electronic logs of access of Critical Assets.
- Detecting cyber-attacks on SCADA systems
- The handling of Critical System during cyber crisis.
- Action plans and procedures to recover or re-establish normal functioning of
- Critical Assets and access thereto following a Cyber Security Incident.
- Hands on SAS/SCADA operation.
- Handling of risks involved in the procurement of COTS Products.

23.0.0 MAINTENANCE

During Guaranteed Availability Period, the Contractor shall take continual actions to ensure the guaranteed availability and shall make available all the necessary resources such as specialist personnel, spare parts, tools, test devices etc. for replacement or repair of all defective parts and shall have prime responsibility for keeping the system operational without any claim to Owner / GIPCL. During guarantee period as specified in tender document, contractor shall arrange fortnight visit of their representative at their own expenses to site to review the performance of system and in case any defect/shortcoming etc. is observed during the period, the same shall be set right by the contractor within latest by two (2) days.

SAS shall permit in-service diagnostic testing to be executed both locally and from remote network management system locations to facilitate performance trending, efficient diagnosis and corrective resolution of all the interfaces in operation.



The testing equipment and tools shall be maintained to facilitate testing of the interfaces of the communication system at the time of fault and during the course of maintenance. For SCADA, Indian standard IS 15953: 2011 "SCADA System for Power System Applications" provides definition and guidelines for the specification, performance analysis and application of SCADA systems for use in electrical utilities (for transmission & Distribution) including guidance on Tests and inspections.

24.0.0 RELIABILITY AND AVAILABILITY

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

- a) Mechanical and electrical design
- b) Security against electromagnetic interference (EMI)
- c) High quality components and boards
- d) Modular, well-tested hardware
- e) Thoroughly developed and tested modular software
- f) Easy-to-understand programming language for application programming
- g) Detailed graphical documentation and application software
- h) Built-in supervision and diagnostic functions
- i) Security
- j) Experience of security requirements
- k) Process know-how
- l) Select before executing at operation
- m) Process status representation as double indications
- n) Distributed solution
- o) Independent units connected to the local area network
- p) Back-up functions
- q) Panel design appropriate to the harsh electrical environment and ambient
- r) conditions
- s) Panel grounding immune against transient ground potential rise



OUTAGE TERMS

1) Outage

The state in which substation automation system or a unit of SAS is unavailable for Normal operation due to an event directly related to the SAS or unit of SAS. In the event, the Owner / GIPCL had taken any equipment/ system other than SAS for a schedule/forced maintenance, the consequent outage to SAS shall not be considered as outage for the purpose of availability.

Total outage period shall be less than sixteen hours on monthly basis each for interface node, wideband node and communication network. The total outages in a rolling twelve months assessment period shall be less than forty-eight (48) hours.

2) Actual Outage Duration (AOD)

The time elapsed in hours between the start and the end of an outage. The time shall be counted to the nearest 1/4th of an hour. Time less than 1/4th of an hour shall be counted as having duration of 1/4th of an hour.

3) Period Hours (PH)

Number of hours in the reporting period is PH. In a full year the period hour are 8760h (8784h for a leap year).

4) Actual Outage Hours (AOH)

The sum of actual outage duration within the reporting period
 $AOH = \sum AOD$

5) Availability:

The SAS shall have a total availability of 99.99 % i.e. the ratio of total time duration minus the actual outage duration to total time duration.

24.1.0 Guarantees Required

The availability for the complete SAS shall be guaranteed by the Contractor. Bidder shall include in their offer the detailed calculation for the availability. The contractor shall demonstrate their availability guaranteed by conducting the availability test on the total sub-station automation system as a whole after commissioning of total Sub-station Automation system. The test shall verify the reliability and integrity of all sub-systems. Under these conditions the test shall establish an overall availability of 99.99%. After the lapse of 1000 Hours of cumulative test time, test records shall be examined to determine the conformance with availability criterion. In case of any outage during the availability test, the contractor shall rectify the problem and after rectification, the 1000 Hours period start after such rectification. If test object has not been met the test shall continue until the specified availability is achieved.

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

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



25.0.0 LIST OF EQUIPMENTS

The SAS shall contain the following main functional parts:

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

- a) Station HMI
- b) Redundant Station HMI (in Hot stand-by mode)
- c) Bay level units along with bay mimic as per detail engineering requirement.
- d) Bay Level Unit for Auxiliary system (as per requirement)
- e) Disturbance Recorder Workstation (Maintenance HMI)
- f) Colour Laser Printer – 1 No. (For Reports & Disturbance records)
- g) Dot matrix printers - (one each for Alarms and log sheets)
- h) All interface equipment for gateway to RLDC
- i) Communication medium (i.e. FO link, Lease line etc.) between these gateways at 132kV substation control room and other SCADA systems is included in bidder's scope. Communication infrastructure between Bay level units, Station HMI, Printers, gateways, redundant LAN etc. as required
- j) Communication link for protection relays
- k) Ethernet switch for station controllers
- l) Ethernet switch fault tolerant ring architecture for each bay
- m) Dual redundant communication bus at station level and at BCU level
- n) Dual redundant communication between intelligent electronic devices (IEDs) and ethernet switches
- o) Remote workstation including HMI and along with One number color laser jet printer (A3/A4 paper)
- p) Modems as per requirement.
- q) Redundant DC Power supply for SAS
- r) All types of Power cable, Control Cable, Communication cable and other cables/special cables required for full functionality of SAS.
- s) Local Control Panel for Substation transducer, protection system, alarm annunciator, local operation facility. Communication between Local Control Pane and BCU.
- t) Any other equipment as necessary.