SECTION 3

CHAPTER-1

TECHNICAL REQUIREMENTS OF RTU

1.0 General

The Remote Terminal Unit (RTU) shall be installed at primary substation to acquire data from Multifunction Transducers (MFTs), discrete transducers & status input devices such as CMRs etc. RTU & shall also be used for control of Substation devices from Master station(s). The supplied RTUs shall be interfaced with the substation equipment, communication equipment, power supply distribution boards; for which all the interface cables, TBs, wires, lugs, glands etc. shall be supplied, installed & terminated by the Contractor.

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.

The RTU shall be designed around microprocessor technology. For easy maintenance the architecture shall support pluggable modules on backplane. The field wiring shall be terminated such that these are easily detachable from the I/O module.

1.2 RTU Functions

All functional capability described herein shall be provided by the Contractor even if a function is not initially implemented.

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

(a) Acquiring analog values from Multifunction Transducers or alternatively through transducer- less modules and the status inputs of devices from the substation, processing and transmitting to Master stations. Capability to acquire analog inputs from analog input cards receiving standard signals viz current loops 4-20Ma standard signals such as 0-5vdc etc for RTD , transducer etc.
(b) Receiving and processing digital commands from the master station(s)
(c) Data transmission rates - 300 to 19200 bps for Serial ports for MODBUS. and 10/100 mbps for TCP/IP Ethernet ports

(d) IEC 60870-5-104protocol to communicate with the Master station(s) , IEC 60870-5-101 for slave devices. & MODBUS protocol over RS485 interface , to communicate with the MFTs.

(e) 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 stations.

(f) Remote database downloading of RTU from master station/SCADA/DMS control centre

(g) Act as data concentrator on IEC60870-5-101/104/MODBUS protocols

(h) Internal battery backup to hold data in SOE buffer memory & also maintaining the time & date.

(i) As the SCADA/DMS system will use public domain such GPRS/CDMA etc, therefore it mandatory to guard the data/ equipment from intrusion/damage/breach of security & shall have SSL/VPN based security.

(j) Shall have SNMP

Support Feature:

All support feature as mentioned below will not be used now & may require in future . However, the same shall be tested in routine /Factory Tests. Further, it should be possible to have following capabilities in the RTU by way of addition of required hardware limited to addition of I/O modules & communication card only & using the same firmware at later date:

a) Support for Analog output in form of standard current loops viz 4-20Ma etc

b) Support for IEC 60870-5-103, IEC 61850 protocols & ability to act as a gateway for Numerical relays may have to be interfaced in future with numerical relays with future vision of Smart grid.

c) Have required number of communication ports for simultaneous communication with Master station(s), /MFTs and RTU configuration & maintenance tool.

(d) PLC support

(e) Communication with at least two master stations simultaneously on IEC 60870-5-104

(f) Receiving and processing analog commands from master station(s) and Capability of driving analog output card.

(g) RTU shall be capable of acquiring analog values through transducers having output as 4-20 mA, 0-10 mA, 0-+10 mA or +/- 5 volts etc using analog input modules.

(h) Capability of time synchronisation with GPS receiver which may be required future at the time of SMART GRID.

1.3 Communication ports

The RTUs shall have following communication ports to communicate with master station, existing /MFTs and configuration & maintenance terminal.

- RTU shall have two TCP/IP Ethernet ports for communication with Master station(s) using IEC 60870-5-104.
- RTU shall have required number of RS 485 ports for communication with MFTs to be connected in daisy chain using MODBUS protocol . Minimum 15 analog values (including 4 energy values) to be considered per energy meter The RTU shall be designed to connect maximum 5 MFTs. Further , bidder to demonstrate during testing that all analog values updated within 2 sec. The updation time shall be demonstrated during FAT(routine) & SAT testing . The bidder can offer MFT on IEC 60870-101/104 protocol to communicate with RTU.
- In addition, if weather transducer & DC transducers are also having RS485 MODBUS port., the same can be also added in the daisy. However, total devices including MFT connected on one port shall not exceed
- RTU shall have one port for connecting the portable configuration and maintenance tool for RTU.
- RTU as a data concentrator, then RTU shall have additional communication ports Ethernet or serial for IEC60870-5-104/101.
- SSL/VPN ,NERC/CIP complaint

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 support the use of a different communication data exchange rate (bits per second) and scanning cycle on each port & different database for each master station. FRTUs & FPIs shall be communicating to SCADA/DMS Master control using IEC60870-5-104 /101 protocol over GPRS/CDMA/Radio .

1.3.1 Master Station Communication Protocol

RTU shall use IEC 60870-5-104 communication protocol for communicating to master station. The RTU communication protocol shall be configured to report analog (except energy values) & status changes by exception to master stations. However, RTU shall support periodic reporting of analog data and periodicity shall be configurable from 2 sec to 1 hour. Digital status data shall have higher priority than the Analog data. The dead-band for reporting Analog value by exception shall be initially set to 1% (user configurable) of the full scale value. In addition, analog values shall also be reported to Master station by exception on violation of a defined threshold limit. All the analog values and status data shall also be assigned to scan groups for integrity check by Master stations at every 10 minutes configurable up to 60 minutes RTU wise.

RTU shall report energy values to master station periodically. The periodicity shall be configurable from 5 minutes to 24 hours (initially set for 15 minutes)

1.3.2 Communication Protocol between RTU & MFTs

The RTU shall acquire data from the MFTs using the MODBUS protocol. In addition, usage of IEC 60870-5-101/104 protocols is also permitted. The MFT will act as slave to the RTU. The RTU shall transmit these values to the master station in the frame of IEC 60870-5-104/101 protocol. As an alternate approach the utility/contractor may use RTU as a data concentrator & acquire all the required analog data from DCU installed & connected to energy meters using MODBUS protocol under IT scheme under R-APDRP. However, performance, functional, availability & update time requirement shall be met in this case also. It is the responsibility of utility /contractor to assess this option & only opt in case it is found feasible,

1.4 Analog Inputs

The real time values like, Active power, Reactive Power, Apparent power three phase Current & Voltage and frequency, power factor & accumulated values of import /export energy values will be acquired RTU from the following in the given manner:

1. MFTs installed in substations
2. RTU shall also take 4-20 mA, 0-20mA, 0- -10mA, 0-+10mA, 0-5V etc as analog inputs to acquire transformer tap position, DC power supply voltage, weather transducer etc.

The RTU analog-to-digital (A/D) converters shall have a digital resolution of at least twelve (12) bits plus sign. The overall accuracy of the analog input system shall be at least 0.2%(i.e. 99.8%) at 25 ºC of full scale . Mean accuracy shall not drift more than 0.002% per degree C within the temperature range of –5 to +55 degree Linearity shall be better than 0.05%. The RTU shall be designed to reject common mode voltages up to 150 Vac (50 Hz). For dc inputs, normal mode noise voltages up to 5 Vac shall be rejected while maintaining the specified accuracy. 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 ability of the RTU to accommodate dc inputs shall include the following signal ranges:
Unipolar Voltage:0-0.5V, 0-1V, 0-5V, 0-10V,
Unipolar Current:0-1mA, 0-10mA, 0-20mA, 4-20Ma,
Bipolar Voltage: 0.5V, 2.5V, 5V, -20-0-20mA (- to +)

The total burden imposed by the RTU/DC analog input circuit shall not exceed 0.5 volt-ampere for current and voltage inputs. As an option, contractor may also provide transducer less solution to connect direct CT/PT secondaries.

1.5 Status input

RTU shall be capable of accepting isolated dry (potential free) contact status inputs. 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 48Vdc.

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.

To take care of status contact chattering, a time period for each point and the allowable number of operations per time period shall be defined. If the allowable number of operations exceed within this time period, the status change shall not be accepted as valid

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.

The 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.

1.6 Sequence of Events (SOE) feature

To analyse the chronology or sequence of events occurring in the power system, time tagging of data is required which shall be achieved through SOE feature of RTU. The RTU shall have an internal clock with the stability of 10ppm or better . The RTU time shall be set from time synchronization messages received from master station using IEC 60870-5- 104 protocol. In addition, the message can be transmitted using NTP/SNTP. SOE time resolution shall be 1ms or better

The RTU shall maintain a clock and shall time-stamp the digital status data. Any digital status input data point in the RTU shall be assignable as an SOE point. Each time a SOE status indication point changes the state, the RTU shall time-tag the change and store in SOE buffer within the RTU. A minimum of 1000 events can be stored in the SOE buffer. SOE shall be transferred to Master Station as per IEC 60870-5-104 protocol. SOE buffer & time shall be maintained by RTU on power supply interruption.

1.7 IED pass through

The Master Station user shall be able to perform a virtual connection with any IED connected to the RTU/DC, provided the communication protocol functionality, to support the information transfer from and to the IEDs. For example, the Master Station shall gather on-demand IED data, visualize IED configuration parameters, and IED source code depending upon the IED capabilities. On the other hand, the Master Station shall be able to download to the IEDs configuration parameters, code changes, etc. depending upon the IED capabilities. This feature is a support function considering in future SMART GRID implementation. The capability can be demonstrated with the upload & download of data from master station with IEDs connected to the RTUs using the support of protocols specified in this chapter. Numerical relays Analog data viz voltage ,current, sag swell instantaneous, momentary , temporary, over voltage, under voltage , over current , phasor measurement , THD, current TDD & current unbalance ratio etc at numerical relays if installed at bay of S/S

1.8 PLC capability

The RTU shall be provided with programmable logic capabilities supported by easy to use editor facilities. The programmable logic capability shall enable the RTU to perform control functions using ladder logic language conforming IEC 1131.

1.9 Control Outputs

The RTU shall provide the capability for a master station to select and change the state of digital output points. These control outputs shall be used to control power system devices such as Circuit breakers relay disable/enable and other two-state devices, which shall be supported by the RTU.

A set of control outputs shall be provided for each controllable device. On receipt of command from a master station using the select check-before-execute operate (SCBO) sequence, the appropriate control output shall be operated for a preset time period which is adjustable for each point from 0.1 to 2 seconds.

Each control output shall consist of one set of potential free NO contact. The output contacts shall be rated for atleast 0.2 Amp. at 48 Vdc. These output contact shall be used to drive heavy duty relays. In case Control output module of RTU does not provide potential free control output contact of this rating, then separate control output relays shall be provided by the contractor. These relay coils shall be shunted with diodes to suppress inductive transients associated with energizing and de-energizing of the relay coils & shall conform to the relevant IEC requirements.

1.9.1 Heavy duty control output relays

The control output contact from the RTU shall be used for initiating heavy duty relays for trip/close of switching devices and energising relays of OLTC raise lower. The contractor shall provide heavy duty relays. Each control output relays shall consist of atleast 2 NO contacts. The output contacts shall be rated for at least 5 Amps Continuous at 220Vdc 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 IEC255-1-00 and IEC 255-5 requirements.

1.9.2 Control Security and Safety Requirements

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

(a) Select- check-before-operate operate (SCBO) sequence for control output.
(b) No more than one control point shall be select ed/executed 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) No control command shall be generated during power up or power down of RTU.

1.9.3 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 output s. 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.

1.9.4 Dummy breaker latching relay

The Contractor shall provide a latching relay to be used to simulate and test supervisory control from the Master station. The latching relay shall accept the control signals from the RTU to open and close, and shall provide the correct indication response through a single point status input.

1.10 Contact Multiplying Relays (CMRs)

Contact Multiplying Relays (CMRs) are required to multiply the contacts of breaker, isolators and protection relays etc. The contacts of these relays shall be used to provide status inputs to the RTUs.

The relays shall be DC operated, self reset type. The rated voltage for relay operation shall be on 24/48/110/220V DC depending on the station DC supply.

The relay shall be able to operate for +/-20% variation from nominal voltage.

The relay shall have a minimum of two change over contacts, out of which one shall be used for telemetry purposes. The contacts shall be rated to carry minimum current capacity of 5A.

The relay shall conform to following requirement.

a) Power Frequency withstand voltage–2KV for 1 minute as per IEC 255-5.
b) Insulation Resistance of 100M ohms measured using 500V DC megger.
c) 5KV Impulse test as per IEC 255-5

The relays coils shall be shunted with diodes to suppress inductive transients associated with energizing and de-enegizing of the relay coils. The relays shall conform to the IEC 255-1-00 and IEC 255-5 requirements or provisions of latest edition or revision of the applicable standard as per Sec-2 Chapter 1 CLAUSE 1.1 of MTS. The relays must be protected against the effects of humidity, corrosion & provide with a dust tight cover. The connecting terminals shall be screw type & legibly marked. The relays may optionally have a visual operation indicator. The relays are to be mounted in Control & Relay (C&R) panels and therefore shall be equipped with suitable mounting arrangements. In case suitable space is not available in C&R panel the same shall be mounted in RTU panel or suitable panels , which shall be supplied & mounted on the top of the C&R panel by the contractor.

1.11 Time facility

The internal RTU time base shall have a stability of 10 ppm. The RTU shall be synchronised through synchronisation message from master station at every 15 minutes (configurable from 15 minutes to 24hrs) over IEC 60870-5-104/101/NTP/SNTP. The RTU shall also carry out time stamping of the events which are not received as time stamped from connected IEDs/ FPIs etc.

1.12 Diagnostic Software

Diagnostic 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 ports errors and failures of other functional areas defined in the specification of the RTU.

1.13 SCADA language based on IEC61131-3

RTU shall have capability to write various programs based IEC 61131-3 SCADA language . it will facilitate user to write various programs using points defined in the database .

1.14 Input DC Power Supply

The RTU will be powered from a 48 V DC power supply 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 Vdc with variation between 40.8 and 57.6 Vdc.(i.e. 48(+20%/-15%)
(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. The specification for DCPS is given in respective section of MTS.

1.15 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 0 to +55 degree C with rate of temperature change of 20 degree C/hour and relative humidity less than 95%, non-condensing. For RTUs to be installed in the hilly region with the history of snowfall, the lower ambient temperature limit shall be -5 degree C.

1.16 RTU Size and Expandability

RTU shall be equipped for the point counts defined in the BOQ (Basic+20% spare (wired & hardware). It shall be possible to expand the RTU capability for additional 100 % of the basic point counts by way of addition of hardware such as modules, racks, panels, , however, RTU software and database shall be sized to accommodate such growth without requiring software or database regeneration.

1.17 RTU Panels

At least 50% of the space inside each enclosure shall be unused (spare) space that shall be reserved for future use. The Contractor shall provide required panels conforming to IEC 529 for housing the RTU modules/racks, relays etc. and other required hardware. The panels shall meet the following requirements:

(a) shall be free-standing, floor mounted and height shall not exceed 2200 mm. All doors and removable panels shall be fitted with long life rubber beading. All non load bearing panels/doors shall be fabricated from minimum 1.6 mm thickness steel sheet and all load bearing panels, frames, top & bottom panels shall be fabricated from minimum 2.0 mm thickness steel sheet

(b) shall have maintenance access to the hardware and wiring through lockable 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.

1.18 Wiring/Cabling requirements

The RTU panels shall gather all signals from and to the devices located in Control & Relay panels in the substation control room. All wires that carry low-level signals shall be adequately protected and separated as far as possible from power wiring. All wires shall be identified either by using ferrules or by colour coding. In addition, cables shall be provided with cable numbers at both ends, attached to the cable itself at the floor plate where it enters the cubicles.

Shielded cables shall be used for external Cabling from the RTU panels. The 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, if applicable and 2.5 mm^2 for Control outputs and 1.5mm^2 for Status inputs

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.

Armoured. Cables shall be used in the area where cable will pass through open area which may experience loading.
The Communication cable shall be of shielded twisted pairs and of minimum 0.22sq mm size.

1.19 Terminal Blocks (TBs)

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. Required number of TBs shall be provided for 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. TBs 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.

1.20 RTU Architecture

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

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

b) Distributed RTU design where distributed I/O modules/processor with I/O modules are housed in respective bay panels/RTU panel. All these distributed I/O modules / I/O modules with processor shall be connected to a central processor for further communication with master station. The bidder shall asses the requirement of RTU panels for such design and supply panels accordingly .

In both cases the RTU requirements as envisaged in this specification shall be followed.

1.21 LOCAL DATA MONITORING SYSTEM (LDMS)

The LDMS is a client workstation of main SCADA/ DMS control centre connected on 2Mbps or 64kbps leased line for local monitoring of SCADA/DMS system . The hardware & software specification, features shall be same as of remote VDU defined for SCADA/DMS system.

SECTION 3

CHAPTER-2

TECHNICAL REQUIREMENTS OF FRTU

2.0 General

The Feeder Remote Terminal Unit (FRTU) shall be installed at Ring Main Units (RMUs) , sectionalizer locations FRTU shall also be used for control of switching devices such as breaker, isolator switches etc inside RMU panel , sectionlizer etc from Master station(s). The supplied FRTUs shall be interfaced with the RMUs, FPI ,communication equipment, power supply distribution boards; for which all the interface cables, TBs, wires, lugs, glands etc. shall be supplied, installed & terminated by the Contractor.

2.1 Design Standards

The FRTUs 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.

2.2 FRTU Functions

All functional capability described herein shall be provided by the Contractor even if a function is not initially implemented.

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

(a) Acquiring analog values from Multifunction Transducers or alternatively through transducer- less modules and the status inputs of devices from the substation, processing and transmitting to Master stations. Capability to acquire analog inputs from analog input cards receiving standard signals viz current loops 4-20Ma , RTD etc.

(b) Receiving and processing digital commands from the master station(s)

(c) Data transmission rates - 300 to 19200 bps for Serial ports for MODBUS. and 10/100 mbps for TCP/IP Ethernet ports

(e) Use of IEC 60870-5-104/101 protocol to communicate with the Master station(s)

(i) Use of MODBUS over RS485 interface , Protocol to communicate with the MFTs.

(j) Have required number of communication ports for simultaneous communication with Master station(s), MFTs and FRTU configuration & maintenance tool.

(k) FRTU 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 stations.
(l) Remote database downloading of FRTU from master station from SCADA/DMS control centre
(m) internal battery backup to hold data in SOE buffer memory & also maintaining the time & date.
(n) As the SCADA/DMS system will use public domain such GPRS/CDMA etc, therefore it mandatory to guard the data/ equipment from intrusion/damage/breach of security & shall have SSL/VPN based security.
(o) Shall support SNMP

Further it should be possible to have following capabilities in the FRTU by way of addition of required hardware limited to addition of I/O modules & communication card only & using the same firmware at later date:

(p) Communication with at least two master stations simultaneously on IEC 60870-5-104 /101
(q) RTU shall be capable of acquiring analog values through transducers having output as 4-20 mA, 0-10 mA, 0-+10 mA etc using analog input modules.

2.3 Communication ports

The RTUs shall have following communication ports to communicate with master station MFTs and configuration & maintenance terminal.

- FRTU shall have one TCP/IP Ethernet port for communication with Master station(s) using IEC 60870-5-104/101 protocol or serial port in case IEC60870-101
- FRTU shall have required number of RS 485 ports for communication with MFTs/ to be connected in daisy chain using MODBUS protocol . Minimum 15 analog values (including 4 energy values) to be considered per energy meter. . The RTU shall be designed to connect maximum 5 MFT per port . Further , bidder to demonstrate during testing that all analog values updated within 2 sec . . The updation time shall be demonstrated during testing . 5
- FRTU shall have one port for connecting the portable configuration and maintenance tool for FRTU. SSL/VPN ,NERC/CIP complaint

It shall be possible to increase the number of communication ports in the FRTU by addition of cards, if required in future. The FRTU shall support the use of a different communication data exchange rate (bits per second) and scanning cycle on each port & different database for each master station.

2.3.1 Master Station Communication Protocol

FRTU shall use IEC 60870-5-104/101 communication protocol for communicating to master station. The FRTU communication protocol shall be configured to report analog (except energy values) & status changes by exception to master stations. However, FRTU shall support periodic reporting of analog data and periodicity shall be configurable from 2 sec to 1 hour. Digital status data shall have higher priority than the Analog data. The dead-band for reporting Analog value by exception shall be initially set to 1% (in %) of the full scale value. In addition, analog values shall also be reported to Master station by exception on violation of a defined threshold limit. All the analog values and status data shall also be assigned to scan groups for integrity check by Master stations at every 10 minutes configurable up to 60 minutes FRTU wise.

FRTU shall report energy values to master station periodically. The periodicity shall be configurable from 5 minutes to 24 hours (initially set for 15 minutes)

2.3.2 Communication Protocol between FRTU & MFTs

The FRTU shall acquire data from the MFTs using the MODBUS protocol. In addition, usage of IEC 60870-5-101/104 protocols is also permitted. The MFT will act as slave to the FRTU. The FRTU shall transmit these values to the master station in the frame of IEC 60870-5-104/101 protocol.

2.4 Analog Inputs

The real time values like, Active power, Reactive Power, Apparent power three phase Current & Voltage and frequency, power factor & accumulated values of import /export energy values will be acquired FRTU from the following in the given manner:

1. MFTs installed in RMU/DTs
2. RTU shall also take 4-20 mA, 0-20mA, 0- -10mA, 0-+10mA, 0-5V etc as analog inputs to acquire DC power supply voltage etc.

The FRTU analog-to-digital (A/D) converters shall have a digital resolution of at least twelve (12) bits plus sign. The overall accuracy of the analog input system shall be at least 0.2%(i.e. 99.8%) at 25 ºC of full scale . Mean accuracy shall not drift more than 0.002% per degree C within the temperature range of –5 to +55 degree Linearity shall be better than 0.05%. The FRTU shall be designed to reject common mode voltages up to 150 Vac (50 Hz). For dc inputs, normal mode noise voltages up to 5 Vac shall be rejected while maintaining the specified accuracy. 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 FRTU input.

The ability of the FRTU to accommodate dc inputs shall include the following signal ranges:

- Unipolar Voltage:0-0.5V, 0-1V, 0-5V, 0-10V,
- Unipolar Current: 0-1mA, 0-10mA, 0-20mA, 4-20Ma,
- Bipolar Voltage: 0.5V, 2.5V, 5V, -20-0-20mA (- to +)

The total burden imposed by the FRTU analog input circuit shall not exceed 0.5 volt-ampere for current and voltage inputs. As an option, contractor may also provide transducer less solution to connect direct CT/PT secondaries.

2.5 Status input

RTU shall be capable of accepting isolated dry (potential free) contact status inputs. 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 Vdc/220VAC.

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.

To take care of status contact chattering, a time period for each point and the allowable number of operations per time period shall be defined. If the allowable number of operations exceed within this time period, the status change shall not be accepted as valid

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.

The 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 FRTU from the field at 1 millisecond periodicity.

2.6 Sequence of Events (SOE) feature

To analyse the chronology or sequence of events occurring in the power system, time tagging of data is required which shall be achieved through SOE feature of RTU. The RTU shall have an internal clock with the stability of 100ppm or better . The RTU time shall be set from time synchronization messages received from master station using IEC 60870-5- 104 protocol. SOE time resolution shall be 10 ms or better

The RTU shall maintain a clock and shall time-stamp the digital status data. Any digital status input data point in the RTU shall be assignable as an SOE point.

Each time a SOE status indication point changes the state, the RTU shall time-tag the change and store in SOE buffer within the RTU. A minimum of 300 events can be stored in the SOE buffer. SOE shall be transferred to Master Station as per IEC 60870-5-104 protocol. SOE buffer shall be maintained by FRTU on power supply interruption.

2.7 Control Outputs

The FRTU shall provide the capability for a master station to select and change the state of digital output points. These control outputs shall be used to control power system devices such as Circuit breakers, isolator, reset, relay disable/enable and other two-state devices, which shall be supported by the RTU.

A set of control outputs shall be provided for each controllable device. On receipt of command from a master station using the select check-before-execute operate (SCBO) sequence, the appropriate control output shall be operated for a preset time period which is adjustable for each point from 0.1 to 2 seconds.

Each control output shall consist of one set of potential free NO contact. The output contacts shall be rated for atleast 0.2 Amp. at 48 Vdc. These output contact shall be used to drive heavy duty relays. In case Control output module of FRTU does not provide potential free control output contact of this rating, then separate control output relays shall be provided by the contractor. These relay coils shall be shunted with diodes to suppress inductive transients associated with energizing and de-energizing of the relay coils & shall conform to the relevant IEC requirements.

2.7.1 Heavy duty control output relays

The control output contact from the FRTU shall be used for initiating heavy duty relays for trip/close of switching devices. The contractor shall provide heavy duty relays. Each control output relays shall consist of atleast 2 NO contacts. The output contacts shall be rated for at least 5 Amps Continuous at 220Vdc 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 IEC255-1-00 and IEC 255-5 requirements.

2.7.2 Control Security and Safety Requirements

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

(a) Select- check-before-operate operate (SCBO) sequence for control output.
(b) No more than one control point shall be selected/executed at any given time.
(e) 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.

(f) No control command shall be generated during power up or power down of FRTU.

2.7.3 Local/Remote selector switch

A manual Local/Remote selector switch shall be provided for each FRTU to disable all control outputs by breaking the power supply connection to the control output s. When in the "Local" position, the Local/Remote switch shall allow testing of all the control outputs of FRTU 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.

2.7.4 Dummy breaker latching relay

The Contractor shall provide a latching relay to be used to simulate and test supervisory control from the Master station. The latching relay shall accept the control signals from the FRTU to open and close, and shall provide the correct indication response through a single point status input.

2.8 Contact Multiplying Relays (CMRs)

Contact Multiplying Relays (CMRs) are required to multiply the contacts of breaker, isolators and protection relays etc. The contacts of these relays shall be used to provide status inputs to the RTUs.

The relays shall be DC operated, self reset type. The rated voltage for relay operation shall be on 24/48/110/220V DC depending on the station DC supply. The relay shall be able to operate for +/-20% variation from nominal voltage.

The relay shall have a minimum of two change over contacts, out of which one shall be used for telemetry purposes. The contacts shall be rated to carry minimum current capacity of 5A.

The relay shall conform to following requirement.

d) Power Frequency withstand voltage–2KV for 1 minute as per IEC 255-5.
e) Insulation Resistance of 100M ohms measured using 500V DC megger.
f) 5KV Impulse test as per IEC 255-5

The relays 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. The relays must be protected against the effects of humidity, corrosion & provide with a dust tight cover. The connecting terminals shall be screw type & legibly marked. The relays may optionally have a visual operation indicator. The relays are to be mounted in junction /termination box and therefore shall be equipped with suitable mounting arrangements. In case suitable space is not available in junction /termination box the same shall be mounted in FRTU panel.

2.9 Time facility

The internal FRTU time base shall have a stability of 100 ppm. The RTU shall be synchronised through synchronisation message from master station at every 5 minutes (configurable from 5 minutes to 60 minutes) over IEC 60870-5-104/101/NTP/SNTP

2.10 Diagnostic Software

Diagnostic Software shall be provided to continuously monitor operation of the FRTU and report RTU hardware errors to the connected master stations. The software shall check for memory, processor, and input/output ports errors and failures of other functional areas defined in the specification of the RTU.

2.11 Input DC Power Supply

The FRTU will be powered from a 48 V DC power supply 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 Vdc with variation between 40.8 and 57.6 Vdc.(i.e. 48(+20%/-15%)
(b) Maximum AC component of frequency equal to or greater than 100 Hz and 0.012 times the rated voltage peak-to-peak.

The FRTU 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.

2.12 Environmental Requirements

The FRTU will be installed in inside RMU Panel or in open environment with no temperature or humidity control. The RTUs shall be capable of operating in ambient temperature from 0 to +55 degree C with rate of temperature change of 20 degree C/hour and relative humidity less than 95%, non-condensing. FRTUs to be installed in the hilly region with the history of snowfall, the same the lower ambient temperature limit shall be -5 degree C.

2.13 FRTU Size and Expandability

FRTU shall be equipped for the point counts defined in the BOQ (Basic+20% spare (wired & hardware). It shall be possible to expand the FRTU capability for additional 100 % of the basic point counts by way of addition of hardware such as modules, racks, panels, , however, FRTU software and database shall be sized to accommodate such growth without requiring software or database regeneration.

2.14 FRTU Panels

At least 50% of the space inside each enclosure shall be unused (spare) space that shall be reserved for future use. The Contractor shall provide required panels

conforming to IEC 529 for housing the FRTU modules/racks, relays etc. and other required hardware. The panels shall meet the following requirements:

(a) shall be pole/ wall mounted compact size cabinet. The size shall be preferably in the order of 400 mm. All doors and removable panels shall be fitted with long life rubber beading. All non load bearing panels/doors shall be fabricated from minimum 1.6 mm thickness steel sheet and all load bearing panels, frames, top & bottom panels shall be fabricated from minimum 2.0 mm thickness steel sheet

(b) shall have maintenance access to the hardware and wiring through lockable 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 outdoor, dust-proof with rodent protection, and meet class of protection. IP41 if housed in RMU panel & IP54 in case of in open outdoor.

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

(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.

2.15 Wiring/Cabling requirements

The FRTU panels shall gather all signals from and to the devices located in Control & Relay panels in the substation control room. All wires that carry low-level signals shall be adequately protected and separated as far as possible from power wiring. All wires shall be identified either by using ferrules or by colour coding. In addition, cables shall be provided with cable numbers at both ends, attached to the cable itself at the floor plate where it enters the cubicles.

Shielded cables shall be used for external Cabling from the FRTU panels. The external cables (except communication cables) shall have the following characteristics:

h) All cables shall have stranded copper conductor.

i) Minimum core cross-section of 2.5 mm^2 for PT cables, 4 mm^2 for CT cables, if applicable and 2.5 mm^2 for Control outputs and 1.5mm^2 for Status inputs

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

k) 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.

l) Shielding, longitudinally laid with overlap.

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

n) 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.

2.16 Terminal Blocks (TBs)

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. Required number of TBs shall be provided for 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. TBs 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.

SECTION 3

CHAPTER-3

3.0 Transducer & Weather Sensor Requirements:

All transducers including weather sensor shall use a 48 Vdc auxiliary power supply as provided for the RTU/FRTU. Optionally , MFTs can also be self powered. All transducers shall have a maximum power consumption of 10 watts. Transducer shall be din rail or wall/plate mounted.

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 to the following requirements, in addition to the requirement of IEC 60688, without damage to the transducer.

Voltage:

Voltage test and other safety requirement compliance as specified in IEC 60688 or 60687and IEC 414.

(c) Impulse Withstand:

IEC 60688 or 60687 compliance is required.

(d) Electromagnetic Compatibility:

IEC 60688 or 60687 and IEC 801-3, level 1 compliance is required.

(e) Permanent Overload Protection:

IEC 60688 or 60687 compliance is required.

(f) Temporary Overload Protection:

IEC 60688 or 60687 compliance is required.

(g) High Frequency Disturbance:

IEC 60688 or 60687 compliance is required.

The transducers shall comply with the following general characteristics:

(a) Shock Resistance:

Minimum severity 50 A, IEC 68-2-27 requirements

(b) Vibration Strength:

Minimum severity 55/05, IEC 68-2-6 requirements.

(c) Input Circuit Consumption:

Less than or equal to 0.2 VA for voltage and 0.6VA for current circuits.

(d) Reference Conditions For Accuracy Class:

IEC 60688 or 60687compliance is required.

(e) Temperature Rise:
IEC 60688 or 60687 compliance is required.

(f) Operating Temperature: 0^{o} C to + 60^{o} C (-5^{o} C to + 55^{o} C for project area with snowfall history)

3.1 Multi Function Transducers (MFTs)

The contractor shall provide the multi function transducers for acquiring the real time analog inputs through 3 phase 3 wire CT/PTs circuits/ 3 phase 4 wire CT/PTs circuits (Based on the field requirement). Based on the CT/PT secondary rating , the multi function transducer shall be designed for nominal 110 V (Ph-Ph voltage) and 1A/5A (per phase current). The MFT shall be suitable for 20% continuous over load and shall be able to withstanding 20 times the normal current rating for a period one second. The MFT shall be able to accept the input voltages upto 120% of the nominal voltage. The MFT shall have low VA burden. MFTs shall be mounted in the interface cabinet to be supplied by the contractor.

Multi function transducers shall provide at least phase voltage, phase current active/reactive power , import & export energy (active & reactive) , pf , frequency with class 0.5 accuracy or better.

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

Multi function transducers shall accept nominal 48 V DC as auxiliary power supply Optionally, MFT can be self powered also. Multi function transducer shall be

provided with RS485 interface to communicate with RTU over Modbus protocol in multi-drop mode. Optionally, the MFT with IEC60870-5-101/104 can be used. Baud rate of data transfer between MFTs and RTU shall be 19.2 Kbps

The MFTs shall be suitable for mounting on DIN rails. The MFT terminals shall accept upto two 2.5 mm2 / 4 mm2 for PT/CT circuit terminations as applicable.

The MFT shall be programmable with password protection thru suitable facia mounted key pad arrangement so that the configuration parameters such as CT /PT ratio , integration time of energy , reset, communication parameters setting (Address, baud , parity) can be set up at site also. The device shall have LCD displays to visualize all parameters being monitored & configuration etc have configurable at site for CT/PT ratio etc.

3.2 DC Transducer

The DC transducer (DCT) are of two types.

(i) Voltage
(ii) Current

The Dc Transducer are required to measure battery charger current & voltage shall be suitable for 20% continuous over load and shall be able to withstanding 20 times the normal current rating for a period one second. The DCT shall be able to accept the input upto 120% of the nominal voltage. The DCT shall have low VA burden. DCT shall be mounted in the interface cabinet to be supplied by the contractor. The input range for current & voltage are site specific & hence the same shall be specified RFP floated by utility/state Out put of the device shall preferably be 4-20ma or MODBUS in order to optimize the BOQ. However, as a specific cases the out put in line ranges specified in analog input card in clause for analog input shall be selected. The accuracy of transducer shall be ±0.5%

3.3 Transformer Tap Position Transducer

The transformer tap position indications shall be either of two types based on field requirement..

(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. Alternatively for RTU, MODBUS link may be

used.
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.

3.4 Weather Sensors

Weather sensors shall be installed at one S/S in each town where SCADA/DMS system is getting implemented. All weather sensors shall be maintenance free and of Industry standard design. The design of sensors shall permit calibration on site. The sensing mechanism shall be rugged enough to avoid frequent recalibration.

The sensor, support structure shall have built-in protection against lightning stroke/electrical surges. The output of all the sensors except rainfall sensor shall be 4 to 20 mA at 0-500 ohm impedance. The output of rainfall sensor shall be in the form of potential free contact and its closure shall be accumulated (over a configurable time period) and reported at master station through RTU. Alternatively, RS 485 with MODBUS protocol may be used. The sensors shall be located in open and in the electrical environment such as outdoor substations. The equipment offered should be suitable for satisfactory operation in the above environment. The Bidder shall submit the details of EMI/EMC compatibility of the sensors and other equipments,

3.4.1 Wind Speed Sensor

Sensor		Anemometer 3 cup assembly, very robust to withstand strong wind gust.
Output	:	4 to 20 mA at 0-500 ohm impedance or RS 485 with MODBUS protocol
Starting Threshold	:	0.5 m/s or better
Range	:	0.9 - 60 m/s
Resolution	:	0.1 m/s
Accuracy	:	2 % or better
Mechanical	:	3 Cup assembly and housing (complete), should be very robust and capable to withstand strong wind gust and made up of suitable non-rusting material
Mounting Accessories	:	Made of suitable good quality material like steel or high strength fibre.

Operating Temperature	:	0 ^{o} C to + 60 ^{o} C (-5 ^{o} C to + 55 ^{o} C for project area with snowfall history)

Note: The Wind Speed and Wind Direction sensors may be supplied in single enclosure or separately.

3.4.2 Wind Direction Sensor

Sensor	:	Wind Direction sensor
Output	:	4 to 20 mA at 0-500 ohm impedance or RS 485 with MODBUS protocol
Starting Threshold	:	0.5 m/s or better
Range	:	0 – 360 ^{o} (Degrees)
Resolution	:	1^{o} (Degree)
Accuracy	:	. 3 ^{o} (Degrees) or better
Construction of Housing and vane	:	Housing (complete) should be very robust and capable to withstand strong wind gust and made up of suitable-non-rusting material having high mechanical strength. Wind vane and control head may be of Aluminium or other light UV resistant material
Operating Temperature	:	0 ^{o} C to + 60 ^{o} C(-5 ^{o} C to + 55 ^{o} C for project area with snowfall history)

Note: The Wind speed and Wind Direction sensors may be supplied in single enclosure or separately.

3.4.3 Air Temperature Sensor

Sensor	:	Air Temperature Sensor
Output	:	4 to 20 mA at 0-500 ohm impedance or RS 485 with MODBUS protocol
Temperature Range	:	0 ^{o} C to + 60 ^{o} C(-5 ^{o} C to + 55 ^{o} C for project area with snowfall history)
Resolution	:	0.1^{o} C
Accuracy	:	$\leq$ 0.5 ^{o} C or better
Radiation Shield	:	Radiation Shield made of weather resistant material and

suitable to sensor used.

3.4.4 Relative Humidity Sensor

Sensor	:	Relative Humidity Sensor
Output	:	4 to 20 mA at 0-500 ohm impedance or RS 485 with MODBUS protocol
Range	:	0 to 100 %
Resolution	:	1 %
Accuracy	:	. 3 % or better
Radiation Shield	:	Radiation Shield made of weather resistant material and suitable to sensor used.
Operating Temperature Range	:	0 ^{o} C to + 60 ^{o} C(-5 ^{o} C to + 55 ^{o} C for project area with snowfall history)

Note: The Air Temperature and Relative Humidity sensors may be supplied in single enclosure or separately.

3.4.5 Rainfall Sensor

Sensor	:	Tipping Bucket Rain Gauge
Output	:	The output of rainfall sensor shall be in the form of potential free contact and its closure shall be accumulated (over a configurable time period) and reported at master station through RTU. Alternatively, RS 485 with MODBUS protocol may be used.
Capacity / Range	:	Unlimited
Resolution	:	0.2 mm per tip or better
Accuracy	:	. 4 %
Collecting Area	:	Minimum 200 sq.mm.
Operating Temperature Range	:	0 ^{o} C to + 60 ^{o} C(-5 ^{o} C to + 55 ^{o} C for project area with snowfall history)

3.4.6 Atmospheric Pressure Sensor

Sensor	:	Atmospheric Pressure sensor
Output	:	4 to 20 mA at 0-500 ohm impedance or RS 485 with MODBUS protocol
Range	:	600 mb to 1100 mb
Resolution	:	1 mb or better
Accuracy	:	. 2 % of range
Operating Temperature Range	:	0 ^{o} C to + 60 ^{o} C(-5 ^{o} C to + 55 ^{o} C for project area with snowfall history)

3.4.7 Weather Sensor Installation Requirement

The weather sensor shall be supplied along with necessary accessories (e.g. tripod, stand, clamps etc.) for installation/ fixing of sensors, signal/power cables etc. as part of weather sensors station. All the accessories shall be made of stainless steel or other suitable 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 Employer 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 mounting arrangement of the Wind Velocity & Wind Direction sensors shall be of suitable height to avoid obstruction from the nearby structures.

SECTION 3, CHAPTER –4

TEST EQUIPMENTS FOR RTU/FRTU

4.0 RTU/FRTU Configuration and Maintenance Tool

Test equipment for RTU/FRTU shall have Configuration and maintenance tool consisting of the followings:

4.1 RTU/FRTU Data base configuration & Maintenance software tool

The RTU/FRTU database configuration & Maintenance software tool shall be required to perform the database modification, configuration, compilation and documentation. The database compiler shall provide error detection services. It shall also perform the downloading of the compiled database into the RTU database.

4.2 Master station-cum-RTU/FRTU simulator & protocol analyzer software tool

The Master station cum RTU/FRTU simulator tool shall be used to test the communication interfaces of Master station, RTU/FRTU and Electronic MFT. The Master station simulator tool shall be capable of emulating the master station for IEC 60870-5-104,101 and MODBUS protocols. The RTU/FRTU simulator shall be capable of emulating the slave protocols for both the IEC 60870-5-104,101, and MODBUS protocols for MFTs. It shall also be possible to prepare illegal messages for transmission, such as messages having invalid checksum.

The protocol analyser shall be used to monitor all communication traffic on a channel (between Master station & RTU/FRTU and between RTU/FRTU & MFT without interfering channels operation. Channel traffic captured in the active or passive modes of operation shall be displayed.

The Master station simulator and protocol analyser tool shall also have following features:

- Each received message shall be checked for validity, including the check sum.
- The tool shall maintain and display error counters so that the number of errors during a period of unattended testing can be determined.
- All fields of a message shall be displayed. A pass/fail indication for the message shall be included.

4.3 Laptop PC for above software tools along with interfacing hardware

A laptop PC shall be used for the above mentioned software tools. The laptop PC shall be provided with all hardware accessories including cables, connectors etc. required for interfacing with Master station, RTU/FRTU and MFT. A suitable Hub shall be provided to use the tool in monitor mode. A carrying case and a suitable power adaptor (input 230VAC, 50Hz) for laptop PC shall also be supplied.

SECTION 3, CHAPTER –5

TESTING, TRAINING & DOCUMENTATION

4.0 RTU/FRTU Testing

This chapter describes testing, training & documentation requirement for RTU/FRTU

(a) Type Testing:

RTU/FRTU in including Transducers shall conform to the type tests listed in the relevant table. Type test reports of tests conducted in NABL accredited Labs or internationally accredited labs with in last 5years from the date of bid opening may be submitted. In case, the submitted reports are not as per specification, the type tests shall be conducted without any cost implication to employer. A complete integrated unit shall be tested to assure full compliance with the functional and technical requirements of the Specification including functional requirement. The testing sample shall include one of each type of cards/modules and devices. The list of Type tests to be performed on the RTU/FRTU is mentioned in **Table-1** & type test requirements are mentioned in **Table-2 of this chapter**. For other items also such as MFT, sensor etc the requirements are mentioned in the respective sub sections of specification.. However, the type tests shall be only be limited to the specification of that item only & not as specified for RTU/FRTU.

(b) Routine Testing or Factory acceptance test (FAT):

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

(c) Site Acceptance Test (SAT)

(i) Field Tests

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

(ii) Availability Tests

After field testing, RTU/FRTU shall exhibit a 98% availability during test period. Availability tests shall be performed along with Master station. The RTU/FRTU - 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.

4.1 TRAINING

The contractor shall provide training to the Employer's personnel. The training program shall be comprehensive and provide for interdisciplinary training on hardware and software. The training program shall be conducted in English. RTU/FRTU training course shall cover the following:

a) RTU/FRTU operation including data flow.
b) Troubleshooting, identification and replacement of faulty Modules.
c) Preventive maintenance of the RTU/FRTU
d) Use of RTU/FRTU configuration and Maintenance tool
e) All functional and Diagnostic testing of RTU/FRTU
f) Database modification and configuration of RTU/FRTU

4.2 DOCUMENTATION

The Contractor shall submit 3 sets of all the standard and customised RTU/FRTU documents for review and approval which includes the following:

a) RTU/FRTU Function design document
b) RTU/FRTU Hardware description document & all the documents referred therein to meet all the clauses of the specification.
c) RTU/FRTU Test equipment user documents
d) RTU/FRTU user guide
e) RTU/FRTU Operation & Maintenance document
f) RTU/FRTU Training documentation
g) RTU/FRTU database document
h) RTU/FRTU I/O list
i) RTU/FRTU Test procedures
j) Data Requirement Sheet (DRS) of all items
k) Protocol documentation including implementation profile etc.
l) RTU/FRTU installation and Layout, GA, BOQ, schematics and internal wiring drawings for each RTU/FRTU site
m) RTU/FRTU to C&R panels/ field device cabling details for each RTU/FRTU site

After approval of all the above documents, the Contractor shall submit three sets as final documents. The site-specific drawings as indicated at item (i) and (j) above shall be submitted in three sets for each site before installation of RTU/FRTU. In case some modifications/corrections are carried out at site, the contractor shall again submit as built site-specific drawings in three sets after incorporating all such corrections as noticed during commissioning of the RTU/FRTU.

Table-1: List of Tests on RTU/FRTU

Test Nos.	DESCRIPTION OF THE TEST	Type test	Routine test	Field test
A	**FUNCTIONAL TESTS FOR RTU/FRTU**			
1.	Check for BOQ, Technical details, Construction & Wiring as per RTU/FRTU drawings	√	√	√
2.	Check for database & configuration settings	√	√	√
3.	Check the operation of all Analog inputs, Status input & Control output points of RTU/FRTU	√	√	√
4.	Check operation of all communication ports of RTU/FRTU	√	√	√
5.	Check for communication with master stations including remote database downloading from master station	√		√
6.	Check for auto restoration of RTU/FRTU on DC power recovery after its failure	√		√
7.	Test for self diagnostic feature	√		√
8.	Test for time synchronization from Master	√		√
9.	Test for SOE feature	√		√
10.	End to end test (between RTU/FRTU & Master station) for all I/O points			√
11.	Test for MODBUS protocol implemented for acquiring data from MFT/ transducers and updation time demonstration in daisy chain configuration	√		√
12.	Test for IEC 60870-5 -104,101 protocol implemented	√		√
13.	Test for supporting other protocol	√		
14.	Test for operation with DC power supply voltage variation	√		
15.	Test for internal Clock stability	√		
16.	Test for Noise level measurement	√		
17.	Test for Control Security and Safety for Control outputs	√		
18.	Test for functionality/parameters verification of , CMRs & Heavy duty trip relays	√	√	√
19.	Test for data concentrator	√*		
20.	Test for IED pass through	√*		
21.	Test for SOE buffer & time data back up	√		
22.	Other functional tests as per technical specification requirements including features in support/ capability (for future)	√		
23.	Test for DCPS of FRTU	√**		
24.	Test for compliance of standards for bought items viz. CMRs, Heavy duty trip relays , MFT,weather sensoretc	√		
25.	Test for functionality/parameters for bought items viz. CMRs, Heavy duty trip relays , MFT , weather sensor etc	√	√	
26.	Test for test tools		√	√
27.	LDMS testing is for RTU		√**	√**
B	**EMI/EMC IMMUNITY TESTS FOR RTU/FRTU**			
28.	Surge Immunity Test as per IEC 60870-2-1	√		
29.	Electrical Fast Transient Burst Test as per IEC-60870-2-1	√		
30.	Damped Oscillatory Wave Test as per IEC 60870-2-1	√		
31.	Electrostatic Discharge test as per IEC 60870-2-1	√		
32.	Radiated Electromagnetic Field Test as per IEC 60870-2-1	√		
33.	Damped Oscillatory magnetic Field Test as per IEC-60870-2-1	√		
34.	Power Frequency magnetic Field Test as per IEC-60870-2-1	√		
C	**INSULATION TEST FOR RTU/FRTU**			
35.	Power frequency voltage withstand Test as per IEC 60870-2-1	√		
36.	1.2/50 µs Impulse voltage withstand Test as per IEC 60870-2-1	√		
37.	Insulation resistance test	√		
D	**ENVIRONMENTAL TEST FOR RTU/FRTU——**			
38.	Dry heat test as per IEC60068-2-2	√		
39.	Damp heat test as per IEC60068-2-3	√		

Note: **1)** Test levels for above type tests mentioned in B, C & D above are elaborated in Table 2 of this Chapter
2) * For RTU only & ** For FRTU only

3) **Contractor can provide test certificates for the type tests mentioned in B,C,D & supporting protocols from Govt of India/NABL/International accredited Labs. If not provided, the same needs to conducted at Govt of India/NABL/International accredited Labs**
4) **Transducer type test requirements are mentioned in the respective sub section of specification.**

Table--2
RTU/FRTU Type Test Requirements

Test Nos.	Test Name	EUT Status	Test Level	Power Supply Points		I/O Points	Passing Criteria
				CM	DM	CM	
20.	Surge Immunity Test	ON	Level 3	2 kV	1 kV	2 kV	A
21.	Electrical Fast Transient Burst Test	ON	Level 3	2 KV	-	1 kV	A
22.	Damped Oscillatory Wave Test	ON	Level 3	2.5 kV	1 kV	2.5 kV	A
23.	Electrostatic Discharge Test	ON	Level 3	+/- 6 kV in Contact discharge mode or +/- 8 kV in Air discharge mode			A
24.	Radiated Electromagnetic Field Test	ON	Level 3	10 V/m electric field strength			A
25.	Damped Oscillatory Magnetic Field Test	ON	Level 3	30 A/m at 1MHz of magnetic field strength			A
26.	Power frequency magnetic field	ON	Level 3	30 A/m of magnetic field strength (Continuous duration sine wave)			A
27.	Power frequency voltage withstand	OFF	-	1 KVrms for 1 minute			No break down or flashover shall occur
28.	1.2/50µs impulse voltage withstand	OFF	-	2 kVp			No break down or flashover shall occur
29.	Insulation Resistance Test	OFF	-	Measure Insulation resistance using 500 V DC Megger before & after Power Freq & Impulse voltage withstand tests			As per manufacturer standard
30.	Dry heat test	ON	-	Continuous operation at 55^0 C for 16 hrs			0
31.	Damp heat test	ON	-	at 95% RH and 40^0 C			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