

FRTUs

2.0 General:

The Feeder Remote Terminal Unit/Fault Restoration Terminal Unit (FRTU) shall be installed at all RMU and Sectionalizer Locations in the Project Area. FRTU shall also be used for control of field devices such as breakers in RMUs and Sectionalizers from Master station.

The supplied FRTUs shall be interfaced with RMUs, FPIs, communication equipment and 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 4-20 mA, RTD etc.
- b) Receiving and processing digital commands from the master station for D/O
- c) Data transmission rates - 300 to 19200 bps for Serial ports for MODBUS and 10/100 mbps for TCP/IP Ethernet ports
- d) Void
- e) Use of IEC 60870-5-104/101 protocol to communicate with slave devices.
- f) Void

- g) Void
- h) Void
- i) Void
- j) Use of MODBUS over RS-485 interface Protocol to communicate with the MFTs.
- k-1 Have required number of communication ports for simultaneous communication with Master station, MFTs and FRTU configuration & maintenance tool.
- k-2) FRTU shall have the capability of automatic start-up and initialization following restoration of power after an outage without need of manual intervention. All restarts shall be reported to the connected master stations.
- l) Accept remote database downloading of FRTU from SCADA/DMS control centre.
- m) Shall have 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., it is mandatory to guard the data/equipment from intrusion/damage/breach of security and 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) Shall support 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 to -10 mA, 0 to +10 mA etc, using analog input modules.
- r) Capability of time synchronization with GPS receiver which may be required future at the time of SMART GRID.
- s) Accept data from FPI

Some of the support feature, as mentioned above may not be used now & may be

required in future. Hence, the same shall be incorporated in the supply and these features would be tested in Factory Acceptance Tests.

2.2.1 I/O Ports:

- a) Analog Inputs: It is through MFTs, each providing 14 distinct inputs. Not more than 8 MFTs shall be connected in one loop of Daisy Chain. Recommended are 5 per loop.
- b) D/I: It is through D/I Card. Opto Couplers may be used before connecting relay points.
- c) D/O: It is through D/O Card. Opto Couplers may be used before connecting relay points.

2.2.2 I/O Requirements:

All hardware necessary to meet the initial point requirements for A/I, D/I and D/O shall be provided. They shall have 20 % spare points per I/O type. The FRTUs shall be physically sized to support the ultimate I/O requirements per FRTU, as explained in Appendix-N

The following FRTU input/output types are described in the following sections:

1. Analog inputs
2. Digital inputs
3. Digital outputs

2.2.3 I/O Sizing:

I/O Counts are detailed in Appendix-N. As a minimum, FRTUs shall support following I/O Sizing.

Sl. No.	FRTU	Location	D/I	D/O	MFT-A/I	Total
1	Type-A	5 Way RMUs	53	20	70	143
2	Type-	4 Way RMUs	44	16	56	116
3	Type-B	3 Way RMUs	35	12	42	89
4	Type-C	Sectionalizers	12	3	14	29

Total Number of Points contributed by FRTUs only from all the 3 Cities:

Sl. No.	FRTU	RNC	JSR	DHN	Total	Pts/FRTU	Total pts
1	Type-A-5 Way	44	26	29	99	143	14,157
2	Type-A1-4 Way	0	0	5	5	116	580
3	Type-B-3 Way	322	191	206	719	89	63,991
4	Type-C-Sectionalizer	300	351	160	811	29	23,519

	Total	666	568	400	1634		1,02,247
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Note: 1) This doesn't include RTU Points, which are detailed in Section-3, Chapter-1.

2.3 Communication ports and Protocols:

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

- 1) 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 IEC 60870-101
- 2) FRTU shall have required number of RS 485 ports for communication with MFTs to be connected in daisy chain using MODBUS protocol.
- 3) Minimum 14 analog values (including 4 energy values) to be considered per energy meter.
- 4) The RTU shall be designed to connect maximum 5 MFTs per port.
- 5) Further, bidder to demonstrate during testing that all analog values updated within 2 sec. The updation time shall be demonstrated during testing.
- 6) FRTU shall have one port for connecting the portable configuration and maintenance tool for FRTU.
- 7) FRTU shall be VPN, NERC/CIP or international equivalent standard compliance

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 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% (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 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 MFTs shall be 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, 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:

- a) MFTs installed in RMU/DTs
- b) RTU shall also take 4-20 mA, 0-20 mA, 0 to -10 mA, 0 to +10 mA, 0-5 V 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 $\pm 0.2\%$ (i.e. 99.8%) at 25^{0C} 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 $\pm 0.05\%$. The FRTU shall be designed to reject common mode voltages up to 150 V AC (50 Hz). For DC inputs, normal mode noise voltages up to 5 V AC 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 up to 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:

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

The total burden imposed by the FRTU analog input circuit shall not exceed 0.5 VA for current and voltage inputs. As an option, contractor may also provide transducer

less solution to connect direct CT/PT secondaries.

2.5 Status Inputs (Discrete Inputs) (D/I):

FRTU shall be capable of accepting isolated dry (potential free) contact status inputs. The FRTU shall provide necessary sensing voltage, current, optical isolation and debounce filtering independently for each status input. **The sensing voltage shall not exceed 48 V DC for 48 V DC Supply, 24 V DC for 24 V DC Supply/220 V AC**

The FRTU 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 FRTU 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 SoE:

To analyze 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 Discrete Control Outputs (D/O):

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 relay disable/enable and other two-state devices, which shall be supported by the FRTU.

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 at least 0.2 Amp at 48 V DC (for 48 V DC System) or 24 DC (for 24 V DC System).** 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 (HDRs):

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 at least 2 NO contacts. The output contacts shall be rated for at least 5 Amps continuous at **48 V DC** and shall provide arc suppression to permit interruptions of an inductive load. Relay coils shall be shunted with diodes to suppress inductive transients associated with energizing and de-energizing of the relay coils.

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 for FRTU:

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 outputs. When in the "Local" position, the Local/Remote switch shall 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 function 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 FRTUs. The relays shall be DC operated self reset type.

The rated voltage for relay operation shall be on 24/48/110/220 V DC depending on the RMU/Sectionalizer 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: 2 kV for 1 minute as per IEC 255-5.
- b) Insulation Resistance: 100 M hms using 500V DC megger.
- c) Impulse test: 5 kV 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 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 FRTU panel.

2.9 FRTU Internal Time facility:

The internal FRTU time base shall have a stability of 100 PPM or better The FRTU shall be synchronized through synchronization message received from master station at every 5 minutes (configurable from 15 minutes to 24 hrs) over IEC 60870-5-104/101/NTP.

2.10 Diagnostic Software:

Diagnostic Software shall be provided to continuously monitor operation of the FRTU and report FRTU 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 FRTU.

2.11 Input Power Supply to FRTU:

FRTUs shall be capable of performing with 48 V /24 V DC from DCPS.

The FRTU shall not place a ground on the input power. The characteristics of input power supply DC shall be nominal voltage of 48 V DC with variations from 40.82 to 57.6 V DC (48V + 20%/-15%) or nominal voltage 24 V DC with variations between 20.4 to 24.8 Volts DC (24 +20 %/-15%)

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.
- (e) 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.
- (f) All panels shall be supplied with 230 V AC, 50 Hz, single-phase switch and 15/5A duplex socket arrangement for maintenance.
- (g) All panels shall be provided with an internal maintenance lamp, space heaters and gaskets.
- (h) 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.
- (i) 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. External cables (except communication cables) shall have the following characteristics:

- 1) All cables shall have stranded copper conductor.
- 2) 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 1.5 mm^2 for Status inputs

- 3) Rated voltage U_0/U of 0.6/1.1 kV
- 4) 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.
- 5) Shielding, longitudinally laid with overlap.
- 6) Dielectric withstand 2.5 kV at 50 Hz for 5 minutes
- 7) External marking with manufacture's name, type, core quantity, cross-section, and year of manufacture.
- 8) The Communication cable shall be of shielded twisted pairs and of minimum 0.22sq mm size.

2.16 Terminal Blocks:

Terminal blocks shall be having provision for disconnection (isolation), with full-depth insulating barriers made from moulded self-extinguishing material. Terminal blocks shall be appropriately sized and rated for the electrical capacity of the circuit and wire used. No more than two wires shall be connected to any terminal. 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.