



**MODEL TECHNICAL SPECIFICATION
FOR
REMOTE TERMINAL UNIT (RTU)
&
LOCAL DATA MONITORING SYSTEM (LDMS)**



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1. GENERAL INFORMATION

This document contains the specifications for the Remote Terminal unit (RTU), Local Data Monitoring System (LDMS) and associated equipment. The Bidder shall provide the complete RTU and LDMS under the scope of supply.

The dual output type transducers/MFTs/Energy Meters are included in the Control and Relay panels and Remote Tap Changer Control (RTCC) Panels. One of the output from these transducers shall be used for wiring to the RTU. Similarly potential free contacts for status signal from control and relay panels are to be used for further wiring to RTU. The Bidder shall be responsible for supplying all hardware, software, installation, cabling and field implementation for RTU and LDMS as defined in this Specification. The Bidder shall also provide complete documentation, training and testing to fully support the hardware and software provided.

Owner may not initially procure all capabilities specified in this document for RTU. Regardless of the RTU configuration purchased, the RTU shall be capable of providing all functions specified herein with the addition of the necessary hardware and software modules in the field when required by Owner.

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

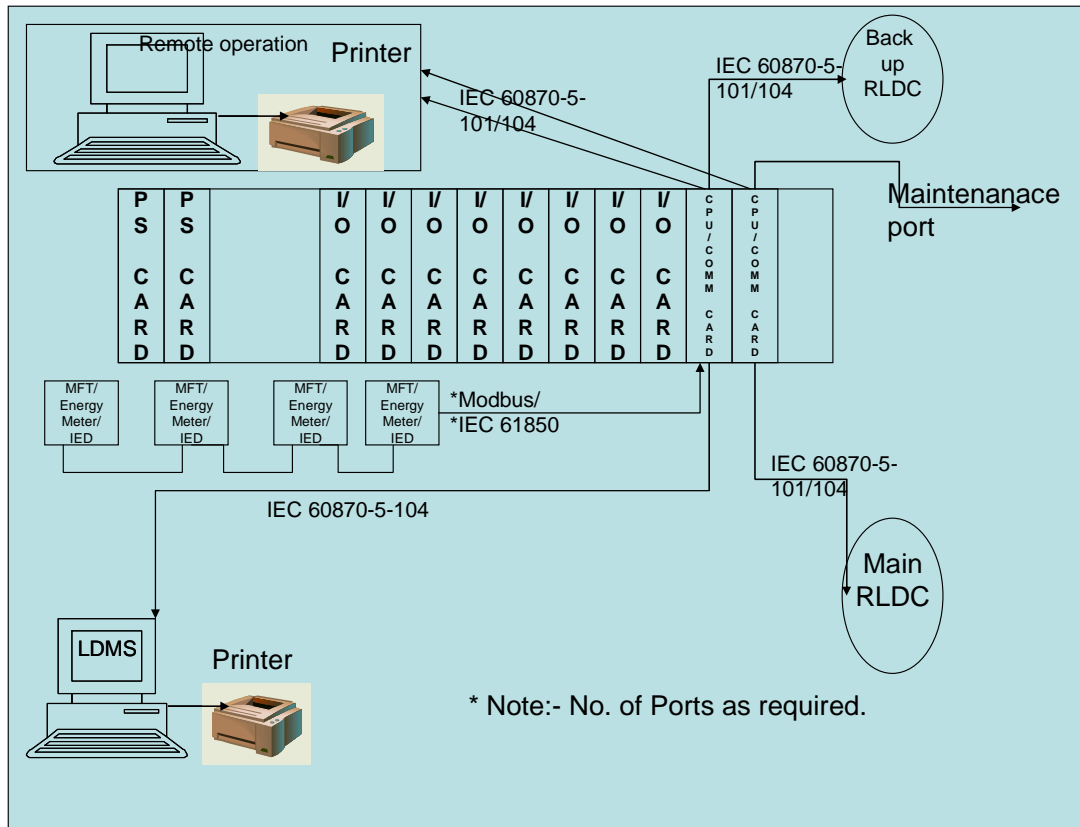
The RTU shall be used for real-time supervision and control of substation/ power plant through owner's Control centres.

See **Exhibit 1-1** for a block diagram of the RTU its interface.

It is Owner's intent that the Bidder uses as much standard hardware and software as possible; however, all of the functional requirements of this Specification must be satisfied. The use of the Bidder's standard hardware and software may cause the Bidder to conclude that there is a need for additional items not specifically mentioned in this Specification. The Bidder shall supply all such items and provide a complete RTU and LDMS 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, Input cards, output cards, Interposing relays and Modems only as indicated in the price schedules for spares.

Exhibit 1.1



2. REMOTE TERMINAL UNIT REQUIREMENTS

This Sub-section describes the overall functions to be performed by the RTU. Each function is presented in sufficient detail to provide the Bidder with as much insight as possible into both the initial and future requirements of the RTU. RTU shall be capable of providing all functional capabilities described herein even if a function is not initially implemented.

As a minimum, the RTU shall be capable of performing the following functions:

- (a) Collecting, processing and transmitting status changes, accumulated values, and analog values
- (b) Receiving and processing digital commands from the master station(s)
- (c) Accepting polling messages from the master station(s)
- (d) Supporting data transmission rates from 300 to 9600 bits per second for IEC 60870-5-101 Protocol or 9600 to 2Mbps for IEC 60870-5-104 Protocol
- (e) MODBUS communication interface with the Multi function Transducers(MFT)/Energy Meters over RS485 interface and IEC 61850 protocol with IEDs.



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- (f) Include typical communication ports as per layout given in Exhibit 1.1. However the details will be finalised during Engineering
- (g) Support multiple concurrent protocols, including the IEC 870-5-T101 and 104 protocol .
- (h) Acting as a data concentrator for collecting data from Slave RTUs using IEC 60870-5-101 protocol
- (i) Redundant Central Processing unit and Power supply unit

2.1. Redundancy in CPU and Power supply

The RTU shall be provided with redundant CPUs and Power Supply Unit so that the RTU can communicate with all masters 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 be transparent and shall not require any manual intervention.

The failover process of the Power Supply Units shall not cause any interruption in the functioning of the RTU.

The failover of process of the CPU shall be completed within 30 seconds of the failure of the primary CPU. All the functions in the RTU shall be operational within 30 seconds of the failover operation i.e. one minute from the time of failure

2.2. Communication Interface

The RTU shall utilize communication ports as follows :

- (a) Two ports for redundant connectivity to RLDCs. (Communication on IEC 60870-1-101 or IEC 60870-5-104 to be decided during detailed Engineering)
- (b) One port for a Local Data Acquisition and Monitoring System (LDMS).
- (c) At least one Ethernet port supporting IEC 60870-5-104 protocol in each CPU.
- (d) Two port for RCC for Remote Operation
- (e) One port for the RTU configuration & maintenance terminal.

The typical communication ports has been shown in the **Exhibit 1.1**.

The communication interface to the master stations shall allow scanning and control of defined points within the RTU independently for each master station. The RTU shall respond to independent scans and commands from Owner's master stations, RTU Maintenance and Configuration Terminal and LDMS/RCC. 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.



Also, each master station's data scan may be different for different data points within the RTU's database.

All ports shall be accessible to Owner to attach the interface equipment and to provide access for the maintenance, test and monitoring equipment.

2.2.1. Master Station Communication Interface

Owner will supply communication channels between the RTU and the SCADA system master stations. The communication channels are not part of RTU and LDMS/RCC scope of supply. The communication channels provided will consist of power line carrier, microwave, optical fibre, VSAT and cable communication using modems specified below.

2.2.2. Modems (Applicable in case of RTU communicating on Analog PLCC)

The Bidder shall supply two (2) number modems along with each RTU (at RTU end) for communicating with the master station. The corresponding two number modems shall also be supplied by the Bidder for remote end. The remote end modems shall be of standalone type (with power supply unit) and can be located either at the Control centre or at wideband communication node. A single modem combining all of the characteristics defined below is preferred such that changing the communication data rate shall only require reconfiguration of the RTU modem.

The modems shall not require manual equalization and shall include self-test features such as manual mark/space keying, analog loop-back, and digital loop-back. The modems shall provide for convenient adjustment of output level and receive sensitivity. The configuration of tones and speed shall be programmable and maintained in non-volatile memory in the modem.

The modems shall meet the following requirements:

- (a) Use CCITT Standards including V.24, V.28, V.52, and V.54.
- (b) Communicate data rates of 300, 600 and 1200 bits per second.
- (c) Use CCITT V.23, R35, R.37, R.38a, and R.38b standard tones for the selected RTU data rate.
- (d) Use frequency shift keying (FSK) modulation.
- (e) Use both 2-wire and 4-wire communication lines.
- (f) Receive level adjustable from 0 to -40 dBm @ 600 ohms.
- (g) Transmit level adjustable from 0 to -24 dBm @ 600 ohms.



- (h) Have a minimum sensitivity of -48 dBm.
- (i) PLCC modem shall use bandwidth upto 4khz and shall accommodate multiple data channels over and above voice channels. It shall conform to CCITT-38 standards.

2.2.3. Portable Configuration & Maintenance terminal Interface

The interface shall provide easy access to allow Owner to use the maintenance terminal at the RTU installed in the field. The contractor shall provide the RTU configuration and maintenance software and its associated license for using it on window based PCs. The software shall be provided on CD /electronic media. The desktop/laptop PC at control centre end , shall be used for RTU configuration and maintenance purpose. The RTU configuration and maintenance software shall include the following features:

- (a) RTU configuration capabilities.
- (b) RTU diagnostics (for processor, memory, I/O ports and any other functional area).
- (c) RTU database compilation.
- (d) RTU configuration listing and display of memory table contents.

2.3. Master Station Communication Protocol

RTU shall be provided with IEC 60870-5-101 as well as IEC 60870-5-104 protocol a communication protocol for communicating with Owner's master stations The communication protocol shall support all the requirements of this standard. The communication protocol shall be non-proprietary and the Bidder shall provide complete description and documentation of the protocol to Owner. The interoperability profile for RTU as implemented at RLDC master is given at Appendix-C of this document. The bidder's scope shall include implementation of RTU protocol exactly in-line with the protocol implemented for RLDC SCADA system and integration of this RTU communication port with RLDC. The Bidder has to define RTU database as per the requirements of RLDC. Necessary information in this regard shall be provided by Owner during detailed engineering.

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 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.



2.3.1. Communication Channel Control

The RTU shall perform as a slave on the communication channel to Owner's Master Stations. All communication shall be initiated by the SCADA system master stations. Where the RTU must notify the master stations of an unusual condition at the RTU (such as a power fail/restoration or RTU malfunction) or must initiate the transfer of changed data, the notification shall be accomplished within the framework of the periodic data acquisition exchanges.

2.3.2. Exception Reporting

The RTU communication protocol shall report status changes by exception. The communication protocol shall also support an integrity scan of all status data by master stations regardless of the lack of any change data.

2.3.3. Message Security

Each RTU communication message shall include an error code, the use of which shall result in a very low probability of an erroneous message being accepted as valid. The error code shall be determined and appended to the message for all messages transmitted by the RTU and verified by the RTU for all messages addressed and received by the RTU. Cyclic error detection codes such as CRC are required.

High data integrity and consistency is required of the RTU protocols. The protocols used shall provide an adequately low Residual Error Rate (RER), depending on the Bit Error Rate (BER) of the line in use. The minimum required RER is as specified for the IEC 870-5-101 protocol with the T-101 profile. This requires the following integrity:

<u>BER</u>	<u>RER</u>
10^{-5}	10^{-14}
10^{-4}	10^{-10}
10^{-3}	10^{-6}

The implemented protocol shall ensure satisfactory performance at Bit Error Rate of 1×10^{-4} .

2.3.4. Control Security

RTU shall operate in remote control mode i.e. Supervisory Control shall be exercised through one of the master station and the remaining Master Station shall be used for display of information only. The operation of control outputs shall use a true select-check-before-execute command sequence between the RTU and the Master Station. The sequence shall include, as a minimum, the following functional capabilities:



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- The Master Station shall transmit a control selection message addressing the proper RTU and control point within the RTU, and indicate the control action desired (such as Close).
- The RTU shall initialize its control logic, reassemble the control selection message received, and transmit the reassembled message to the Master Station. The information in the message sent to the Master Station shall be generated by the RTU point-selection logic indicating that the point and control function have been selected. It shall not be a simple repeat of the Master Station message transmission.
- The Master Station will verify the returned message with the message sent and, if valid, shall issue an execute control message to the RTU.
- The RTU shall only operate the control point selected after the check-before-execute sequence above has been performed without error or interruption by any other messages. The RTU shall reset its control logic upon any error in the sequence or if the execute message is not received within a set time (user adjustable from 2 - 20 seconds) after the command message is received at the RTU.

2.3.5. Data Concentrator Communication Protocol

The RTU shall act as a IEC 60870-5-104 protocol master and collect data and also allow control on the existing RTUs on IEC 60870-5-101 protocol (if provided by the Employer) and communicate it to the SCADA system at Master control centre.

The Contractor is responsible for making any necessary modification in his implementation of the communication protocol, if required, for the successful integration of the existing RTU. The detail of the protocol implementation of the existing RTU on IEC 60870-5-101 protocol is attached at **Annexure-C**.

2.4. Communication interface between RTU & MFT/Energy Meters

The RTU shall acquire data from the MFTs / Energy meters using the MODBUS protocol. The MFTs / energy meters will act as slave to the RTU. The RTU shall have the ability of issuing retry scan to acquire data from the MFTs / Energy Meters in case of communication failure between RTU and MFTs/energy meters.

2.5. 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 data from the IEDs.



The RTU shall store data acquired from the MFTs & 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 necessary mapping of information to the protocol requirement for communication with Control Center.

2.6. Analog Inputs

The RTU shall accommodate analog current inputs which are isolated, uni-polar or bipolar, 2-wire ungrounded differential signals with full resolution as follows:

- (a) +4 to +20 mA
- (b) 0 to +10 mA
- (c) -10 to +10 mA.

The analog input accuracy shall be 99.8% or better at 25 deg.C ambient temperature. Mean accuracy shall drift no more than 0.002% per deg C within the temperature range of -5 to +50 deg. C. Determination of accuracy shall be made while the analog multiplexer is operating at rated speed. The analog-to-digital converter shall have a minimum resolution of 2048 counts (sign plus 11 data bits).

Each input shall have surge protection and filtering to provide protection against voltage spikes and residual current at 50 Hz, 0.1 ma (peak-to-peak). Overload of up to 50% of the input shall not sustain any failures to the input.

The RTU shall make all appropriate signal level conversion and conditioning to allow full utilization of analog inputs and meaningful reasonability checking. Including signal conditioning components, the input impedance shall not be greater than 250 Ω . Input scaling shall allow for 20% over range.

2.7. Digital Status Inputs

The digital status input interface shall be capable of accepting isolated wet or dry contact status inputs. The Bidder shall supply necessary sensing voltage, current limiting, optical isolation, and debounce filtering independently for each digital status input. The Bidder sensing voltage shall not exceed 48 Vdc. The sensing voltage source shall be isolated from that of the RTU logic power such that any noise or a short circuit across the sensing supply's output terminals would not disrupt the RTU operation other than the shorted digital status input.

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.



2.7.1. Two-State Devices

All switching devices (breakers) shall be supported by a dual-contact status indication. Breakers with reclosing capability shall also be supported with momentary change detection (MCD). All other status indications shall be two-state single-contact status inputs without MCD.

Single-contact two-state status point inputs will be from a single normally-open (NO) or normally-closed (NC) contact. Dual-contact two-state status point inputs will be from two complementary contacts (one NO and one NC). 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. The state definition shall be set by Owner for each contact position.

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). The duration used to determine change versus bounce shall be adjustable from 4 to 25 ms in increments of 1 ms.

2.7.2. 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 RTU scans (e.g., breakers with reclosing devices that operate faster than the 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. Operation of less than 20 ms shall be considered no change (contact bounce). The capture duration shall be adjustable between 4 and 25 ms in increments of 1 ms.

2.7.3. Digital Telemetry

Digital telemetry input points shall be provided for sixteen-bit inputs from Owner telemetry contacts. The digital telemetry may use BCD (4-bit decimal characters without sign) and/or binary (16 bit) codes.

2.7.4. RTU Sequence of Events (SOE) Collection

The RTU shall collect digital status input data and time-of-operation from fast-acting power system devices. The RTU shall maintain a clock and shall time-stamp the data with a time resolution of one millisecond. The time resolution will enable Owner's operating and engineering personnel to determine the sequential operation device state changes throughout the power system.

Any digital status input data point in the RTU shall be assignable by Owner as an SOE point. The SOE buffer shall be sized for at least 1000 events.



Each time a SOE status indication point changes state, the RTU shall time-tag the change and store the change (open, close) and the time-tag of the event in SOE buffers within the RTU. Separate and independent SOE data storage buffers shall be provided in the RTU for each master station. The RTU shall transfer all Status points with time tag to master station by exception and within resolution of 1 ms.

When requested from a SCADA system master station, the RTU shall transmit the SOE data stored in its buffer corresponding to that master station. An acknowledgement of receipt by the master station shall be made prior to the deletion of any data in the RTU SOE buffer.

2.8. Digital Control Outputs

The RTU shall provide the capability for a master station to select and change the state of digital output points. 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 (AGC), transformer load-tap-changers (LTC), and other variable output devices.

The RTU shall have the capability for control outputs as described in the following Sub-sections

2.8.1. Two-State 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.

2.8.2. Raise/Lower Pulse Outputs

The RTU shall provide the capability to output Automatic Generation Control signals to generation equipment upon command from a SCADA system. The raise/lower output controls will also be used for transformer tap position settings.

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.

2.8.3. Control Output Relays

Control output interposing relays shall be supplied by the Bidder for each control output described above. Each control relay shall consist of three isolated contacts. The output contacts shall be rated 10 amps at 220 Vdc, 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 255-1-00 and IEC 255-5 requirements.

2.8.4. RTU Control Security and Safety Requirements

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

- (a) Select-check-operate sequence for control output. The verification message for check-before-operate control sequences shall be obtained by re-encoding the verification message directly from the control point selection lines. Thus, a simple reflection of the received message is not acceptable.
- (b) No more than one control point shall be selected at any given time. A detection and lockout method shall be provided that prevents a control operation if more than one control point has been selected.
- (c) The control selection shall be automatically cancelled if after receiving the "control selection" message, the "operate" command is not received within the set time period.
- (d) No false output shall result during power up or power down. No false output shall result from inadvertent connections to a circuit card.
- (e) All connections with a voltage of fifty (50) volts or more shall have a protective cover.
- (f) All control output connections shall have protective covers.

2.8.5. Control Disable

A manual Local/Remote switch shall be provided for each RTU to disable all control output interposing relays by breaking the power supply connection to the control output interposing relays. When in the "Local" position, the Local/Remote switch shall allow testing of the control outputs without activating the interposing control relays.

A status input indication shall be provided for the Local/Remote switch to allow the SCADA system to monitor the position of the switch.



2.8.6. Dummy breaker relay

The Bidder 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.

2.9. Analog Outputs

The RTU shall be capable of driving Analog outputs as setpoint control for AGC (future implementation) or other setpoint devices. The analog outputs shall have an accuracy of 99.8% of full scale at an ambient temperature of 25 deg. C. Mean accuracy shall drift no more than 0.01% per deg. C over a temperature range of -5 to +50 deg. C. The Digital-to analog converter shall have a minimum resolution of 2048 counts (sign plus 11 data bits).

The RTU shall accommodate analog outputs which are isolated, unipolar or bipolar, 2-wire ungrounded differential signals with full resolution as follows:

- (a) +4 to +20 ma (@ less than 1,500 ohms)
- (b) 0 to +10 ma (@ less than 3,000 ohms)
- (c) -10 to +10 ma (@ less than 3,000 ohms)

2.10. Time Synchronization

The RTU shall maintain real-time clock and shall have an internal RTU time base with a stability of 1 ppm i.e. 3.6 milliseconds per hour or better. The RTU shall maintain the real-time clock information even when the auxiliary power to the RTU is switched OFF.

The accuracy of the internal clock shall be maintained by protocol messages from the master station. The RTU time will be set from time synchronization messages received from master station at every 10 minutes when using the IEC 60870-5-101 communication protocol over dedicated lines.

The RTU shall be provided with suitable hardware and software for accepting time synchronisation from a GPS using IRIG –B/ASCII time messages/1 pps signals also. This shall be preferred means of time synchronisation wherever the RTU can not be directly synchronised from a master stations (e.g. reporting through Data concentrator, reporting on TCP/IP connection etc.). Any hardware required for multiplication of the ports of the GPS shall also be supplied by the Contractor.

2.11. Spare Parts



The Bidder shall provide spare parts for the RTU supplied. The minimum essential spare parts to be provided are defined in the Annexure B

2.12. Power Supply

The RTU shall accept power from the DC system with the following characteristics:

- Nominal voltage of 48 Vdc with operation between 41 and 53 Vdc. The voltage may vary during normal operation between these limits with a duration not less than 1 ms.
- Reversed polarity protection.
- Positive DC earth system.

The Bidder shall supply any hardware required to convert RTU input voltage to the required internal voltages for the RTU hardware. The RTU shall operate with grounded input power from Owner. The RTU shall not place a ground on the input power.

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

Secondary power shall be provided to the RTU at 230 Vac, 50 Hz, single-phase for non-critical auxiliary equipment including heaters, internal lighting, and internal maintenance outlets.

2.12.1. Power Supply Protection

Over voltage and under voltage protection shall be provided to the input and output of the power supply in addition to output over current protection to safeguard the RTU internal logic from being damaged as a result of a component failure in the power supply and to prevent the RTU internal logic from becoming unstable and causing mal-operation as a result of voltage fluctuations.

2.12.2. Power Supply Failure Indicators

The RTU shall have a status point which shall be set if the power to the RTU's has been cycled (off-on) for any reason (including maintenance). The master station shall reset the power fail status point.

2.13. RTU Panel

The Bidder shall provide simplex type panel for the RTU. The constructional features of the panel shall be similar to the construction features defined of Control and Relay Panels specifications.



2.14. Interconnections

The bidder shall supply, install, terminate at both ends, test and commission all interconnection cables (power, control and signal cables) as follows:

- Between RTU and LDMS/RCC equipment
- Between RTU and C&R panels
- Between RTU and RTCC panel
- Between RTU and Communication equipments at station end
- Between communication equipment and SCADA equipment at remote end
- Between RTU, LDMS/RCC and power supply equipment

All power and control cables shall be as per owners technical specifications for the same. The signals cables for communication, I/O points shall be shielded type to provide suitable protection against noise and electromagnetic interference. All the cables shall be suitably sized to meet the functional requirements.

2.15. Panel Internal Wiring

The Panel internal wiring shall be similar to the owner's technical specifications of control and relay panels.

2.16. Terminal Blocks

Terminal blocks shall be screw-type/ stud type/ cage clamp type/ self stripping/spring type having provision for disconnection(isolation), with full-depth insulating barriers made from moulded self-extinguishing material. Rust-proofing of metallic components shall be provided by means of the metal used or a suitable coating. Terminal blocks shall be appropriately sized and rated for the electrical capacity of the circuit and wire used.

2.17. Assembly and Components Identification

Each assembly (to the level of printed circuit cards) shall be clearly marked with the manufacturer's part number, serial number, and the revision level of the component. Changes to assemblies shall be indicated by an unambiguous change to the marked revision level.

All electronic parts (such as capacitors, resistors, and integrated circuits) shall be marked either with the characteristics of the part or with an industry standard part number. Where custom parts are provided (such as read-only memories), the part shall be marked such as to specifically identify the part when similar parts may exist.



All printed circuit card cages and all slots within the cages shall be clearly labelled. Printed-circuit cards shall be keyed for proper insertion. It is desirable that printed-circuit cards be keyed to prevent insertion into incorrect locations.

All circuit protection breakers shall be of the manually operated, moulded-case type, and shall provide thermal over-current and instantaneous short-circuit protection in each pole. All circuit breakers for 48 Vdc circuits or less shall be rated at not less than 125 Vdc. 240-Vac circuit breakers shall be rated at not less than 480-Vac.

2.18. Noise Level

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

2.19. Environmental Requirements

The RTU will be installed in control buildings without temperature or humidity control. The RTU shall be capable of operating in ambient temperatures from -5 to +50 deg C and relative humidity from 5 to 95%, non-condensing with rate of temperature change of 30 deg C/hour.

2.20. Availability

The RTU will perform data acquisition and control of important equipment necessary for the operation of Owner's power system. Any failure of an RTU to perform its functions will adversely affect power system operations. An availability of 99.9% is required exclusive of communication channel availability. An RTU shall be considered unavailable when:

- (a) Any function is lost for all points of a single type
- (b) One entire data scan group fails
- (c) More than one input card or output card of the same type fails
- (d) One input card or output card of each type fails
- (e) Failure of any modem.

2.21. RTU Size and Expandability

The RTU shall be supplied for the sizing as per Annexure A. The RTU delivered shall have further capability to add additional I/O modules to expand the overall point count of the RTU by a minimum of fifty percent (50%) of the actual RTU count as defined in Annexure A. Expansion shall be accomplished in the field by Owner by only adding additional distributed input/output modules within the main unit.

2.22. Maintainability



Model Technical Specification For RTU and LDMS

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
- (b) On-line error detection capabilities within the RTU and detailed reporting to the connected master stations of detected errors



3.0 LOCAL DATA MONITORING SYSTEM (LDMS)

The LDMS shall be used for local data acquisition, monitoring and control of substation parameters through RTU.

The scope of LDMS shall include installation and integration of LDMS software on a Personal computer. The bidder has the option to use personal computer and printer being supplied as part of C & R panel specification for disturbance recorder/event logger for LDMS purpose as well. However if bidder feels that Disturbance/event logger PC and printer are not adequate to meet LDMS requirement, then separate PC and/or printer shall be provided for LDMS at no additional cost to owner.

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 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) Time Synchronization
- (v) Sequence of Events Processing
- (vi) Supervisory control
- (vii) Alarm, tagging, trending, quality codes etc.
- (viii) 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 every 5 minutes (adjustable to 15,30,45,60 minutes). The software and hardware shall be sized for storage of all above data at every 5 minutes for at least six months duration. All alarms, events, SOE etc. shall also be stored on regular basis. It shall be possible to define daily, weekly, monthly Substation 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 conversion to standard spreadsheet programs (Calc, Excel) shall be provided.

The LDMS shall update analog data from RTU every ten seconds (programmable) and status data by exception. The SOE status data shall be recoded with resolution of 1 ms timestamp.



4.0 SOFTWARE REQUIREMENTS

The software provided to support the functions of the RTU/LDMS shall meet the characteristics described in this Sub-section. The term "software" is used throughout this Specification to mean either software or software implemented in firmware.

4.1 Design Characteristics

All software shall be implemented according to the Bidder's established design and coding standards. Owner reserves the right to reject any software that does not conform to these standards. Complete and comprehensive documentation shall be provided for all software.

The software and the database shall be sized to accommodate growth within the sizing parameters defined for the RTU without requiring software or database regeneration. The design of the software and the database shall not restrict future expansion beyond the sizing parameters. Expansion beyond the original design parameters may require software or database regeneration.

At the time the RTU is accepted, all software delivered must be up to date and in final form, including all standard software changes and field changes initiated by the Bidder or the sub-contractor prior to acceptance. The software documentation must reflect these changes.

4.2 Operating System

The Bidder shall use a non-proprietary operating system capable of managing the distributed applications of the RTU. If a proprietary operating system is offered then Bidder shall provide the corresponding source code. The operating system shall support multi-tasking and multi-programming. The minimum real-time facilities to be provided shall include process, job, database, and memory management, process synchronizing, message services for communication between jobs, and device and interrupt handling. Industry Standard operating system shall be provided for LDMS.

4.3 Initialization/Restart Program

Software shall provide automatic restart of the RTU upon power restoration, memory parity errors, hardware failures, and upon manual request. The software shall initialize the RTU and begin execution of the RTU functions without intervention by master station. All restarts shall be reported to the connected master stations.

4.4 RTU Operations Monitoring



Software shall be provided to continuously monitor operation of the RTU and report RTU hardware errors to the connected master stations. The software shall check for memory, processor, and input/output errors and failures.

4.5 RTU Configuration Support

The Bidder shall supply a database compiler which will enable to configure and document each RTU's database. A compiler shall be provided to completely generate or modify the database of the RTU. The database compiler shall provide error detection services and shall produce a printed listing of the input data and the resulting RTU configuration. It shall be possible to maintain the RTU database locally and from a master station.

4.6 Diagnostic Software

RTU shall have diagnostic software which monitors and individually test each of the modules of RTU. The diagnostics shall provide comprehensive user interaction and printout capabilities.

4.7 Software Deliverables

RTU & LDMS software shall be delivered on electronic media in two copies with requisite licenses. The List of deliverable software shall be submitted during detailed engineering.



5.0 INSPECTION AND TEST

All materials, hardware, and software to be furnished and all work to be performed under this Specification shall be subject to inspections and tests. No equipment shall be shipped until all required inspections and tests have been made, demonstrating that the equipment conforms to the Specification and that the hardware and software have been approved for shipment by Owner

Approval of inspection and test results, acceptance of hardware and software, or the waiving of inspection and tests thereof, shall in no way relieve the Bidder of the responsibility for furnishing equipment which meets the requirements of this Specification, nor shall such actions invalidate any claim which Owner may make because of defective or unsatisfactory hardware and software. Owner reserves the right to request additional tests on the equipment at no extra charge on any work Owner determines not to be in accordance with this Specification.

Whenever the results of any inspections or tests performed or requested by Owner in accordance with the requirements of this Sub-section indicate that specific hardware, software, or documentation does not meet the specification requirements, the Bidder shall replace, modify, or add, at no cost to Owner, hardware, software, or documentation as necessary to correct the noted deficiencies.

5.1 Inspection

Representatives of Owner shall have free entry into the shops of the manufacturer at any time while design, fabrication, or testing of the equipment is taking place and into any mill, shop, or factory where the hardware or software described in this specification is being produced.

The Bidder shall provide to Owner's representatives, free of cost, all reasonable facilities, equipment, and documentation necessary to satisfy Owner's representatives that the hardware is being fabricated in accordance with the Specification. The inspection rights described above shall apply to the facilities of the Bidder or the Bidder's sub-Bidder where the hardware is being manufactured. The inspection rights shall not apply to the facilities of sub-Bidders supplying unit components to the manufacturer. Such items will be inspected and tested by Owner's representatives at the manufacturing site.

Inspections by Owner will include visual examination of the physical appearance of the hardware, cable dressings, and equipment and cable labelling. Bidder documentation will also be examined to verify that it adequately identifies and describes all hardware, software, and spare parts. Owner shall have access to inspect the Bidder's and manufacturer's quality assurance standards, procedures, and records, which are applicable to this project. Inspection shall not relieve the Bidder of the responsibility for furnishing material and equipment conforming to the requirements of the Specification, nor shall such inspection invalidate any claim which Owner may make because of defective or unsatisfactory hardware or software.



5.2 Test Procedures

The Bidder shall submit the test procedures for approval twelve weeks prior to the start of factory tests. Fully approved test procedures shall be submitted to Owner at least four weeks prior to the commencement of the tests. Owner will approve test procedures if they are inclusive, thoroughly testing each of the equipment. The Bidder shall use IEC standards as a guide in preparing the test procedures. The test procedures shall include the following:

- (a) The test schedule, including provision for eight hours of unstructured tests to be performed by Owner
- (b) The purpose of each test
- (c) The function to be tested
- (d) The plans/procedures to be followed
- (e) Specific references to project documentation for correlation with the procedures and for verification of the documentation
- (f) The test setup, equipment, and conditions for each part of the test
- (g) All test inputs and outputs
- (h) Test software descriptions and listings
- (i) A copy of any certified test data to be used in lieu of testing
- (j) Expected results
- (k) The acceptance criteria
- (l) A procedure for handling the variances that are identified during testing.

5.3 Test Records

The Bidder shall maintain a complete record of the results of all tests. This record shall be keyed to the steps enumerated in the previously approved test procedures. The record shall include the following items:

- (a) Reference to the appropriate Sub-section of the test procedure
- (b) Description of any special test conditions or special action taken
- (c) Test results, passed/failed.



A copy of the test records shall be delivered to Owner at the conclusion of the tests.

5.4 Factory Tests

The RTU, and cabling elements of the RTU procurement shall be tested in two parts i.e. type test and routine test as described below

(1) Type Testing:

A minimum of one of each major complete integrated units shall be fully tested to assure full compliance with the functional and technical requirements of the Specification. The type test reports for the RTU shall be submitted by the bidder which shall include the tests listed in **Table-1** & **Table -2** below.

TABLE –1 List of Type Tests on RTU

Test Nos.	DESCRIPTION OF THE TEST
	EMI/EMC IMMUNITY TESTS FOR RTU
1.	Surge Immunity Test as per IEC 60870-2-1
2.	Electrical Fast Transient Burst Test as per IEC-60870-2-1
3.	Damped Oscillatory Wave Test as per IEC 60870-2-1
4.	Electrostatic Discharge test as per IEC 60870-2-1
5.	Radiated Electromagnetic Field Test as per IEC 60870-2-1
6.	Damped Oscillatory magnetic Field Test as per IEC-60870-2-1
7.	Power Frequency magnetic Field Test as per IEC-60870-2-1
	INSULATION TEST FOR RTU
8.	Power frequency voltage withstand Test as per IEC 60870-2-1
9.	1.2/50 μ s Impulse voltage withstand Test as per IEC 60870-2-1
10.	Insulation resistance test
	ENVIRONMENTAL TEST FOR RTU
11.	Dry heat test as per IEC60068-2-2
12.	Damp heat test as per IEC60068-2-3

TABLE - 2 Test Level Requirements

SI No	Test Name	EUT Status	Test Level	Power Supply Points		I/O Points	Passing Criteria
				CM	DM	CM	
1.	Surge Immunity Test (1.2/50 μ s)	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 Electro-magnetic 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 KV rms for 1 minute			No break down or flashover shall occur
9.	1.2/50 μ s impulse voltage withstand	OFF	-	2 kVp			No break down or flashover shall occur
10.	Insulation Resistance Test	OFF	-	Measure Insulation resistance using 500 V DC Megger before & after Power Freq & Impulse voltage withstand tests			As per manufacturer standard
11.	Dry heat test	ON	-	Continuous operation at 55 ^o C for 16 hrs			0
12.	Damp heat test	ON	-	at 95% RH and 40 ^o C			0

Note: -

EUT - Equipment Under Test

CM - Common Mode; DM - Differential mode

I/O points do not include communication ports

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, however issuance of control output command is not allowed.



(2) Routine testing :

Each complete RTU shall undergo functional testing to demonstrate compliance with specified requirements, standards, and functional capabilities including:

- (a) Inventory check and inspection for general construction, cabling, connections, drawing conformance and labelling.
- (b) Tests of proper functioning of hardware and software by a thorough exercising of all RTU functions, both individually and collectively.
- (c) Test operation and accuracy of all RTU analogue inputs over entire range.
- (d) Test operation of all RTU digital input points.
- (e) Test operation of all RTU control outputs.
- (f) Test SOE and RTU time synchronization and accuracy.
- (a) Test of RTU power failure and recovery
- (h) Tests of communications, including all communications ports, modems and local interfaces.

For any variations in the configuration, hardware components used or variations from the Type accepted equipment, Owner has the right to perform any of the Type Testing before successful completion of the Routine Testing.

5.5 Field Performance Tests

The Bidder shall be responsible for providing field installation and testing. All hardware will be installed, aligned, and adjusted, interfaces to all field inputs and outputs established, operation verified and all test readings recorded. Upon completion, a field performance test shall be performed to exercise all functions of the RTU and duplicate selected routine tests to the extent possible. The SCADA database and displays at regional SCADA master station shall be developed by Owner, however for this purpose all necessary information shall be provided by the bidder. This testing will include, but not be limited to, the following tests:

- RTU initialization.
- Proper functioning of hardware and software by exercising of selected RTU functions using the master station.
- Proper RTU communications interface.
- Test operation of all diagnostic software and confirm issuance of meaningful messages for all types of error conditions.



- Test time synchronization and accuracy of the RTU from the master station.
- Development and integration of database at RTU and LDMS end in-line with regional SCADA master database design will be the responsibility of the bidder.
- RTU database verification including point-to-point operation and scaling accuracy using the master station.
- Integration of RTU with LDMS, printer and regional SCADA master.

The test procedures shall be submitted at least 12 weeks prior to installation of RTU.



6.0 TRAINING AND SUPPORT SERVICES

The Bidder shall provide training and support services to create Owner's in-house maintenance and support capabilities for the hardware and software. The training program shall be comprehensive and provide for interdisciplinary training hardware and software. The required training of Owner's personnel shall be conducted by the Bidder in English.

6.1 RTU and LDMS Training

The Bidder shall provide RTU and LDMS hardware, software, and operation & maintenance training. The courses shall familiarize Owner's course participants with RTU installation, card/circuit board level troubleshooting and repair procedures, and the recommended preventive maintenance procedures for the RTU equipment. Courses shall include use of the RTU configuration and maintenance terminal and shall demonstrate all facets of its operation. Courses shall also include hands-on trouble-shooting experience with the RTU supplied by the Bidder and shall cover any special equipment required for maintenance. Actual RTU to be supplied under this procurement shall be used for training.

The Bidder shall also provide RTU software training in the following areas:

- (a) RTU configuration, modification, and expansion.
- (b) RTU database generation and maintenance.
- (c) RTU software and operation, including data flow.

The Bidder shall also provide LDMS software training in the following areas:

- (a) LDMS system configuration
- (b) Addition/ Edit of database, displays, reports, trends.
- (c) LDMS system operation and maintenance.

6.1.1 Attendance

RTU maintenance training shall be provided to two participants.

6.1.2 Training Schedule

The training schedule shall coincide with the delivery of the RTU to Owner. The training course shall be a optimum mix of class-room and laboratory training, the duration of training shall be 5 days.

6.1.3 Training Location and Classrooms

The RTU maintenance courses shall be given at the site/ Bidder's facility in India, or optionally, at Owner's facility. Adequate training manuals shall be provided to the trainees.



7.0 DOCUMENTATION

The Bidder shall submit hardware and software documentation for RTUs and LDMS to Owner for review and approval. After approval four set of all the documents shall be submitted as final documentation. Any changes observed during field implementation shall be incorporated in the as-build drawing and four sets of same shall be submitted to owner. In addition to paper copies all the documents shall also be provided on electronic media in two copies.

7.1 Hardware Documentation

The Bidder shall provide documentation for all hardware supplied to Owner. Documentation describing the circuitry, operation of the circuitry, and troubleshooting and maintenance procedures shall indicate the revision level of the hardware to which the documentation applies. Generic manuals are not acceptable unless they clearly show what is supplied and what is not supplied. This documentation shall satisfy the following requirements:

- An inventory of the hardware
- General arrangement drawing of the RTU panel
- General Arrangement drawing of RTU rack indicating card location etc.
- RTU Installation drawing / manual.
- Schematic drawing for all I/O point terminations and communication ports.
- Cabling and wiring diagrams.
- RTU Hardware, maintenance and operation manuals.
- LDMS hardware, maintenance and operation manuals.

7.2 Software Documentation

The Bidder shall supply documentation for all software provided with the RTU and LDMS. This documentation shall include the following documentation as a minimum:

- Software Inventory.
- Functional Design specification of RTU software and LDMS software.
- Software maintenance manuals for RTU configuration and maintenance software, LDMS software, RTU softwares.
- RTU and LDMS database documents.
- Implemented Protocol detailed document.



Annexure A

Point Counts for the Remote Terminal Unit (RTU)

S. no.	Type of Telemetry point	Qty.*	Requirement for RLDC	Additional Requirement for LDMS
1.	Analog Input	Nos.	(a) P, Q for each feeder, transformer, reactor. (b) Bus V, F for each bus. (c) OLTC position for each transformer. (d) 32 Analog points for future use	(e) Current I of each phase for each feeder, transformer (f) Line Voltage of each phase for each feeder (g) OTI , WTI for each Transformer. (h) Auxiliary system -15 points
2.	Digital Input	Nos.	(a) Dual status contacts: (1 NO & 1 NC) for each breaker. (b) Single status contacts: Protection contact 1 per feeder/transformer/reactor/BUS. (c) Single status contacts: 1 per Isolator. (d) 64 Single Status Points for Future Use	(e) Single Status contacts for alarms /Trip/ Supervision events:- 400 nos for Substations having voltage levels of 220kV & above . 200 nos for Substations having voltage levels of 132kV and below.
3	Digital Control output (with interposing relays)	Nos.	TRIP/CLOSE of 8 circuit breakers.	

Note:

1. Cabling with control and relay panels shall be carried out for current bays as per single line diagram of the substation, however all analog and digital points shall be wired to terminal blocks in the RTU for external interface.
2. All contacts shall be defined as SOE.
3. Quantity Nos will be as per Single Line Diagram.



Annexure B

SPARES FOR REMOTE TERMINAL UNIT CARD/MODULE

Sl.no.	Card/Module Type	Quantity (nos.)
1	Power supply card	1
2	CPU card	1
3	Modem (standalone type) As Applicable	1
4	Communication Card	1
5	Analog Input Card	1
6	Digital Input Card	1
7	Digital Output Card	1
8	Other cards (as per suppliers design)	1 each
9	Master PROM/EPROMs etc. as applicable	1 each.



Annexure C

Inter Operability Profile of Regional Control Centre

(The interopeartibility Profile of Concerned region is attached herewith)