TECHNICAL SPECIFICATIONS OF REMOTE TERMINAL UNITS

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TECHNICAL SPECIFICATION OF RTU

1.0 General

The Remote Terminal Unit (RTU), shall be installed at Substations & Power stations to acquire analog data, device status and events. RTU shall also be used for control of station devices from Master station. The supplied RTUs shall be interfaced with the Control & Relay (C&R) panels, Transducers, IEDs, Metering Equipment, Communication equipment, Power supply distribution boards; for which all the interface cables shall be supplied by the Contractor.

This document describes the specifications for the Remote Terminal Unit (RTU). Contractor shall supply RTU, associated equipment such as transducers, relays, weather sensors, modems, cabling etc. and required number of panels for housing of all the hardware envisaged for the RTU and system interface cubicle (SIC).

The contractor shall be responsible for supplying all hardware, software, installation, cabling and field implementation for RTU as defined in this Specification. The contractor shall also be responsible for integration of supplied RTUs with the existing SCADA/EMS System of the owner as per the specified protocols and interoperability profile annexed at **Appendix–A**. Necessary additions/modifications in SCADA System databases and displays for integration of RTU with SCADA/EMS System shall be in the owner's scope. The contractor shall also provide complete documentation, training and testing to fully support the hardware and software provided. The RTU shall be used for real-time supervision and control of substation/ power plant through SCADA system. RTU configuration/ point count, MFT/MFM count, modems and requirement of weather sensors quantity is given in **Appendix - B**.

Should the Contractor elect to subcontract manufacturing, installation, testing & commissioning or any work defined herein, it shall remain the Contractor's responsibility to complete the assigned work.

It is Owner's intent that the Contractor uses as much standard hardware and software as possible; cabling should be minimised; system design should be as much modular as possible and CMRs should be used only when absolutely essential. However, the system supplied by the vendor should satisfy all the functional requirements of this Specification. The Contractor shall supply all the necessary items and provide a complete RTU design that meets all of the Owner's functional requirements defined in this Specification.

In event of the configuration of RTU given in specification undergo changes during detailed engineering, the prices of particular RTU shall also be adjusted based on the unit prices of Transducers, Meters, status Input cards, analog input cards, control output cards, control output relays, CMRs and Modems etc.

Owner may not initially procure all capabilities specified in this document. Regardless of the RTU configuration purchased, the RTUs shall be capable of all functions specified herein with the addition of the necessary hardware and software modules in the field when required by Owner. Each function is presented in sufficient detail to provide the Contractor with as much insight as possible into both the initial and future requirements of the RTUs.

The weather Sensors to be supplied under the project shall be field proven and shall have been in successful operation for meteorological application for at least one year as on date of Bid opening. The Bidder shall furnish the documentary evidence in support of the above and submit the same along with the bid.

1.1 Design Standards

The RTUs shall be designed in accordance with applicable International Electro-technical Commission (IEC), Institute of Electrical and Electronics Engineer (IEEE), American National Standards Institute (ANSI), and National Equipment Manufacturers association (NEMA) standards, unless otherwise specified in this Technical specification. In all cases the provisions of the latest edition or revision of the applicable standards in effect shall apply.

1.2 RTU Functions

All functional capability described herein shall be provided by the Contractor even if a function is not initially implemented. The term master station is used to denote the SCADA systems. As a minimum, the RTUs shall be capable of performing the following functions:

(a) Collecting and processing the digital status inputs, analog inputs, event records, accumulated values and transmitting to master station(s).

(b) Receiving and processing digital & analog control commands from the master station(s).

(c) Accepting polling messages from at least four master station(s) simultaneously using separate logical databases for each master station.

(d) Communication simultaneously on all Communication ports and using multiple concurrent protocols including IEC 60870-5-101, 60870-5-104, IEC 61850, MODBUS (Serial & TCP/IP) and DNP 3.0 (Serial & TCP/IP).

(e) Data transmission rates from 300 to 9600 baud for serial ports (for both IEC 60870-5-101 & MODBUS) and 10/100 Mbps for TCP/IP Ethernet ports.

(f) RTU shall be compatible with protocol 61850 for communication with IEDs.

(g) RTU shall have the capability of automatic start-up and initialisation following restoration of power after an outage without need of manual intervention. All restarts shall be reported to the connected master station(s).

(h) RTU shall have dual redundant CPU and Power Supply unit.

(i) RTU shall support time synchronization through messages received from master station using IEC 60870-5-101 protocol.

(j) RTU shall support downloading of RTU database from the master station using the IEC 60870-5-101 and IEC 60870-5-104 protocol.

(k) RTU shall support SOE (Sequence of events) feature.

(l) Acting as a data concentrator for acquiring data from Slave RTUs, MFMs /MFTs and exercising supervisory control on slave RTUs, MFMs/MFTs using IEC 60870-5-101, IEC 60870-5-104, MODBUS and DNP 3.0 protocols.

(m) RTU shall support acquisition of real time and accumulated real & reactive power values from Energy Meters using MODBUS protocol.

(n) RTU shall be equipped with advanced Cyber Security Features such as Integrated Firewall, User Access Control and Data Encryption etc., implemented as per NERC-CIP.

(o) Harsh environmental coating.

1.3 Communication ports

The RTUs shall support simultaneous communications with multiple independent master stations (SCADA system), maintenance and configuration terminal (Laptop PC), a local logger (printer), Multi-function transducers and Local Data Monitoring System (LDMS)/Logger.

The RTUs shall have the following minimum number of communication ports:

a) Two Ethernet ports for connectivity to Master Station on IEC 60870-5-104.

b) Required number of Ethernet ports (minimum two) for communication with IEDs on IEC 61850, Energy Meters on MODBUS TCP/IP and DNP 3.0 TCP/IP etc.

c) Minimum 2 Nos Serial ports for communication on IEC 60870-5-101 in dual standby mode (with single master) or active/active mode (with dual master).

d) Port(s) required for Cellular Data Communication.

e) One port for the RTU maintenance and configuration terminal.

f) One port for Local Data Monitoring System (LDMS)

g) Required number (minimum two) RS485 ports and/or TCPIP ports for polling Multi-function Meters, Multi-function Transducers using MODBUS, IEC 60870-5-101 protocol in multi-drop (party line) mode or IEC 60870-5-104 protocol. In multi-drop mode maximum 8 No MFTs/MFMs shall be connected to a single port.

It shall be possible to increase the number of communication ports in the RTU by addition of cards, if required in future. The RTU shall respond to independent scans and commands from Master Station, LDMS and Configuration & Maintenance Terminal simultaneously. The RTU shall support the use of a different communication data exchange rate (bits per second) and scanning cycle on each port. The RTU shall be capable of being configured into point to point and party-line communication mode.

1.4 CPU and Power Supply

The RTU shall have redundant CPU and Power Supply unit so that the RTU can communicate with the Master Stations even when one of the redundant units fails. A failover process shall cause the assignment of all the functions of the failed unit to the healthy unit. The failover between the two redundant units shall not require any manual intervention and shall not cause any interruption in the functioning of RTU. The failover process of the CPU shall not take more than 30 seconds after the failure of primary CPU. All the functions of RTU shall be operational within 30 seconds of the failover operation i.e, within one minute from the time of failure of primary CPU. (With optional dual chassis).

1.5 Modems

The modems can be used for establishing communication between RTU and master station over IEC 60870-5-101 protocol. The Contractor shall supply requisite number of PLCC modems to establish communication between RTU and master station(s) (multiple masters including main & backup) as specified in Appendix – B.

The modems for control centre end, complete in all respects including power supply unit & rack shall be supplied. These modems can be located either in the FEP at Control Centre end or at other Communication nodes (Stand Alone Modem).

The modems shall meet the following requirements:

a) Use CCITT Standards including V.24, V.28.

b) Use frequency shift keying (FSK) modulation.

c) Communicate at data rates of 300, 600 and 1200 bps.

d) Use CCITT R.38a, and R.38b standard tones for the selected RTU data rate.

e) Use PLCC bandwidth upto 4 kHz and shall accommodate multiple data channels over and above voice channels.

f) Use both 2-wire and 4-wire communication lines.

g) Receive level adjustable from -8 to -40 dBm @ 600 ohms.

h) Transmit level adjustable from 0 to -24 dBm @ 600 ohms.

i) Have a minimum sensitivity of -48 dBm.

j) Shall operate on 48 VDC power supply

k) Compatible with IEC 60870-5-101 protocol.

1.6 Cellular (GPRS/3G/4G) Modem and Gateway

The RTU shall be equipped with Cellular Modem for data communication with Master Station over IEC 60870-5-101/104. In case PLCC or Optical Fibre network is available at RTU Station, the Cellular Communication Modem will provide a manually switchable redundant communication link to Master Station, which may be enabled by the owner's personnel in the event of failure of PLCC/Optical Fibre network. In such case Cellular Communication will use the same protocol as is used for PLCC or Optical Fibre network. However, in case no PLCC/Optical Fibre network is available at RTU Station, the Cellular Communication will act as main communication link with Master Station. The provision of SIM and payment of data charges for GRPS shall be in the scope of vendor up to operational acceptance; thereafter the monthly data charges for GRPS shall be borne by the owner. The RTU port used for Cellular communication shall be adequately protected and firewalled to avoid any cyber security attacks.

The provision of PLCC or Optical Fibre Network between RTU and Master Station is in the scope of owner, however the supply, installation and commissioning of necessary cabling and Integration of RTU with Master Station(s) using the owner's communication system will be in the scope of contractor.

The contractor shall also provide and integrate the GRPS Gateway at Master Stations (Main & backup). The Gateway shall be equipped with requisite number of RS 232 Ports (minimum 10) for IEC-101 and Ethernet Ports (minimum six) for IEC-104 communication. The Gateway shall have at-least 50% spare ports of each type for future expansion. Provision of Internet connectivity with Static IP address at Master Station end shall be in the Owner's scope. The communication

between RTU and Master Station using Cellular Communication shall be point to point and no intermediate hub shall be used by the contractor to route the Cellular traffic between RTU and Master Station(s). The Gateway shall be equipped with a firewall to avoid any cyber security threat emanating from public Interface used for Cellular traffic.

1.7 Local Configuration & Maintenance Interface

The RTUs shall include the interface to support the portable configuration and maintenance terminal (PCMT). The interface shall provide easy access to allow owner to use the maintenance terminal at the RTUs installed in the field.

1.8 Local Data Monitoring System (LDMS) Interface

The LDMS shall be used for local data acquisition, monitoring and control of substation parameters through RTU. The LDMS shall be a mini SCADA system providing MMI capability for use in the sub-station control room building. The LDMS software shall include following functions:

I. data acquisition for analog, digital, events and pulse accumulator type data

II. data processing – Conversion to engineering units, limit monitoring, data validity test, calculated data

III. Calculated data (such as maximum, minimum, average values with associated time-stamping etc.) of all the station parameters.

IV. Sequence of Events Processing

V. Supervisory control

VI. Alarm, tagging, trending, quality codes etc.

VII. Single Line Diagrams, Trends, daily, weekly, monthly reports etc. shall be prepared by the bidder and integrated on LDMS system. The LDMS shall also have capability to generate additional displays, single line diagrams, reports and trends.

The LDMS shall store all real-time telemetered & calculated data after every 1 minutes (adjustable to 5, 15,30,45,60 minutes). The software and hardware shall be sized for storage of all the above data after every 1 minutes for at least one year duration. All alarms, events, SOE etc. shall also be stored on regular basis. It shall be possible to define daily, weekly, monthly Sub-Station reports on LDMS. It shall be possible to generate reports highlighting the maximum, minimum, average with associated time-stamping etc. of all the station parameters. The historical data stored on the storage medium shall be in standard format and necessary tools for its export to standard spreadsheet programs (Excel and .csv) shall be provided.

The LDMS shall update analog data from RTU by exception or cyclically after every five to sixty seconds (programmable) and status data by exception. The SOE status data shall be recoded with resolution of 1 ms timestamp.

The contractor shall supply separate license for each copy of LDMS software.

1.9 Communication between RTU & MFT/MFM

The MFT/MFMs will act as slave to the RTU. The RTU shall communicate with MFT/MFMs to acquire real time analog data, digital data, and time stamped events and execute control commands issued by the master station. The RTU shall acquire analog data from MFT/MFMs cyclically and digital data by exception. All data from the devices connected on a single port shall be acquired within 5 seconds. The RTU shall have the ability of issuing retry scan to acquire data from the MFT/MFMs in case of communication failure between RTU and MFT/MFMs.

1.10 Communication Protocol between RTU & IEDs

The RTU shall use the IEC 61850 protocol for communication with IEDs over Sub-station LAN. The RTU shall act as a Client and collect digital data and events from the IEDs. The contractor shall be provided an Ethernet Port on the existing IEC 61850 Sub-Station Switch by the owner to connect RTU to the existing Sub-Station LAN. The necessary IED Configuration (.icd and .scd) files required to configure the RTU for communication with IEDs shall be provided by the owner. The list of events to be acquired from IEDs is annexed at Appendix – C.

1.11 Master Station Communication Protocol

The Contractor shall provide a communication protocol for communicating with SCADA master stations using the IEC 60870-5-101 and IEC 60870-5-104 communication protocol standard. The communication protocol shall support all the requirements of this standard. The communication protocol shall be non-proprietary and the Contractor shall provide complete description and documentation of the protocol to Owner.

The RTU shall perform as a slave to SCADA master station when using the IEC 60870-5-101 protocol. All communication shall be initiated by the SCADA master stations. RTU must notify the master stations of unusual conditions at the RTU (such as a power fail/restoration or RTU malfunction), the transfer of changed data etc. All the notifications shall be accomplished within the framework of the periodic data acquisition exchanges.

The RTU shall store the data acquired from the MFT/MFMs & IEDs in its database and do processing like change detection/deadband processing on the data for optimizing its transmission to the Master Station (SCADA Control Centre). The processing shall include requirements of mapping of information from the protocol of MFT/MFM/IEDs to the protocol requirement for communication with Control Center.

The RTU shall process the various messages/commands for communication to the Master station using the following priority.

a) Control command

b) Status data by exception

c) Analog data by exception

d) Analog data periodic

e) Status data integrity scan

The communication interface to the master station(s) shall allow scanning and control of defined points within the RTU independently for each master station using a separate logical database in the RTU. It shall be possible to pick points from the RTU database randomly and assign it for reporting to a Master station. Further, the RTU shall support the use of a different communication data exchange rate (bits per second), scanning cycle, and/or communication protocol to each master station.

1.11.1 Scan groups

Analog and digital input points (including points reported by exception) shall be assignable to scan groups. A scan group shall be a specified set of data points within the RTU central database which will be communicated to a master station when requested by a specific (addressed) scan request. A scan group size shall only be limited by the communication protocol message length. Any RTU input point shall be assignable to any scan group. The RTUs shall support at least sixteen scan groups and all scan groups per communication port (i.e. master station/ LDMS interface). The Contractor shall provide a convenient and flexible scheme for assigning points in the RTU to scan groups.

1.11.2 Reporting of status points

The RTU communication protocol shall be configured to report digital status changes by exception to master station. Digital status data shall have higher priority than the Analog data. All the digital status data shall also be assigned to scan groups for integrity check by Master stations at every 10 minutes.

1.11.3 Reporting of Analog points

The analog data shall be reported periodically to update all the values at the master station within 10 seconds (configurable from 5 to 20 seconds). Analog data shall also be reported by exception if the analog value exceeds its previous value by more than 20% (configurable from 1% to 20% in the RTU).

1.11.4 Digital control commands

The RTU shall follow the select-and-execute sequence for operation of digital control commands from the master station. The RTU shall reset its control logic upon any error in the sequence.

1.12 Data Concentrator Communication Protocol

The RTU shall have the functionality to act as a IEC 60870-5-101 and IEC 60870-5-104 protocol master and collect data and also perform supervisory control from/on the slave RTUs and communicate it to the Control Center. The Master protocol implementation shall be such that the data polling requirements mentioned at section 1.11 is at least accomplished.

In case the RTU is proposed to be used as a Data concentrator as per Appendix – B, it shall be provided with at least four (4) IEC 101 input ports/cards and shall have capability to report to two master stations on IEC 104 interface. Data concentrator shall support at least 1,500 (fifteen hundred) data points. The RTU as a Data Concentrator shall be supplied with GPS receiver system with antenna, cable etc. for time stamping of Data concentrator which in turn shall synchronize the IEC 101 protocol connected RTU/device. The RTU as a Data Concentrator shall come complete with built in monitoring mechanism to avoid loss of any data, especially the one reported by exception. The data concentrator shall have dual CPU and dual Power supply unit. The overall data update requirement from any Sub-RTU to Control centre should not affect the functionality defined elsewhere in the specification.

The Data concentrator shall have the provision for remote login from Control centre. The SLDC computer system shall be able to configure and poll health of Data concentrator from remote on 104 connected interface after due authentication of the users.

It shall support diagnostic & maintenance activities remotely. Individual RTU configuration shall be possible from Data Concentrator including accommodating devices from heterogeneous suppliers. The RTU as a Data Concentrator shall have following communication ports & support for protocols:

i. IEC 104 for SCADA control centers.
ii. IEC101/104 for Sub-RTUs.
iii. IEC 104 for local SCADA

The other requirements given for RTU elsewhere in the specification shall be applicable to RTU as a Data concentrator also

1.13 Analog Inputs

The RTU shall accommodate analog inputs which are unipolar or bipolar, 2-wire ungrounded differential signals. All analog inputs are of +4 to +20 mA. However, the RTU shall be capable of accepting other standard analog input ranges (0 to 5V, 0 to 10V, 0 to 10mA, -10 to +10 mA).

The RTU shall make all appropriate signal level conversion and conditioning to allow full utilization of analog inputs and meaningful reasonability checking. The analog-to-digital converter shall have a minimum resolution of 32767 counts (sign plus 15 data bits). Each type of analog input shall be converted with full resolution. The RTU shall monitor the drift in characteristics of its ADC and mark the analog

points with a drift quality code if a drift is detected. This drift quality code shall be sent to the master station also.

The RTU accuracy, for analog input measurement, shall be 99.8% or better at 25 degree C ambient temperature. Mean accuracy shall drift no more than 0.002% per degree C within the temperature range of –5 to +55 degree C. Determination of accuracy shall be made while the analog multiplexer is operating at rated speed.

Each input shall have suitable protection and filtering to provide protection against voltage spikes and residual current at 50 Hz, 0.1 ma (peak-to-peak) and overload. Loading upto 150% of the input value shall not sustain any failures to the RTU input. The total input impedance offered by the RTU shall not be greater than 250Ω (for +4 to +20 mA range).

All analog inputs shall be scanned by the RTU from the field at least at 1 second periodicity.

1.14 Status Inputs

RTU shall be capable of accepting isolated Dry Contacts, internally wetted @ 48VDC or Wet contact @ 220VDC or 110VDC (±30%) for status inputs. All status inputs shall be wired by the contractor to MFT/MFM or RTU through 220VDC or 110VDC or 48VDC (±30%) Wet Contact wired directly from semaphores in the C&R panels. In case the contacts are wired to MFT/MFM, the status input data shall be reported to RTU with time stamp using IEC – 101/104 or DNP 3.0 protocol. It is the owner's intent to minimise the use of Contact Multiplying Relays (CMRs), in order to minimise the number of components and its associated failures. The contactor shall use CMR to convert wet contact to isolated dry contact only when it is absolutely necessary for satisfactory performance of the system.

For dry contacts, the RTU shall provide necessary sensing voltage, current, optical isolation and de-bounce filtering independently for each status input. The sensing voltage shall not exceed 48 V DC. The sensing voltage source shall be isolated from that of the RTUs logic power so that any noise or a short circuit across the sensing supply of a digital status input terminals would not disrupt the RTU operation other than the shorted digital status input.

The RTU shall be set to capture contact operations of 20 ms or more duration. Operations of less than 20 ms duration shall be considered no change (contact bounce condition). The RTU shall accept two types of status inputs i.e. Single point Status inputs and Double point status inputs.

Single point status input will be from a normally-open (NO) or normally-closed (NC) contact which is represented by 1-bit in the protocol message.

Double point status input will be from two complementary contacts (one NO and one NC) which is represented by 2-bits in the protocol message. A switching

device status is valid only when one contact is closed and the other contact is open. Invalid states shall be reported when both contacts are open or both contacts are closed.

All status inputs shall be scanned by the RTU from the field at 1 millisecond periodicity. The RTU shall store all status changes detected for retrieval by the master stations. For communication delays or short-term failure of communications with a master station, the RTU shall store a minimum of 300 status change events. The RTU shall report any overflow of this status change buffer to the master stations.

1.14.1 Contact Multiplying Relay

Contact multiplying relays (CMRs) may be required to multiply the auxiliary contacts of breaker/isolators etc. The contacts of these relays shall be used to provide status input to the RTUs. The relays shall be of self reset type. The relay shall have a minimum of two changeover contacts each with minimum current carrying capacity of 5 A at 110V/220 V DC.

The relays shall conform to the following requirements:

a) Power frequency withstand voltage: 2 kV for 1 minute as per IEC standards.

b) Insulation resistance of 100 M ohms at 500 V DC.

c) 5 KV Impulse test as per IEC standards

The CMRs shall have a LED indication which shall light up when the CMR is energized (picked up) condition. The CMR coil shall be rated for the voltage existing at the site. The CMRs shall be generally mounted in existing control & Relay panel but in case of non-availability of space, it shall be accommodated in the System Interface Cabinets (being supplied by the Contractor).

1.14.2 Momentary Change Detection

Two-state status input points with momentary change detection shall be used by Owner for points where multiple operations (changes of state) can occur between scans from the master station (such as breakers with auto-reclosing devices that operate faster than the master station scan rate). The RTU shall capture and maintain all of the momentary changes, up to 4 per MCD digital status point. The MCD status input points shall be set to capture operations of greater than 20 ms duration.

Alternatively, the RTU can store and report the multiple state changes of a digital input as discrete events. It shall be ensured that all the changes are reported to the Master station in the sequence in which they occur in the RTU.

1.15 Sequence of Events (SOE) feature

SOE is the time-stamped digital status data. SOEs will enable Owner's personnel to determine the sequential operation of digital status input devices for their state changes. The RTU shall time-stamp the digital status data with a time resolution of one millisecond.

Initially, all breakers, protection contacts digital status input points in the RTU & events captured from IEDs shall be configured as SOE points. However it shall be possible to assign any digital status input data point in the RTU as SOE point.

Each time a SOE status input point changes state, the RTU shall time-tag the change and send it to the Master station. The RTU shall maintain a SOE buffer within the RTU for communication delays and communication failure. SOE buffer shall be sized to store, as a minimum, of 5000 events. The RTU shall transmit the SOE data stored in its buffer to master station. An acknowledgement of receipt by the master station shall be made prior to the loss of any data in the RTU SOE buffer. Data not received at the master station shall be retransmitted. The RTU shall send a message to the master station to indicate the RTU SOE data buffer overflow condition.

1.16 Control Outputs

The RTU shall provide the capability for a master station to select and change the state of digital output points either directly or through MFT/MFM. In case the Control Output is provided through MFT/MFM, the communication between RTU & MFT/MFM shall also support select before operate functionality. Device control will be used by owner to control power system devices including:

(a) Two-state Devices: Circuit breakers, motor-operated switches, auto/manual switches, relay disable/enable, and other two-state devices

(b) Variable Output Devices: Raise/lower control of generators, transformer load-tap-changers (LTC), and other variable output devices.

The RTUs shall have the capability for control outputs as described in the following sections

1.16.1 Two State Momentary Control

A pair of outputs shall be supplied for each two-state (open/close) control output point that drive control relays. One output shall be supplied for open, the other for close. Upon command from a master station using the check-before-execute sequence, the appropriate control output shall be operated for a preset (momentary) time period. The operation period shall be adjustable for each point from 0.1 to 2 seconds.

1.16.2 Raise/Lower Pulse Output

A pair of outputs shall be supplied for each (raise/lower) control output point that drive control relays. One output shall be supplied for raise, the other for lower. When commanded from the master station, the appropriate raise or lower output shall be operated for the selected time interval. The closure time interval for raise/lower pulse output points shall be specified in the operate command from the master station. The raise/lower output for each point shall operate over a range of 0.1 to 4 seconds in a minimum of eight equal increments.

1.16.3 Timed Supervisory Control

The RTU shall store Timed Supervisory control command received from the SCADA system. This supervisory control command from the SCADA system shall contain the 'time' up to a resolution of milliseconds and the type of control Operation.

The RTU shall then perform the supervisory control command at the specified time. The SCADA system shall be able to cancel this command prior to the occurrence of the specified Time of Operation.

1.16.4 Control Output Interposing Relays (Double Contact Digital Output)

Control output interposing relays shall be supplied by the Contractor for each control output specified in Appendix - B. Each control relay shall consist of two isolated single-pole double-throw contacts. The output contacts shall be rated to carry minimum current of 10 amps at 220 V DC, and shall provide arc suppression to permit interruptions of an inductive load. Relay coils shall be shunted with diodes to suppress inductive transients associated with energizing and de-energizing of the relay coils. The relays shall conform to the IEC standards.

1.16.5 Latching (Dummy Breaker) Relay

The Contractor shall provide a latching relay to be used to simulate and test supervisory control from the RTU. The simulation relay shall accept the control signals to open and close from the RTU, and shall provide the correct indication response through a single contact indication input point. This point is not included in the RTU point count in **Appendix - B.**

1.16.6 Control Security and Safety Requirements

The RTU shall include the following security and safety features as a minimum for control outputs:

(a) Select-and-execute sequence for control output.

(b) No more than one control point shall be selected at any given time.

(c) The control selection shall be automatically cancelled if after receiving the "control selection" message, the "control execute" command is not received within the set time period.

(d) The control selection shall be automatically cancelled if after receiving the "control selection" message, the "operate" command is not the next received message and is not received within the set time period.

(e) No control command shall be generated during power up or power down of RTU.

1.16.7 Local/Remote selector switch

A manual Local/Remote selector switch shall be provided for each RTU to disable all control outputs by breaking the power supply connection to the control outputs. When in the "Local" position, the Local/Remote switch shall allow testing of all the control outputs of RTU without activating the control outputs to field devices. A status input indication shall be provided for the Local/Remote switch to allow the SCADA system to monitor the position of the switch. This point is not included in the RTU point count defined in Appendix - B.

1.17 Time facility

The RTU shall have an internal clock with the stability as defined in **Table-1.** The RTU shall be synchronised through synchronisation message from master station at every 10 minutes using IEC 60870-5-101 protocol. The RTU shall support the calculation of the propagation delay dynamically by the Master station. However, all the RTUs shall have a suitable interface for receiving synchronization signals from a local GPS receiver.

The RTUs communicating over IEC-60870-5-104 shall be supplied with a GPS receiver for synchronization of RTU clock.

The RTU shall synchronize its internal clock with the master station system clock when time synchronization messages are available and shall mark all the time stamped information/data as invalid when the RTU clock is not synchronised with the Master station.

1.18 Diagnostic features

The RTU design shall facilitate isolation and correction of all failures. The following features which promote rapid problem isolation and replacement of failed components shall be provided:

a) Self-diagnostic capabilities within each RTU which can be initiated at the RTU site. The diagnostic software shall check for memory, processor, and input/output ports errors and failures of other functional areas defined in the specification of the RTU.

b) On-line error detection capabilities within the RTU and detailed reporting to the connected master station of detected errors. It shall be possible to choose the errors to be sent to the Master station within the framework of the communication protocol.

c) Local indication of major RTU failures

d) A non-volatile event buffer that shall record all fatal errors/restarts/ faults.

1.19 Input DC Power Supply

The RTU will be powered from a 48 V DC (+ve earthed) system. The RTU shall not place additional ground on the input power source. The characteristics of the input DC power supply shall be

(a) Nominal voltage of 48 V DC with operation between 41 and 60 V DC.

(b) Maximum AC component of frequency equal to or greater than 100 Hz and 0.012 times the rated voltage peak-to-peak.

The RTU shall have adequate protection against reversed polarity, over current and under voltage conditions, to prevent the RTU internal logic from being damaged and becoming unstable causing mal-operation.

1.20 Environmental Requirements

The RTU will be installed in control room buildings with no temperature or humidity control. The RTUs shall be capable of operating in ambient temperature from -5 to +55 degree C with rate of temperature change of 20 degree C/hour and relative humidity less than 95%, non-condensing. At some locations, environmental temperature may go below –5 degree C for which the contractor shall take suitable measures for successful operation of RTU.

1.21 Noise level

The audible noise generated by the RTU equipment shall not exceed 50 dbA one meter from the enclosure.

1.22 RTU Size and Expandability

The software and the database shall be sized to accommodate growth within the ultimate sizing parameters as defined in this specification for the RTU without requiring software or database structure regeneration.

The point counts for the RTUs have been defined in the **Appendix - B**. The RTU shall have additional wired available reserve capacity of twenty percent (20%) for each type of points defined in the BOQ. This reserve capacity shall be used without any additional hardware such as I/O cards and terminal blocks.

The RTUs delivered shall have the capability to accommodate additional I/O modules to expand the overall point count of the RTU by a minimum of fifty percent (50%) i.e. 80% more than the actual RTU count defined in the BOQ. The I/O

modules here means Status Input module, Analog input module and the Control output module. Other modules, such as processor module, racks etc. as required to meet the overall expandability requirement defined above shall also be supplied by the contractor.

1.23 RTU and SIC panels

The Contractor shall provide RTU & System Interface Cabinet (SIC) panels. The SIC shall primarily house all MFTs, interposing control relays and interface terminal blocks. However, the owner may at his discretion prefer to install the MFTs/MFMs in the C&R panels and interposing control relays & interface terminal blocks etc., in the RTU panel. In such case no SIC panel may be required. Generally, the SIC shall be mounted adjacent to the RTU panel. However, in a few cases, the SIC may be mounted separately at a different locations. The panels shall meet the following requirements:

(a) Shall be free-standing, floor mounted and height shall not exceed 2100 mm.

(b) Shall have maintenance access to the hardware and wiring through lock-able full height doors.

(c) Shall have the provisions for bottom cable entry

(d) The safety ground shall be isolated from the signal ground and shall be connected to the ground network. Safety ground shall be a copper bus bar. The contractor shall connect the panel's safety ground of to the Owner's grounding network. Signal ground shall be connected to the communication equipment signal ground.

(e) All panels shall be supplied with 230 Vac, 50 Hz, single-phase switch and 15/5A duplex socket arrangement for maintenance.

(f) All panels shall be provided with an internal maintenance lamp, space heaters and gaskets.

(g) All panels shall be indoor, dust-proof with rodent protection, and meet IP41 class of protection.

(h) There shall be no sharp corners or edges. All edges shall be rounded to prevent injury.

(i) Document Holder shall be provided inside the cabinet to keep test report, drawing, maintenance register etc.

(j) All materials used in the enclosures including cable insulation or sheathing, wire troughs, terminal blocks, and enclosure trim shall be made of flame retardant material and shall not produce toxic gasses under fire conditions.

k) The structural frame of the panels shall be of cold rolled sheet steel of thickness not less than 3 mm for the weight bearing members of the panels such as base frame, front sheet & door frames and 2mm for sides, door, top and bottom portions.

(l) All sheet steel work shall be degreased, pickled, phosphated in accordance with IS6005. The phosphate coating shall be sealed with application of two coats of ready mixed, stoving type zinc chromate primer. Two coats of synthetic enamel paint (RAL7032 shade) shall be applied both in the exterior and the interior of the panel.

1.24 Interconnections

All cabling between component units of the RTU, RTU to interface cabinet, RTU to MFTs/MFMs and to the Owner control and relay panels (located in the substation control room) shall be supplied and installed by the Contractor and shall be shown on Contractor supplied drawings. Plug-type connectors with captive fasteners or compression type connectors shall be used for all internal interconnections. The connectors shall be polarized to prevent improper assembly. Each end of interconnection cables shall be identified by a marker which includes the cable number and the identifying number and location of each of the cable's terminations. This information shall match with the Contractor's drawings.

Adequate space and hardware shall be provided for routing of the field wiring within the enclosures. Contractor wiring within enclosures shall be neatly arranged and shall not be directly fastened to the enclosure frame. All internal interconnection wiring and cables shall be routed separately from field wiring to the RTU terminals & power wiring. All wiring shall use copper conductors and have flame retardant insulation. Conductors in multi-conductor cables shall be individually colour coded.

The use of non-flammable, self-extinguishing, plastic wire troughs is permissible. Metal clamps must have insulating inserts between the clamps and the wiring. Wiring between stationary and movable components, such as wiring across door hinges or to components mounted on extension slides, shall allow for full movement of the component without binding or chafing of the wiring.

1.25 Wiring/Cabling requirements

Shielded (screened) cables shall be used for external Cabling from the RTU/ SIC panels. These external cables (except communication cables) shall have the following characteristics:

a) All cables shall have stranded copper conductor.

b) Minimum core cross-section of 2.5 mm^2 for PT cables, 4 mm^2 for CT cables and 2.5 mm^2 for Power & Control outputs and 1.5mm^2 for Digital Status inputs, transducer mA current output

c) Rated voltage Uo/U of 0.6/1.1KV

d) External sheathing of cable shall have oxygen index not less than 29 & temperature index not less than 250. Cable sheath shall meet fire resistance test as per IS 1554 Part- I.

e) Shielding, longitudinally laid with overlap.

f) Dielectric withstand 2.5 kV at 50 Hz for 5 minutes

g) External marking with manufacture's name, type, core quantity, cross-section, and year of manufacture.

The Communication cable shall be of shielded, twisted pairs and of minimum 0.22sq mm size.

1.26 Terminal Blocks

Terminal blocks shall be having provision for disconnection (isolation), with full-depth insulating barriers made from moulded self-extinguishing material. Terminal blocks shall be appropriately sized and rated for the electrical capacity of the circuit and wire used. No more than two wires shall be connected to any terminal. Each analog input signal, digital status input and digital output signals shall require two terminals per point plus a common shield termination for each cable.

All terminal blocks shall be suitably arranged for easy identification of its usages such as CT circuits, PT circuits, analog inputs, status inputs, control outputs, auxiliary power supply circuits, communication signals etc.

Terminal Blocks for CT circuits shall have feature for CT shorting (on CT side) & disconnection (from load side) to facilitate testing by current injection. Similarly, TBs for PT circuit shall have feature for disconnection to facilitate voltage injection for testing.

1.27 System Architecture

Bidder has the option to offer RTUs having following system architectural design:

a) Centralized RTU design where all I/O modules are housed in RTU panel and communicating with master station through communication port.

b) Distributed RTU design where I/O modules are contained in the respective MFT/MFM and are housed in respective bay C&R panels. The RTU shall acquire analog and digital data from these MFTs/MFMs over standard protocols such as IEC – 101/104 or DNP 3.0 for further communication with master station.

The bidder shall asses the requirement of RTU/SIC panels based on the system design and supply panels accordingly.

1.28 Transducer & Weather Sensor Requirements

All transducers shall use a 48 V DC auxiliary power supply as provided for the RTU. All transducers shall have a maximum power consumption of 10 watts.

1.28.1 Transducer Protection

The input, output and auxiliary circuits shall be isolated from each other and earth ground. The transducer output shall be ungrounded and shall have short circuit and open circuit protection. The transducers shall comply with the following requirements, in addition to the requirement of IEC 60688, without damage to the transducer:

(a) Electromagnetic Compatibility: IEC 61000-4-3, Level 1

(b) Electromagnetic Compatibility: IEC 61000-4-4, Level 1

(c) Shock Resistance: Minimum severity 50 A, IEC 68-2-27 requirements

(d) Vibration Strength: Minimum severity 55/05, IEC 68-2-6 requirements.

(e) Input Circuit Consumption: Less than 0.5 VA for voltage and current circuits.

1.28.2 Multi-function Transducer

The Multi-function Transducers shall be used for acquiring real time analog & digital inputs and issuing digital output commands. The transducers shall be capable of bi-directional measurements as shall comply to the following specifications:

i. Wiring Configuration: 3 phase 4 wire /3 phase 3 wire ,CT/PTs circuits.
ii. Nominal Input Voltage : 110 V (Ph- Ph voltage)
iii. CT Input: 1A/5A (per phase current).
iv. Display: Single line, bright LCD.
v. PT ratio and CT ratio should be programmable at site.
vi. CT Withstand Capacity: 3 times RMS continuous and at least 20 times for 1 sec.
vii. CT Burden : < 0.1 VA
viii. Voltage Withstand Capacity: 1 kV Continuous and 2 KV for 1 sec.
ix. PT Burden : < 0.15 VA
x. Communication Speed: < 50 milli-sec.

The Multi-function Transducer shall have a local single line display to show the real time electrical parameters being acquired by the meter. The parameter(s) to be displayed shall be selectable through a push button.

Display parameters :

i. Three Phase Voltage
ii. Three Phase Current
iii. Frequency
iv. Per Phase & Total Power Factor (PF).,Lag/Lead
v. Per Phase & Total Active Power (MW),Import /Export
vi. Per Phase & Total Re-active Power (MVAR) Import/Export
vii. Per Phase & Total Apparent Power (MVA)
viii. Import & Export Energy

The Multi-function Transducer shall comply to the EMI/EMC level test requirements as specified for the RTU except for Fast transient burst test requirement which shall be for level 4. The test reports shall be submitted by the vendor during detailed engineering.
Mutli function transducers shall provide at least the following parameters as a minimum with the specified accuracies.

Sr. No.	Parameter	Accuracy
(i)	Voltage	±0.2%
(ii)	Current	±0.2%
(iii)	Frequency	± 0.02%
(iv)	Active Power/Reactive power	±0.2%
(v)	Power Factor (measuring range shall be 0.6 to 1.0 lag & lead)	

The parameters to be acquired from multifunction meters shall be selectable. MFT shall provide the 15 minute values (configurable 5minute/15 minute/1 hour) of Active Energy Import, Active Energy Export, Reactive Energy Import and Reactive Energy Export.

i. Accuracy Standard For Analog Signal : IEC60688 ,0.2
ii. Accuracy Standard For Energy : IS 14697/IEC 62053 : 22 ,0.2S
iii. Aux. Power Supply : 48VDC/110 VDC/220 VDC
iv. Communication Port : Isolated RS 485
v. Communication protocol : Modbus RTU
vi. Mounting : DIN rail mounted.

Optional Features:

i. Digital Inputs having dry contact Potential free or wet contact 48/110/220 VDC
ii. Digital Outputs

iii. Communication Port : Isolated RS 485 Serial / Ethernet
iv. Communication Protocol : IEC 60870-5-101/104 & DNP 3.0

1.28.3 Multi-function Meter

The Multi-function Meters shall be used for acquiring real time analog & digital inputs and issuing digital output commands. The meters shall be capable of bi-directional measurements as shall comply to the following specifications:

i. Wiring Configuration : 3 phase 4 wire /3 phase 3 wire ,CT/PTs circuits.
ii. Nominal Input Voltage : 110 V (Ph- Ph voltage)
iii. CT Input : 1A/5A (per phase current).
iv. Display : Three display simultaneously, bright LED .
v. Display Size : min. 12 mm
vi. PT ratio and CT ratio should be programmable at site.
vii. CT Withstand Capacity : 3 times RMS continuous and at least 20 times for 1 sec.
viii. CT Burden : < 0.1 VA
ix. Voltage Withstand Capacity : 1 kV Continuous and 2 KV for 1 sec.
x. PT Burden : <0.15 VA
xi. Communication Speed : < 50 milli-sec.

The Multi-function Meter shall have a local display to show all the real time electrical parameters. The parameters being displayed shall be selected through a push button and auto scroll basis.

Display parameters :

i. Three Phase Voltage
ii. Three Phase Current
iii. Frequency
iv. Per Phase & Total Power Factor (PF).,Lag/Lead
v. Per Phase & Total Active Power (MW),Import /Export
vi. Per Phase & Total Re-active Power (MVAR) Import/Export
vii. Per Phase & Total Apparent Power (MVA)
viii. Energy parameters.

The Multi-function Meters shall comply to the EMI/EMC level test requirements as specified for the RTU except for Fast transient burst test requirement which shall be for level 4. The test reports shall be submitted by the vendor during detailed engineering.

Mutli function Meter shall provide at least the following parameters as a minimum with the specified accuracies.

Sr. No.	Parameter	Accuracy
(i)	Voltage	±0.2%
(ii)	Current	±0.2%
(iii)	Frequency	± 0.02%
(iv)	Active Power/Reactive power	±0.2%
(v)	Power Factor (measuring range shall be 0.6 to 1.0 lag & lead)	

The parameters to be acquired from multifunction meters shall be selectable. MFM shall provide the 15 minute values (configurable 5minute/15 minute/1 hour) of Active Energy Import, Active Energy Export, Reactive Energy Import and Reactive Energy Export.

vii. Accuracy Standard For Analog Signal : IEC60688 ,0.2
viii. Accuracy Standard For Energy : IS 14697/IEC 62053 : 22 ,0.2S
ix. Aux. Power Supply : 48VDC/110 VDC/220 VDC
x. Communication Port : Isolated RS 485
xi. Communication protocol : Modbus RTU
xii. Mounting : Flush Panel

Optional Features:

v. Digital Inputs having dry contact Potential free or wet contact 48/110/220 VDC
vi. Digital Outputs
vii. Communication Port : Isolated RS 485 Serial / Ethernet
viii. Communication Protocol : IEC 60870-5-101/104 & DNP 3.0

1.28.4 Transformer Tap Position Transducer

The existing transformer tap position indications are of two types.

(i) Variable resistance type

(ii) Lamp type

The Contractor shall provide suitable resistance tap position transducers which shall have the following characteristics

(a) The input measuring ranges shall be from 2 to 1000 ohms per step, which is tuneable at site with at least 25 steps.

(b) Dual output signal of 4 to 20 mA DC, 0.5% accuracy class as per IEC 688 shall be provided. One output will be used for driving a local digital indicator (to be provided by the contractor) and the other will be used for interfacing with the RTU.

(c) In case of lamp type, additional resistance/potentiometer unit shall be provided to convert the dry type contacts to a variable resistance as defined in (a) above, suitable for the remote indication.

1.28.5 Weather Sensors

All weather sensors shall be maintenance free and of Industry standard design. The weather sensor shall be a robust ultrasonic sensor with aluminium alloy construction. The sensor shall be a solid-state device with no moving parts, and shall use ultrasonic measurement technology. The robust aluminium alloy housing shall be hard-anodised to ensure suitability in harsh environments. The sensors shall be supplied with the complete support/mounting structure as required. The sensor, support structure shall have built-in protection against lightning stroke/electrical surges etc.

The weather sensor shall be supplied along with necessary accessories for installation/ fixing of sensors, signal/power cables etc. as part of weather sensors. All the accessories shall be made of material having sufficient mechanical strength and corrosion resistance to withstand atmospheric temperature, pressure, wind speed and relative humidity up to the working range (Minimum to Maximum) of sensors for these parameters as defined.

The Owner will prefer to install the sensors on roof top of control centre/substation or other building. The mounting arrangement for all the sensors shall be designed suitably for installation on the roof top.

The weather sensor shall have the following specifications:

1.28.5.1 Wind Speed

Range	:	0.1 m/s to 60 m/s
Accuracy	:	± 3% to 40 m/s, ± 5% to 60 m/s
Resolution	:	0.01 m/s
Starting Speed	:	0.1 m/s
Sampling Rate	:	1 Hz
Units	:	m/s, km/hr, mph, kts, ft/min

1.28.5.2 Wind Direction

Range	:	0-359°
Accuracy	:	± 3° to 40 m/s ± 5° to 60 m/s
Resolution	:	1°
Sampling Rate	:	1 Hz
Units	:	Degrees

1.28.5.3 Temperature

Range	:	-40°C to +70°C
Resolution	:	0.1
Accuracy	:	± 0.3°C @ 20°C
Sampling Rate	:	1 Hz
Units	:	°C, °F, °K

1.28.5.4 Humidity

Range	:	0-100%
Resolution	:	1%
Accuracy	:	± 2% @ 20°C (10%-90% RH)
Sampling Rate	:	1 Hz
Units	:	% Rh, g/m3, g/Kg

1.28.5.5 Global Solar Radiation

Wavelength Sensitivity	:	300 to 3000 nm
Output Range	:	0 to 1600 w/m²
Resolution	:	1 w/m²
DIN Standard	:	ISO 9060 Second Class
Sampling Rate	:	1 Hz
Units	:	w/m²

1.28.5.6 Outputs

Output rate	:	1/s, 1/min, 1/hr
Digital Communication	:	Serial RS232, RS422, RS485, SDI-12, NMEA, MODBUS, ASCII

1.28.5.7 Environmental Conditions

IP Rating	:	IP 66
Operational Temperature	:	-40°C to +70°C
EMC Standard:	:	BS EN 61326 : 2013 FCC CFR47 parts 15.109
CE Marking	:	YES
RoHS compliant	:	YES

1.29 Portable Configuration and Maintenance Terminal (PCMT)

Contractor shall supply a Portable Configuration and maintenance Terminal (Laptop PC) which shall provide followings capabilities:

(a) RTU Data base configuration & Maintenance

(b) Local Operator Interface & RTU Diagnostics

(c) Master Station and RTU simulator cum protocol analyzer

(a) RTU Data base configuration

The **RTU database Configuration** software being supplied with the PCMT shall have the following features

i) Full graphics windows User Interface

ii) Standard editing capabilities e.g. cut, paste, copy, sorting etc.

iii) Capable of controlling revisions of various RTU database files and storing multiple versions of databases for all the RTUs.

iv) Capable of uploading database from the RTU and compare that with another version of database stored in the PCMT.

v) Provide standard template for database modelling required for I/O modules, MFTs & IEDs, communication setting.

vi) Provide mapping of the individual data points acquired from one protocol to another protocol for transmission.

The database configuration software shall use the same terminology for configuration of the various protocol parameters as specified in the communication protocol standard i.e. it shall be possible to define these parameters by the user discreetly. Also it shall be possible to select an ASDU type to be used for transmission of a measurand e.g. measured value to be transmitted as ASDU 9 or ASDU 11.

(b) Local Operator interface and RTU diagnostics

The Local **Operator interface** software shall support operator inquiries to demand current status and data values of various RTU points, or an overall substation snap-shot, or of the status change buffer.

The local operator interface software shall provide the following reports:

i) Status Reports: Display of all substation status indications, of all tele-metered values, and the RTU's status.

ii) Event Report: Display all the stored events in the event buffer of the RTU.

iii) Print Request: Provide user interface for requesting print out of the Reports on the Logger

iv) Maintenance activities: User interface for interacting with the RTU for maintenance activities like diagnostics, database online requests.

The **RTU** shall have inbuilt features for monitoring the healthiness of the RTU modules and detecting the type of error. The **diagnostics software** shall have diagnostics for the RTU's processor(s), memory, I/O ports, and any other functional

areas of the RTU. It shall list the errors recorded by the RTU and provide troubleshooting tools for the RTU.

(c) Master station-cum-RTU simulator & protocol analyzer software tool

The Master station and RTU simulator cum Protocol Analyser software shall be used to monitor and test the RTU's operation using the master station communication protocol. It shall have the following features

i) capable of emulating both the master station and the RTU messages in all the communication protocols used in the RTU, subject to the minimum of IEC 60870-5-101, 104 & MODBUS. When the Master station and RTU simulator cum Protocol Analyser software has received or transmitted a message, it shall be possible to immediately "turn around" and transmit or receive a response message.

ii) capability of interfacing to digital side of the RTU for the above purpose.

iii) capable of receiving single and repeated messages using the supplied RTU communication protocol. Each received message shall be checked for validity, including the checksum code. The messages shall be displayed in HEX format or in the 'interpreted form' as desired by the user. It shall maintain and display error counters so that the number of errors during a period of unattended testing can be accurately determined.

iv) capable of formatting and transmitting, both as one-time and periodic transmissions, any master station-to-RTU command.

v) capable of preparing illegal messages, such as messages having invalid check codes, for transmission.

The Master station and RTU simulator cum Protocol Analyser software shall also be capable of passively monitoring all communication traffic on a channel without interfering with channel operation.

Channel traffic captured in the active or passive modes of operation shall be displayed. All fields of a message shall be displayed. A pass/fail indication for the security check code shall be included with each code displayed.

1.30 TESTING

1.30.1 RTU/SIC Testing

(a) <u>Type Testing</u>

A complete integrated unit shall be type tested to assure full compliance with the functional and technical requirements of the Specification. The testing sample shall include at least one of each type of cards/modules and devices. The list of Type

tests to be performed on the RTU/SIC is mentioned in **Table-2** & type test requirements are mentioned in **Table-3**.

The contractor may optionally submit type test reports for all the EMI/EMC tests conducted at accredited laboratory for review & approval by Owner. However, in the event, the type test reports are not meeting the specification requirement, Owner may ask for the type testing of any or all of the above tests as required at no additional cost to the owner.

The type test of RTU w.r.t. functional tests shall be carried out in all cases. Contractor shall commence commercial production of RTUs/SICs after successful completion of all type tests and approval from Owner.

Further, type test reports for meters, transducers and relays shall be submitted as per relevant standards. All weather sensors shall be calibrated as per Indian Metrological Department standards and certificate shall be submitted in this regard.

(b) Routine Testing

Each complete unit shall undergo routine testing. The list of Routine tests to be performed in the factory is mentioned in **Table-2**.

(c) Field Tests

After RTU/SIC panel installation and interface cabling with C&R panels and communication equipment, the Contractor shall carry out the field-testing. The list of field tests is mentioned in **Table-2**.

(d) Availability Tests

After field testing, RTU/SIC shall exhibit 98% availability during test period of 500 hours. Availability tests shall be performed along with Master station. The RTU/SIC shall be considered available only when all its functionality and hardware is operational. The non-available period due to external factors such as failure of DC power supply, communication link etc., shall be treated as hold-time & availability test duration shall be extended by such hold time.

Table-1: Technical Particulars of RTU

Sl. no.	Item Description	Value	Remarks
1	Data transmission rate	300 to 9600 bps for serial port & 10/100 Mbps for Ethernet port.	Configurable
2	**Communication ports**	Minimum following Ports : ▪ 2 Ethernet port for comm. with master stations on IEC-104 ▪ 2 Ethernet ports for comm. with IEDs, Energy Meters. ▪ 2 RS232 ports for comm. with master stations on IEC-101. ▪ 1 Port for Cellular Data Communication. ▪ 1 Port for RTU configuration & Maintenance tool ▪ 1 port for LDMS ▪ 1 Optical comm. Port ▪ 2 RS 485 ports for polling MFMs/MFTs/ Energy Meters	
3	Communication protocol with Master stations	IEC 60870-5-101/ 104	
4	Communication Protocol with LDMS	IEC 60870-5-104	
5	Communication Protocol with MFTs/MFMs/Energy Meters	MODBUS/IEC 60870-5-101/104 or DNP3.0	
6	Communication Protocol with IEDs	IEC 61850	

7	Status data transfer to Master station	by exception	
8	Analog data transfer to Master station	Normally Periodic For major change – by exception	
9	No. of Scan Groups supported	16	
10	No. of Separate Logical Database for each Master Station	4	
11	RTU shall be able to capture contact operations	of 20 ms or more dura-tion.	
12	SOE buffer size	at least 5000 events	
13	Time stamping accuracy for SOE	1 ms	
14	Supporting Control of Devices	Two state & OLTC capacitors	
15	Downloading of RTU database from master station	Supported	
16	Nominal Power supply voltage	48V DC	
17	Compliance to cl. 1.28.1 – Transducer Protection	Yes	
18.	Advanced Cyber Security Features such as Integrated Firewall, User Access Control and Data Encryption etc., as per NERC-CIP.	Supported	

Table-2: List of Tests on RTU/SIC

Test Nos.	DESCRIPTION OF THE TEST	Type test	Routine test	Field test
	FUNCTIONAL TESTS FOR RTU/SIC			
1.	Check for BOQ, Technical details, Construction & Wiring as per RTU/FRTU/SIC drawings	√	√	√
2.	Check for RTU database & configuration settings	√	√	√
3.	Check the operation of all Analog inputs, Status input & Control output points of RTU/SIC	√	√	√
4.	Check operation of all communication ports of RTU/FRTU	√	√	√
5.	Check for communication with master stations or master station simulator for RTU/ FRTU	√	√	√
6.	Test for downloading of RTU database from Master station	√		
7.	Test for RTU time synchronization from Master	√		√
8.	Test Power Supply Voltage Margin, Ripple Levels and Short Circuit Protection	√		
9.	Test for RTU operation with DC power supply voltage variation	√		
10.	Check for auto restoration of RTU on DC power recovery after its failure	√	√	√
11.	Test for RTU/ FRTU diagnostic feature	√		
12.	Test for RTU SOE feature	√		
13.	RTU Analog accuracy test for analog input	√		
14.	Transducer accuracy test	√	√	
15.	Test for IEC 60870-5 -104, 61850 & Modbus protocol implemented	√		
16.	Test for RTU internal Clock stability	√		
17.	Test for RTU Noise level measurement	√		
18.	Test for Control Security and Safety for Control outputs	√		
19.	Other functional tests as per technical specification requirements	√		
20.	End to end test (between RTU/ FRTU & Master station) for all I/O points			√
	EMI/EMC IMMUNITY TESTS FOR RTU/ FRTU			
21.	Surge Immunity Test as per IEC 60870-2-1	√		
22.	Electrical Fast Transient Burst Test as per IEC-60870-2-1	√		
23.	Damped Oscillatory Wave Test as per IEC 60870-2-1	√		
24.	Electrostatic Discharge test as per IEC 60870-2-1	√		
25.	Radiated Electromagnetic Field Test as per IEC 60870-2-1	√		
26.	Damped Oscillatory magnetic Field Test as per IEC-60870-2-1	√		
27.	Power Frequency magnetic Field Test as per IEC-60870-2-1	√		
	INSULATION TEST FOR RTU/ FRTU			
28.	Power frequency voltage withstand Test as per IEC 60870-2-1	√		
29.	1.2/50 µs Impulse voltage withstand Test as per IEC 60870-2-1	√		
30.	Insulation resistance test	√		
	ENVIRONMENTAL TEST FOR RTU/ FRTU			
31.	Dry heat test as per IEC60068-2-2 / 2-3	√		
32.	Damp heat test as per IEC60068-2-78	√		
33.	Cold Test as per IEC60068-2-1	√		

Note: Test levels for above type tests are elaborated in Table 3

Table-3: RTU Type Test Requirements

Test Nos.	Test Name	EUT Status	Test Level	Power Supply Points		I/O Points	Passing Criteria
				CM	DM	CM	
1	Surge Immunity Test	ON	Level 3	2 kV	1 kV	2 kV	A
2	Electrical Fast Transient Burst Test	ON	Level 3	2 KV	-	1 kV	A
3	Damped Oscillatory Wave Test	ON	Level 3	2.5 kV	1 kV	2.5 kV	A
4	Electrostatic Discharge Test	ON	Level 3	+/- 6 kV in Contact discharge mode or +/- 8 kV in Air discharge mode			A
5	Radiated Electromagnetic Field Test	ON	Level 3	10 V/m electric field strength			A
6	Damped Oscillatory Magnetic Field Test	ON	Level 3	30 A/m at 1MHz of magnetic field strength			A
7	Power frequency magnetic field	ON	Level 3	30 A/m of magnetic field strength (Continuous duration sine wave)			A
8	Power frequency voltage withstand	OFF	-	1 KVrms for 1 minute			No break down or flashover shall occur
9	1.2/50µs impulse voltage withstand	OFF	-	2 kVp			No break down or flashover shall occur
11	Insulation Resistance Test	OFF	-	Measure Insulation resistance using 500 V DC Megger before & after Power Freq & Impulse voltage withstand tests			As per manufacturer standard
12	Dry heat test	ON	-	Continuous operation at 55^0 C for 16 hrs			0
13	Damp heat test	ON	-	at 95% RH and 40^0 C for 16 hrs			0
14	Cold test	ON	-	Continuous operation at 0^0 C for 96 hrs			0

Note:-

1. EUT - Equipment Under Test
2. CM - Common Mode; DM - Differential mode
3. I/O pints do not include Communication ports
4. Passing Criteria
   0 - no failure: normal performance within the specified limits
   A : minor failure : temporary degradation or loss of function or performance which is self-recoverable
5. Functional test as per the sl. nos. 1-18 of Table-2 shall also be done during type testing.

APPENDIX – A

INTEROPERABILITY PROFILE

I/O Count For RTU - Appendix-B

S.No.	Name of the Sub-station /Power House	Communication with Master Station(s)				LDMS Required (Yes/No)	Data Concentrator Functionality Required. (Yes/No)	AI & Transducers					DI (Digital Status input)						No. of Double Contact Digital Outputs
								MFT/MFM (MODBUS/IEC 60870-5-101/104)			Weather Sensor (Yes/No)	OLTC Transducers (4-20 mA)	No. of Double Status Points CB (NO & NC)		No. of Single Status Points (Protection/ Isolator/ES/Alarm)		Event Logging		
		Protocol (IEC 60870-5-101/104)	Primary Media (OPGW/ PLCC etc.)	Secondary Media (OPGW/ PLCC etc.)	Tertiary Media (OPGW/ PLCC/ Cellular)			Total No. of Bays	Total No. of MFM/ MFT	Aux. Power Supply for MFM/MFT (48/110/ 220V DC)			Dry Potential free Contacts (CMR Required)	Wet Contacts (CMR not Required)	Dry Potential free Contacts (CMR Required)	Wet Contacts (CMR not Required)	Single Status Points (Hard-Wired through CMRs)	No. of IEC 61850 IEDs to be Integrated	
Total								0		0	0	0	0		0	0		0	

Notes:

1. Integartion of RTU with owner's Communication OPGW/PLCC equipment or Cellular Network including supply of necessary hardware (Modems, Switches etc) and Cabling etc. at Sub-Station as well as at the Control Centre(s) end is in the scope of vendor.

2. The IO Count depicted in this document is tentative and may very during actual site survey. The RTU shall be supplied as per the IO Count finalised during detailed engineering after site survey.

APPENDIX - C

LIST OF POINTS TO BE INTEGRATED WITH RTU FROM NUMERICAL RELAYS

A) Common for Substation/Power House.

1. ACDB Incomer-I On/Off (hard wired to RTU)
2. ACDB Incomer-II On/Off (hard wired to RTU)
3. 415V Bus-I/II U/V (hard wired to RTU)
4. 415V bus coupler breaker on/off (hard wired to RTU)
5. DG set bkr on/off (hard wired to RTU)
6. Alarm/trip signals for DG set (hard wired to RTU)
7. LT transformer-I Bunchholz Alarm & trip (hard wired to RTU)
8. LT transformer-I WTI Alarm & trip (hard wired to RTU)
9. LT transformer-I OTI Alarm & trip (hard wired to RTU)
10. PLCC exchange fail (hard wired to RTU)
11. Time sync. Signal absent (hard wired to RTU)
12. Battery Voltage (hard wired to RTU)
13. 220v DC-I earth fault(hard wired to RTU)
14. 220v DC-II earth fault(hard wired to RTU)

B) LINE BAYS/BUS COUPLER/TRANSFORMER BAYS

1. Status of each pole of CB. (from relay)
2. Status of Isolator, Earth switch (**from relay/hard wired to RTU**)
3. CB trouble (from relay)
4. CB operation/closing lockout (from relay)
5. Pole discrepancy Operated.
6. Trip coil faulty (**hard wired to RTU)**
7. LBB Operated (from relay)
8. Auto-reclosure operated (from relay)
9. Auto-reclosure lockout (from relay)
10. Main I/II blocking (from relay)
11. Main I/II-Inter trip send (from relay)
12. Main I/II-Inter trip received (from relay)
13. O/V STAGE – I operated (from relay)
14. O/V STAGE – II operated (from relay)
15. MAIN-I/II CVT FUSE FAIL(from relay)
16. MAIN-I PROTN TRIP (from relay)
17. MAIN-II PROTN TRIP (from relay)
18. MAIN-I PSB ALARM (from relay)
19. MAIN-I SOTF TRIP (from relay)
20. MAIN-I R-PH TRIP (from relay)
21. MAIN-I Y-PH TRIP (from relay)
22. MAIN-I B-PH TRIP (from relay)
23. MAIN-I START (from relay)
24. MAIN-I/II Carrier aided trip (from relay)
25. MAIN-I/II fault in reverse direction (from relay)
26. MAIN-I/II ZONE-2 TRIP (from relay)
27. MAIN-I/II ZONE-3 TRIP (from relay)
28. MAIN-I/II weak end infeed Operated (from relay)
29. MAIN-II PSB alarm (from relay)
30. MAIN-II SOTF TRIP (from relay)

31. MAIN-II R-PH TRIP (from relay)
32. MAIN-II Y-PH TRIP (from relay)
33. MAIN-II B-PH TRIP (from relay)
34. MAIN-II start (from relay)
35. MAIN-II carrier aided trip (from relay)
36. MAIN-I/II fault in reverse direction (from relay)
37. Back-up o/c Operated (from relay)
38. Back-up e/f Operated (from relay)
39. Overflux Alarm (from relay)
40. Overflux Trip (from relay)
41. Bus Cvt Fuse FAIL (from relay)
42. OTI Alarm/Trip (from relay)
43. WTI Alarm/Trip (from relay)
44. PRD Operated. (from relay)
45. OVERLOAD Alarm (from relay)
46. BUCHOLZ Trip (from relay)
47. 220V DC-I/II source fail (hard wired to RTU)
48. PLCC Protection Channel-I FAIL (from relay)
49. PLCC Protection Channel-II FAIL (from relay)
50. Bus Bar Operated (from relay/hard wired to RTU)

C) GENERATOR / TRANSFORMER BAYS

1. 86 A Trip (From Relay)
2. 86 C Trip (From /Relay)
3. 86 D Trip (From Relay)
4. CB Open close status (hard wired to RTU)
5. Field Breaker Open/Close status (From Relay)
6. Excitation Trip
7. Main-I/II Generator Differential (87G)
8. Main-I/II Overall Differential Protection(87GT)
9. Main-I/II Stator Earth Fault (64G1)
10. Main-I/II Stator Earth Fault 100% (64G2)
11. Main-I/II Field failure (40G)
12. Main-I/II Reserve Power Protection (32G)
13. Main-I/II Negative Phase sequence stage-I (46G)
14. Main-I/II Negative Phase sequence stage-I I(46G)
15. Main-I/II Stator winding Inter-turn (59G)
16. Main-I/II back up Impedance (21G)
17. Main-I/II Generator Overload (51)
18. Instantaneous over Voltage (59 G3)
19. Main-I/II Over flux (V/F) trip Stage-I (99GT)
20. Main-I/II Over Flux (V/F) trip Stage-II (99GT)
21. Main-I Rotor earth fault stage-I
22. Main-I Rotor Earth fault stage-II (64R)
23. Main-I/II GT REF Protection Trip(64TR)
24. Dead machine Protection (27/50G)
25. Main-I/II Under Frequency trip (81U)
26. Main-I/II Over Frequency Trip (81O)
27. Main-I/II Pole Slip Protection (98G)
28. Over Voltage stage-I (59G1)
29. Main-I/II Under voltage Protection.
30. Generator Over Speed
31. Governor failure