Executing the report generating functions shall not interfere in any server of the system with the on-line SCADA/DMS functions.

5.9 System Generation and Build

System generation includes the activity of generating an executable object code of all databases, displays, and reports as required for SCADA/DMS system. System build is the process under which all the above executable and the executable provided for SCADA/DMS application software are ported to the SCADA/DMS system hardware and configuring to make it operational.

The contractor shall do the complete system generation and build as required for successful operation of the SCADA/DMS system. The contractor shall also provide the complete backup of the SCADA/DMS system in electronic media such as tapes, CDs, MO disks etc. Employer personnel shall be able to restore the SCADA/DMS system at site by using above backup tapes/CDs etc. The contractor shall provide the procedures necessary to restorethe system from the backup tapes/CDs etc. The DR system shall always have updated set of system build. It shall be synchronized with the SCADA/DMS control center .

5.10 Software Utilities

All software utilities used to maintain SCADA/DMS software, whether or not specifically required by this Specification, shall be delivered with the system.

The software utilities shall operate on-line (in background mode) without jeopardizing other SCADA/DMS application functions that is running concurrently. This utility software shall be accessible from workstations, programming terminals, and command files on auxiliary memory. Multiple users shall have concurrent access to a utility program task, provided there are no conflicts in the use of peripheral devices.

5.10.1 File Management Utility

File management utilities shall be provided that allocate, create, modify, copy, search, list, compress, expand, sort, merge, and delete program files, display files, and data files on auxiliary memory and archive storage.

5.10.2 Auxiliary Memory Backup Utility

A utility to backup auxiliary memory of server and workstation files onto a user- selected auxiliary memory or archive device shall be supplied. The backup utility shall allow for user selection of the files to be saved based on:

(a) Server and workstation

(b) File names (including directory and wildcard designations)

(c) File creation or modification date and time

(d) Whether or not the file was modified since the last backup.

A backup utility that can backup all server and workstation auxiliary memories on to a single target auxiliary memory or archive device shall be provided. The backup utility must ensure that the source auxiliary memory files are captured properly regardless of caching activity.

5.10.3 Failure Analysis Utility

Failure analysis Utility shall be provided to produce operating system and application program

status data for analyzing the cause of a fatal program failure. The failure information shall be presented in a condensed, user-oriented format to help the user find the source of the failure. The information shall be presented on displays and recorded for historical records and user-requested printed reports.

5.10.4 Diagnostic Utility

The system shall have suitable auto diagnostic feature, on line & offline diagnostic Utility for on-line and off-line monitoring for equipments of SCADA/DMS system shall be provided.

5.10.5 System utilization Monitoring Utility

Software utility shall be provided in each server and workstation to monitor hardware and software resource utilization continuously and gather statistics. The monitoring shall occur in real-time with a minimum of interference to the normal SCADA/DMS functions. The period over which the statistics are gathered shall be adjustable by the user, and the accumulated statistics shall be reset at the start of each period. The statistics shall be available for printout and display after each period and on demand during the period.

5.10.6 Other Utility Services

On line access to user and system manuals for all software/Hardware products (e.g., Operating System and Relational Database Software/hardware) and SCADA/DMS applications shall be provided with computer system.

End of Chapter 5

CHAPTER -6: HARDWARE REQUIREMENTS FOR SCADA/DMS

6.0 Introduction

This chapter articulates the hardware requirements for the SCADA/DMS system. The conceptual hardware configuration diagram of SCADA/DMS control center is indicated in Figure-1 of chapter 1. The bidders are encouraged to optimize the hardware for servers where SCADA, DMS & ISR applications can be combined or distributed in any combination with adequate redundancy. However, quantity of servers shall be as per detailedbill of quantities for SCADA/DMS defined in chapter 19. Bidder shall assess the adequacy of hardware specified in the BOQ & if any additional hardware is required to meet all the requirements of the technical specifications, the same shall also be included in the offer. TheBidder shall offer the minimum hardware configuration as specified here for various equipment, however if required, higher end hardware configurations shall be offered to meetall the requirements of the technical specification. The redundant hardware such as servers (Except DTS, development server) , CFE, etc. shall work in hot standby manner. It is necessary to ensure that the functional requirements, availability & performance aspects are met as per SCADA/DMS system specification. This chapter is applicable to Group A,B,C, Utowns as per functional requirements

6.1 General Requirements for Hardware

All hardware shall be manufactured, fabricated, assembled, finished, and documented with workmanship of the highest production quality and shall conform to all applicable quality control standards of the original manufacturer and the Contractor. All hardware components shall be new and suitable for the purposes specified. All hardware such as computers, computer peripherals/accessories etc. and networking products proposed and implemented shall conform to latest products based on industry standard. All hardware shall be of reputed make.

All servers and workstations shall include self-diagnostic features. On interruption of power they shall resume operation when power is restored without corruption of any applications.

The hardware shall be CE/FCC or equivalent international standard compliance. The specification contains minimum hardware requirement. However, the contractor shall provide hardware with configuration equal or above to meet the technical functional & performance requirement. Any hardware /software that is required to meet functional, performance & availability requirement shall be provided by Contractor & the same shall be mentioned in the BOQ at the time of bid . If not mentioned at the time of bid, contractor shall provide the same without any additional cost to the owner The proposed system shall be designed for an open & scalable configuration, to ensure the inter-compatibility with other systems of the Utility, the future smooth expansion as well as the easy maintainability. The proposed hardware configuration should be extended by adding either CPU processors / memory boards / disks etc.in delivered units or additional units for capacity extension.

The configuration of the SCADA/DMS shall comprise a distributed computing environment with an open systems architecture. The system architecture shall be open internally and externally to hardware or application software additions, whether supplied by the original supplier of the SCADA/DMS or obtained from third party vendors, both for capacity expansion and for upgrading functionality, without affecting existing SCADA/DMS components or operation.

To be recognized as a true open computer system, all internal communications among the

SCADA/DMS Servers and all external communications between the SCADA/DMS and other computer systems shall be based on widely accepted and published international or industry standards which are appropriate and relevant to the open systems concept or should have a field proven acceptance among utilities. This applies to the operating system, database management system, and display management system, as well as to APIs providing standardized interfacing between System software and application software.

The contractor should ensure that at the time of final approval of hardware configuration/BOQ, all the above hardware are current industry standard models and that the equipment manufacturer has not established a date for termination of its production for said products. Any hardware changes proposed after contract agreement shall be subject to the following: -

a) Such changes/updates shall be proposed and approval obtained from Employer along with the approval of Drawings/documents.

b) The proposed equipment shall be equivalent or with better features than the equipment offered in the Contract.

c) Complete justification along with a comparative statement showing the original and the proposed hardware features/parameters including technical brochures shall be submitted to the Employer for review and approval.

d) Changes/updates proposed will be at no additional cost to the Employer.

6.2 Hardware Configuration

In this technical specification all hardware has been broadly classified as server and Peripheral device. The term "server" is defined as any general-purpose computing facility usedfor hosting SCADA, DMS & ISR application functions as defined in the specification. The servers typically serve as the centralized source of data, displays and reports. The term “Peripheral Device” is used for all equipment other than servers. Peripheral device includesOperator Workstations, WAN router, LAN, Printer, Time and Frequency system, External Autoloader, External Cartridge Magnetic tape drive, VPS, RTU/FRTU etc.

6.2.1 Servers

The OEM of servers shall be member of TPC/SPECMARK. can be broadly classified into the following categories:

A) Application server

- SCADA
- DMS (Group A /UONLY)
- OMS (Group A/U ONLY)
- ISR
- NMS
- Web server

B) Communication server

- Front –End server (Communication Front End) FEP(CFE)
- ICCP /Inter control center communication server

C) De –militarized server (DMZ)

- Web server with load balancing

D) Training & development system server

- DTS #
- Developmental server #

E) Data recovery

/DRR/DR/ Communication server ^

The minimum hardware configuration of the servers shall be:

- *2.8GHZ each processor - Min 2X8 Core (in case the offered server is RISC & EPICbased processor speed shall be at least 2GHz)*
- Minimum 2 Processors
- *64GB Main memory (RAM)*
- *Hard disk - SAS HDD with 1 TB or better configuration (For ISR Server SSD type hard disk with Min. 4 TB*
- 19" LED color monitor
- Keyboard & Mouse
- *4 nos. of Gigabit Ethernet ports (2 nos. for DTS & Development Server)*
- *DVD-R/W drive*
- *One hot pluggable port for external Storage drive (Servers for which external storage connectivity is required)*
- Redundant power supply (230 VAC) & fan

SCADA/DMS and other servers shall be RISC (Reduced Instruction Set for Computation) or Non RISC e.g. EPIC/CISC etc.

Contractor shall provide cubicle mounted servers. The main & standby servers shall be provided with separate cubicles where each cubicle can be provided with one set of LED monitor, keyboard, and mouse through KVM switch with re-traceable tray.

6.2.1.1 Application servers

Redundant SCADA/DMS servers shall house SCADA/DMS application. Redundant ISR application shall be provided with common external memory for mass historical data storage and retrieval. The external memory shall comprise of multiple hot pluggable type hard disks configured in RAID configuration. (Except RAID-0) The external memory shall be connected either directly to the ISR server through SATA/ SCSI /SAS interface or directly on the LAN (Network Attached Storage). Alternatively, the bidder may offer RAID with each server to meet the mass storage requirement in place of common external memory.. The minimum requirement for external RAID for ISR servers is as below. The SCADA shall include historical data storage configured to store historical data at the storage rates, for the required period of time, and for the Ultimate historical database sizes given in section8.

- Storage Array
- Controller Cache: 512 MB per controller standard
- Integrated RAID controller with an LCD/LED status display and 256 MB
- read/write battery-backed cache (expandable to 512 MB per controller).
- Host Interface: Fiber Channel connection per controller from the host side
- Host Ports per Controller: Dual 2 Gb/s RAID Levels (EXCEPT RAID 0)
- Redundant Controller: Yes

Redundant Web / Active Directory Services Server shall host Web Applications for SCADA/DMS LAN and the DNS configuration

Redundant NMS server shall be provided to host NMS application

6.2.1.2 Communication Servers:

6.2.1.2.1 FEP (CFE) Server

The redundant FEP server shall be a functional unit that offloads the task of communication & pre-processing between RTUs/FRTUS/FPIs & SCADA/DMS servers. All RTUs/FRTUs/FPIs shall be connected to CFE through IEC 60870-5-104/101 link.. For any existing RTUs/FRTU/FPI that are to be integrated, interface must be available to use existing protocols. Free slots shall be made available inside the FEP server, so as additional communication boards can be plugged-in to meet the network future expansion. Each channel shall be assigned a different protocol and the front-end shall be able to manage several protocols in parallel.

The redundancy of front-end servers shall allow handling of RTUs/FRTUs/FPIs connected either through single channel or redundant channels. In both cases, one FEP server shall be able to take control of all RTUs/FRTUs/FPIs channels. In order to meet network's expansion behind the full capacity of a pair of FE servers, it shall be possible to connect additional FE servers' pairs to the LANs. Each communication line shall be able to support its own communication protocol. The CFE shall comply VPN / SSL based security for connecting with IEC 60870-5-104 &101 nodes on public networks. Further the nodes and CFE shall be self-certified by manufacturers as NERC/CIP compliant to comply with future smart grid requirements.

All FEPs shall not have open ports other than needed for protocol traffic / SCADA traffic, and shall have an audit trace of all login attempts / connection attempts. This FEP shall exchange data through secured SSL / VPN and encryption of protocol traffic whether it is a is public network or a dedicated one. The equipment should take control command from designated Master IP address only and no other IP.

All RTU/FRTU/FPI shall be connected to the SCADA/DMS Control Center.

RTU Communication Card / Module shall support VPN / SSL Security / Encryption of data coming to it through Public network, and then send over private & secure Utility network to the SCADA Control Center.

The Communication Servers shall be able to process time – stamped data and can be directly connected to GPS device for time synchronization

6.2.1.2.2 ICCP Server /inter control center communication server

Depending upon the protocol i.e ICCP o other intercontrol center protocol used as permissible as per this specification for , the server shall be called as ICCP or inter control center communication server. The redundant ICCP//***inter control center communication server*** servers shall be installed at each SCADA/DMS control centers of eligible towns of the state and DR center & shall be used to retrieve, transmit and process data to and from remote sources i.e. remote control centers. Data retrieved and processed from remote sources maybe stored in communication servers, which then distributes the data to other servers periodically or on demand. The server may also be used by utility to exchange data with StateLoad Dispatch Centers (SLDC) of the state where scheme will be implemented for exchangeof scheduling data.

6.2.1.2.3 Network Management System (NMS) Servers

Redundant NMS servers shall be used for configuration management, fault management & performance monitoring of servers, workstations, routers & LAN equipments etc. Part of the above functions may be performed by other servers as per the standard design of offered product.

6.2.1.2.4 Web servers with Active directory:

Redundant Web servers with active directory LDAP, DNS shall be provided.

6.2.1.3 Demilitarized/ Security servers

6.2.1.3.1 Web servers with Firewalls and IPS:

Redundant Web servers shall be provided to allow the access of SCADA/DMS system data, displays by outside users. One router shall be provided which shall be connected to the external LAN/WAN communicating SCADA/DMS system. The external LAN/WAN users shall be able to access SCADA/DMS data through the Web server system through this router.

Web servers shall also be provided with host based Intrusion prevention & detection system (IPS). The host-based IPS will be installed in both the Web-servers. The Network based IPS shall be supplied for both the SCADA/DMS dual LAN and DMZ dual LAN.

All necessary hardware & software for Web Servers with firewalls and IPS shall be supplied by the contractor.

The design & configuration, permertization, placement of DMZ shall be such that SCADA /DMS system shall be protected from intrusion /vulnerabilities from outside world as per IEC62443, IEC 62351-3, ISO/IEC27001. The cyber security shall be certified on SAT by CERT.IN empanelled agency/ NCIIPC or any GoI agency before Operational acceptance by SIA . The same shall be required to be verified at least once annually or Major upgrade or change on the system or data of validity of certification which ever earlier during the FMS period also and maintain required performance and functional requirements

6.2.1.3.2 Firewall:

Two firewalls shall be provided, one between Web servers & SCADA/DMS dual LAN and another between Web servers & W eb server dual LAN. Specification of the firewall is given in the chapter for software requirements.

Contractor shall provide equivalent tools such as Apache etc.for Web servers if UNIX or LINUX O/s is used to meet the security requirement as envisaged in the specification.

6.2.1.4 Training & development system server

6.2.1.4.1 DTS server;

A non - redundant server to host DTS applications shall be provided to impart the training.

6.2.1.4.2 Development server

A non- redundant server to host Developmental applications shall be provided

6.2.1.5 Data recovery cum communication server

Redundant DR server shall be provided with common external memory for mass historical data storage and retrieval. The external memory shall comprise of multiple hot pluggable type hard disks configured in RAID configuration. (Except RAID-0) The external memory shall be connected either directly to the ISR server through SCSI/SAS interface or directly on the LAN (Network Attached Storage). Alternatively, the bidder may offer RAID with each server to meet the mass storage requirement in place of common external memory.. The minimum requirement for external RAID for ISR servers is as below. The SCADA shall include historical data storage configured to store historical data at the storage rates, for the required period of time, and for the Ultimate historical database sizes given in chapter 19

- Storage Array
- Controller Cache: 512 MB per controller standard
- Integrated RAID controller with an LCD/LED status display and 256 MB read/write battery-backed cache (expandable to 512 MB per controller).
- Host Interface: Fiber Channel connection per controller from the host side
- Host Ports per Controller: Dual 2 Gb/s FC enabled
- RAID Levels(EXCEPT RAID 0)
- Redundant Controller: Yes

6.2.2 Operator Workstations

The operator Workstation console shall be used as a Man Machine Interface (MMI) by despatcher for interacting with all SCADA/DMS system. Operator Workstation consoles shall also be used as development console to take up developmental/ maintenance activities such as generation/updation of database, displays etc.& to impart training through DTS workstation consoles.

Each workstation shall consist dual monitors & single keyboard and a cursor positioning device/mouse.

Workstation consoles for development system shall also be available with single TFT monitor Operator workstation consists of a console driving single/ dual monitors as defined in the BOQ.The user shall be able to switch the keyboard and cursor-positioning device as a unit between both monitors of console. The minimum hardware configuration of operator workstation shall be:

- *Multi core , Processor Speed : 3.2Ghz or better.*
- *16GB Main memory (RAM)*

- 1TB Auxiliary memory (Hard disk drive)
- 21 inch LED colour monitors
- Graphic adaptor cards
- Two speakers for audible alarms with configurable tones
- Keyboard & Mouse
- Dual 10/100/1000Mbps Ethernet ports

The specification of Remote VDU, LDMS is same as of workstation for SCADA/DMS system mentioned above, except, it shall have suitable software & hardware to facilitate remote VDUuser to monitor remotely, the real time power system from SCADA/DMS system & have facility to generate report. The additional associated hardware is mentioned in the BOQ.

6.2.3 LED color monitor

The LED monitor shall have flat panel color screen. The following is the minimum characteristics of LED color monitors

S. No	Specification	For 19" monitor	For 21"monitor
1	Diagonal Viewable size	19"	21"
2	Viewing angle	Sufficiently wide horizontal & vertical viewing angles	Sufficiently wide horizontal & vertical viewing angles
3	Response time	5ms or better	5ms or better
4	Resolution	1920x1080 (Full HD)	1920x1080 (Full HD)
5	On screen Control	Yes	yes
6	Anti glare & anti static	Yes	yes
7	Tilt , Swivel	yes	yes

Monitor shall have inbuilt audio and speaker

6.2.4 WAN router

WAN router shall be required for data exchange of SCADA /DMS control centers with other systems (Other Data center,SLDC etc. if envisaged in the RFP), remote VDUs and LDMS & SLDC optional. Further, data exchange between RTU and SCADA control center is also envisaged over MPLS using routers. The data exchange between the two centers shall be over TCP/IP using Ethernet based communication network on various mediums viz FO, radio etc. The router shall have the following features:

- support the OSI and TCP/IP protocols
- support X.21/V.35/G.703 interface for interfacing communication links

The data exchange between the two centers shall be primarily over MPLS based secured network using TCP/IP on various mediums as per the requirement and availability in

the respective project area viz FO, radio, V-SAT etc.by network bandwidth service provider(NBSP) part of SIA team. The router shall support the OSI and TCP/IP protocols.

The Wide Area Links are planned for 2Mbps or higher Bandwidth capacity from ISPs (BSNL, MTNL or any other NBSP)

The Router offered shall deliver high performance IP/MPLS features and shall support Layer 3 MPLS VPN connection. It shall support PPP/Frame Relay transport over MPLS.

The Routers shall be configurable and manageable through local console port, http interface, NMS software and as well through Telnet.

The Router shall provide built-in monitoring and diagnostics to detect failure of hardware. The Router shall be provided with LED/LCD indication for monitoring the Operational status.

The configuration changes on the Router should take effect without rebooting the router or modules.

1) **Memory Flash:** Minimum *2GB*
2) **Console Port:** 01 No. for configurations and diagnostic tests
3) **LAN/WAN Port:** The router shall support variety of interfaces as per the concerned utility's requirement at site like V.24/V.35, E1, Channelized E1 etc. along with following minimum number of ports:
   - Two fixed 10/100Mbps high speed Ethernet ports
   - Two fixed Serial ports with synchronous speed up to 2 Mbps and with interface support for V.35/V.24 ports
   - Two fixed ports of G.703 E1 (2 Mbps) interface
   - One AUX port

   Total no of ports shall be determined by the connectivity requirement.

   All the interface cables for interconnecting all LAN/WAN ports as well as connection to SCPC/MCPC/ leased E1 – V.35 ports etc. shall be in the scope of bidder.
4) **Scalability:** Should have provision of at least 100% additional number of free ports for future scalability
5) **Network Protocol:** TCP/IP and support for IP version 6. Shall provide IP address Management

6) Routing Protocols:

RIP v1 (RFC 1058), RIPv2 (RFC 1722 AND 1723), OSPFv2 (RFC1583 & RFC 2328), OSPF on demand (RFC 1793), BGP4 with CIDR implementation as per RFC 1771. The implement should be compliant as per RFC1745 that describes BGP4/IDRP IP OSPF interaction. It shall provide Policy routing to enable changes to normal routing based on characteristics of Network traffic. IS-IS protocol support (RFC 1195).

7) WAN Protocols:

Frame Relay(LMI & Annexed & ITU Annex A), PPP (RFC1661), Multi-link PPP

(RFC1717), HDLC/LAPB, Frame Relay support shall include Multi-protocol encapsulation over Frame relay based on RFC1490, RFC 1293 for Inverse ARP/IP, DE bit support. Support of protocols of VPNL, L2TP,L2VPN, L3VPNs

8) High Availability:

Shall support redundant connection to LAN

For high availability, the router should support the standards based RFC 2338 Virtual

Router redundancy Protocol (VRRP) or equivalent

9) Network Management:

SNMP, SNMPv2 support with MIB-II and SNMP v3 with Security authentication. Implementation control configuration on the Router to ensure SNMP access only to SNMP Manager or the NMS work Station.

- RMON 1 & 2 support using service modules for Events, Alarms, History.
- Should have accounting facility.
- Shall support multilevel access.
- Shall be Manageable from any Open NMS platform.
- Shall support for telnet, ftp, tftp and http & https enabled Management.
- Should have debugging facility through console.
- AAA Authentication support shall be provided via RADIUS (Remote Authentication Dial-IN User Service) and/or TACACS, PAP/CHAP authentication for P-to-P links, 3DES/IPsec encryption with hardware based encryption services.

10) Optimization feature:

Data Compression for both header and payload to be supported for Frame Relay and Leased/Dial-up WAN Links. Dial restoral on lease link failure Dial on demand or congestion, Load Balancing.

Support for S/W downloads and quick boot from onboard Flash. Online software re- configuration to implement changes without rebooting. Should support Network Time Protocol for easy and fast synchronization of all Routers.

11) QOS Support:

RSVP (Resource Reservation Protocol as per RFC 2205), IGMP v1, v2 (Inter Group Management Protocol Version 2 as per RFC 2236), Multicast Routing support like PIM- SM (RFC 2362), PIM-DM etc.

Policy based routing (It shall be possible to affect the normal routing process for specific mission critical traffic through specified alternate routes in the network).

A class based scheduling, Priority Queuing mechanism that shall provide configurable minimum Bandwidth allocation to each class and IP Precedence.

Congestion Avoidance –Random Early Detection (RED). Support for Differentiated

Services as per RFCs 2474, 2475, 2598 & 2597.

12) **Switching Performance:** *should be SD-WAN ready and should support current (200 Mbps) upgradable up to 1Gbps*

The following routers will be required as minimum, The minimum port requirement is specified above. However, bidder shall determine no. of ports requirement on the basis the interface & performance, availability & functional requirements & shall provide additional features/ ports over and above minimum requirement specified:

- SCADA/DMS router
- Intranet router at/DMZ
- DR router
- Router at S/S & remote VDUs locations

The router shall conform to UL 60950 or IEC 60950 or CSA 60950 or EN 60950 Standards for Safety requirements of Information Technology Equipment.
The router shall conform to EN 55022/32 Class A/B or CISPR22/32 Class A/B or CE Class A/B or FCC Class A/B Standards for EMC (Electro Magnetic Compatibility) requirements or equivalent BIS standard

6.2.5 Local Area Network (LAN) and Device Interfaces

Servers, consoles and devices are connected to each other on a local area network (LAN), which allows sharing of resources without requiring any physical disconnections & reconnections of communication cable. Four LAN shall be formed namely SCADA/DMS OR SCADA, DTS, developmental system & DMZ. Dual LAN is envisaged each for the SCADA /DMS system & DMZ system & Single LAN is envisaged each for DTS & development system. At DR center also redundant LAN is envisaged. LAN shall have the following characteristics:

- Shall conform to the ISO 8802 or IEEE 802 series standards.
- Shall preclude LAN failure if a server, device, or their LAN interface fails.
- Shall allow reconfiguration of the LAN and the attached devices without disrupting operations
- Shall be either controlled LAN such as Token passing or uncontrolled LAN such as CSMA/CD
- Shall have minimum of twenty four (48) ports of 10/100/1000Mbps per LAN switch for SCADA/DMS LAN & (24)ports be considered for DMZ system, DTS & development system & DR system each,)

6.2.6 Printers

Except for the output capabilities unique to any printer type (such as extended character sets, graphic print and colouring features), there shall be no limitations on the use of any printer to perform the functions of any other printer. All the SCADA/DMS system printers shall have dual LAN interface either directly or through internal/external print servers. Printers for DTS & development system shall have single LAN interface. The characteristics for each type of printer are described below:

a) Color inkjet printer

Color inkjet printer shall be used to take colored hardcopy printout. The Printer shall have the following features:

- Shall be suitable for printing on A4 & A3 size normal paper.
- The printout shall match to object/content to be printed in color & size.
- Shall have resolution of at least 1200 X 1200 dots per inch.
- Print time shall be less than 60 seconds per page for a colour printout in normal mode for A4 size of printing.
- Shall have suitable port for connectivity with Remote VDU.
- Shall have input & output trays
- Shall have landscape and portrait print orientation

B) Black & White Laser Printer

It is a multipurpose printer used to take prints of displays, reports etc. The laser printer shall have the following features:

- Shall be black & white laser printer
- Have speed of at least 17 pages per minute
- minimum resolution of 1200 dots per inch
- Landscape and portrait output orientation
- Memory buffer of at least 48 mbyte
- Shall be suitable for a4 size normal paper

C) Colour Laser Printer

It is a multipurpose printer used to take prints of displays, reports etc . The color laser printer shall have the following features:

- shall be color laser printer
- have speed of at least 10 pages per minute for A3 & 17 pages for 20pages per minute
- in color
- 600 X 600 dpi
- Landscape and portrait output orientation
- Duplex printing
- Memory buffer of at least 128 Mbyte

6.2.7 Time and Frequency system

GPS based time facility, using Universal Time Coordination (UTC) source, shall be provided for time synchronization of computer system at SCADA/DMS control center. The time receiver shall include an offset adjustment to get the local time. It shall have propagation delay compensation to provide an overall accuracy of $\pm$1.5microsec. The GPS system shall have dual 10/100/1000Mbps LAN interface. The GPS receiver shall be provided in redundant configuration

The time receiver shall detect the loss of signal from the UTC source, which shall be suitably

indicated. Upon loss of signal, the time facility shall revert to its internal time base. The internal time base shall have a stability of 2ppm or better.

The GPS system shall include digital displays for time and date in the format DDD: HH:MM:SS (the hour display shall be in 00 to 23 hour format)

GPS system shall also be used to drive separate time, day & date indicators which shall be wall mounted type. The display for time shall be in the 24-hour, HH:MM:SS format. The display for the day & date shall be xxx format (MON through SUN) & DD:MM:YYYY respectively.

Contractor shall provide wall mounted type digital display units for time, day, date & frequency indication. The display of frequency shall be in the xx.xx Hz format. The frequency shall be derived from 230V AC supply.

Each digit on the time, day and frequency indicators shall be at least 7.5 cm in height and shall be bright enough for adequate visibility in the control room from a distance of 15 meters.

The offered GPS clock shall also provide at least one 2 MHz (75 ohm interface confirming to ITU-T G.703) synchronization interface to meet the time synchronization requirement of the communication system. This interface shall confirm to the requirements specified in ITU-T G.811 for accuracy, jitter, wander etc. Alternatively, a separate GPS clock for synchronization of communication system is also acceptable.

6.2.8 Digital Light Processing (DLP) Laser based Video Projection System

The contractor shall provide a video projection system based on modular DLP (Digital Light Processing) Laser technology. All the screen modules of the VPS system, shall be suitableto form combined high resolution projection images. The VPS system will be used to project displays of SCADA/DMS system independently of workstation console monitors. All the operations envisaged from workstation console (dispatcher) shall be possible from VPS also.

The Contractor shall supply all necessary hardware and software, including the multi- screen drivers, adapters and memory to seamlessly integrate the video projection system with the user interface requirements described in the specification.

The video projection systems shall be rear projection systems and shall be complete with all projection modules, supporting structures and cabling. Design & installation of the video projection systems shall be coordinated with the Employer during project implementation. The requirement for each modular video display system include:

a) VPS screen with 3x4 matrix with each module minimum 70” diagonal and depth of module 700mm max

b) VPS screen shall form a seamless rectangular array, using modules. (0.5mm) max

c) VPS Graphics controller shall be interfaced to the SCADA/DMS system through dual LAN connectivity.

d) Each projector shall provide a minimum resolution of 1920x1080 pixels per module. The rear projection screens shall be capable of displaying full resolution of the Laser source.

e) The VPS shall be capable of supporting multiple display modes in which one or more modules show one or more SCADA/DMS displays concurrently as selected by the user.

f) This system shall provide the same functional display capability as the full graphics workstations.

g) The VPS shall have a horizontal & vertical viewing angle of approximately 160 degrees minimum .The half gain angle shall be at least 36 degrees horizontal and 34 degree vertical .The overall brightness of individual projector shall be at least 550 ANSI lumens. The luminance measured at the screen shall be minimum 100 candelas/sqm.

h) The light source shall have an average operating life of 1,00,000 hours (typical).

i) Centre to corner brightness shall be generally uniform.

j) The configuration of the VPS (no. of screens and size of each screen) is defined in the BOQ.

k) The VPS controller shall have audio out-and DVI and HDMI ports

l) VPS shall have Rail Kit mounting arrangement to optimize control room space

6.2.9 Furniture

Utility shall provide necessary furniture & shall look aesthetically pleasing. It is not in the scope of contractor.

6.3 Auxiliary Power Supply for Computer systems

The computer system should be suitable for operation with single-phase, 230 ±10% Vac,50 ±5.0% Hz power supply. To ensure uninterrupted & regulated power supply to computer system, suitable rating UPS are envisaged under auxiliary power supply specification. All cables supply, laying & their termination between UPS panel & computer system shall be in the scope of contractor.

The input circuit breakers are provided in the UPS for protection against short circuits, any additional fuses, switches and surge protection if necessary to protect the hardware shall also be supplied by the Contractor.

The auxiliary power to all computer system hardware shall be fed from parallel operating UPS system. On interruption of input AC power to UPS, the load shall be fed through UPS inverter through it's batteries. In case of battery capacity low conditions (due to prolonged failure of input supply to UPS), the computer system shall go for orderly shutdown to avoid corruption of any applications. The orderly shutdown of computer system can be implemented either through RTU (where UPS alarms shall be wired to RTU) or through suitable interface with UPS Supplier software.

6.4 Environmental Conditions

Equipment to be located in the SCADA/DMS control center building shall operate over an ambient temperature range of 16 C to 32 C, with a maximum rate of change of 5 C per hour. Relative humidity will be less than 80% non-condensing. In case of Altitude of 2000MSL or more, the same may be specified by utility

6.5 Acoustic Noise Level

The noise level of any equipment located in the control room shall not exceed 60dbA measured at three feet from equipment especially for the printers.

6.6 Construction Requirements of panels

In case the equipments are mounted in panel type of enclosures, then such enclosures shall meet the following requirements:

a) shall be free-standing, floor mounted and shall not exceed 2200 mm in height.

b) Enclosures shall be floor mounted with front and rear access to hardware and wiring through lockable doors.

c) Cable entry shall be through the bottom. No cables shall be visible, all cables shall be properly clamped, and all entries shall be properly sealed to prevent access by rodents.

d) The safety ground shall be isolated from the signal ground and shall be connected to the ground network Each ground shall be a copper bus bar. The grounding of the panels to the owner's grounding network shall be done by the contractor.

e) All enclosures shall be provided with, 230 VAC 15/5A duplex type power socket & switch for maintenance purpose.

f) All panels shall be provided with an internal maintenance lamp and space heaters, 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) Cooling air shall be drawn from the available air within the room.

k) 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.

l) Suitable sized terminal blocks shall be provided for all external cablings.

6.7 Assembly and Component Identification

Each assembly in the system, to the level of printed circuit cards, shall be clearly marked with the manufacturer's part number, serial number, and the revision level. Changes to assemblies shall be indicated by an unambiguous change to the marked revision level. All printed circuit card cages and all slots within the cages shall be clearly labelled. Printed circuit cards shall be keyed for proper insertion orientation.

6.8 Interconnections

All signal cabling between component units of the computer systems shall be supplied by the Contractor. Plug-type connectors shall be used for all signal interconnections. The connectors shall be polarized to prevent improper assembly. Each end of each interconnection cable shall be marked with the cable number and the identifying number and location of each of the cable's terminations. Each cable shall be continuous between components; no intermediate splices or connectors shall be used. Terminations shall be entirely within the enclosures.

6.9 Consumables

The Contractor shall supply, at its own expense, all consumables required for use during all

phases of the project through completion of the system availability test. The consumable items shall include as minimum :

(a) Printer paper

(b) printer toner, ink. Ribbons and cartridges

(c.)storage devices like bluray disc /CD in line with storage device of Server or Workstation

6.10 Certain criteria for Hardware /Configuration

1. Each SCADA /DMS control center and ZSCC shall have 1 DTS at control center .
2. Each DISCOM can have maximum 1 common or Disaster Recovery center for SCADA/DMS cities (Group A) . However, as per availability of infrastructure by utility , the same may corresponding to each control center .
3. Each DR for ZSCC
4. For (Group B&C) or combined can be considered as per infrastructure availability by utility
5. Workstation

   For S/S - 2 minimum and 1 per each 20s/s and maximum upto 5 workstations

   For network - 1minimum and 1 per each per 100 FPIs locations and maximum upto 3 workstations
6. Remote VDUs shall be required at one each at Circle, Division, Sub-division office, HQ (Common for all towns) , control center in-charge.

End of Chapter 6

CHAPTER 7: CONFIGURATION & SYSTEM AVAILABILITY

7.0 General

This chapter describes the requirement of monitoring and managing the SCADA/DMS system with regard to its configuration and availability under normal conditions and under hardware and software failure conditions. This chapter is applicable to Group A, B, C ,U,towns as per functional requirements except legacy system

7.1 System Redundancy

The SCADA/DMS/OMS system envisages some functions as critical functions and others as non-critical functions as defined in Chapters 1 and 2.The critical functions shall have sufficient hardware and software redundancy to take care of hardware or software failure condition whereas non-critical functions may not be provided with hardware and software redundancy.

The redundancy requirement for hardware of SCADA/DMS system shall be as follows:

a) Servers: The servers for SCADA/DMS, OMS, ICCP, Communication servers, ISR application, servers for DMZ/ security system systems, DR and shall be configuredas redundant system. (Except for DTS , development server)

b) LAN and device interface: LAN shall be configured as redundant. All equipment, except DTS, development system shall have single LAN)

c) Printers: All Printers shall be non- redundant devices.

d) Operator workstations/ Remote VDUs: These shall be configured as non-redundant devices.

e) Time and frequency system: The GPS receiver of time and frequency system shall be configured as a redundant device at SCADA/DMS control center.

f) Communication front end (CFE): Communication front end shall be configured as redundant system.

g) WAN Router: The WAN router connected to dual LAN shall have channel redundancy. Video Projection System (VPS) shall be non-redundant.

Every critical function must be supported by sufficient hardware redundancy to ensure that no single hardware failure will interrupt the availability of the functions for a period exceeding the automatic transfer time.

Non-critical functions are those that support maintenance and development of database, application software and training of users. No hardware redundancy is envisaged for these functions.

7.2 Server and Peripheral Device States

Server and peripheral device states represent the operating condition, of each server and peripheral device. The various states have been defined below: The system's reaction to restart/failover operations shall be governed by the state. Server and peripheral device states shall be assigned by the function restart, server and device failover functions, and by user command.

7.3 Server States

Each server shall be assigned to one of the following states:

(a) Primary State: In primary state, a server performs any or all of the on-line functions described in this specification and is referred as primary server. A primary server shall concurrently perform maintenance functions (e.g. update of database, display and reports).

(b) Backup State: A server in backup state is referred as backup server. A backup server replaces a primary server/primary server group in the event of primary server/primary server group failure or upon user command. It shall communicate with the primary server(s) to maintain backup databases and monitor the state of the primary server(s). A backup server shall concurrently perform maintenance functions.

(c) Down State: A server in down state shall not communicate with the computer system and is not capable of participating in any system activity

7.4 Peripheral Device States

Each peripheral device shall be assigned to one of the following states:

(a) Primary state: A device in primary state is referred as primary device. The primary device is logically attached to a primary server or primary server group. If the primary server or primary server group fails and its functions are reassigned to a backup server or backup server group, the device shall follow the reassigned functions.

(b) Backup state: A device in backup state is referred as backup device. A backup device is used to replace a primary device in the event of primary device failure. It shall communicate with the primary server or primary server group to inform its readiness for it's assignment as a primary device. A device may be assigned to the backup state by the server function and by user action.

A backup device may participate in on-line activity alongwith the primary device as can be the case with LAN s. For such cases, failure of any one device shall cause other device to take up the role of both devices.

(c) Down state: A device in down state is referred as down device.

A down device cannot be accessed by the computer system.

7.5 Functional Redundancy

Every critical function must be supported by sufficient hardware redundancy to ensure that no single hardware failure will interrupt the availability of the functions for a period exceeding the automatic transfer time.

Non-critical functions are those that support maintenance and development of database, application software and training of users. No hardware redundancy is envisaged for these functions.

7.6 Backup Databases

Copies of all databases shall be maintained on the Backup server so that system operations may continue in the event of Primary server, peripheral device or software failure. The backup databases shall be updated with the current contents of the primary databases such that all changes to a primary database are reflected in the backup database within 60 seconds of the change. The backup databases shall be maintained in such a manner as to be protected from corruption due to server and device failure. Backup databases shall be preserved for system input power disruptions of any duration. The information maintained in the backup databases

shall include:

a) Telemetered, calculated, and manually-entered values and their attributes, including quality codes, control inhibit state, and tag data

b) Data and associated attributes maintained by the Information storage and Retrieval function

c) Alarm, event, and summary displays (such as off-normal, control inhibit, and alarm inhibit displays) or sufficient information to rebuild the displays in their entirety (including the time and date of the original data entries, not the time and date the display is newly created)

d) Application function execution, control, and adaptive parameters and input and output data, including DMS functions save cases.

e) Changes resulting from the addition or deletion of items and restructuring of databases in an existing database shall be automatically accommodated in the backup database.

7.7 Error Detection and Failure Determination

All servers, peripheral devices, on-line software functions, and maintenance functions in SCADA/DMS/OMS system shall be monitored for fatal error and recoverable errors. All errors shall be recorded for review by maintenance personnel. Each type of error (e.g., server failure, memory access violation, device reply time-out, or message checksum error) shall be recorded separately with a date and time tag.

7.8 Server and peripheral device Errors

The Server/Device shall be declared as failed in case of fatal error. Server and peripheral device failure shall be detected and annunciated to the user within 10 seconds of the failure. For each type of recoverable error the programmer shall assign a threshold. When the count of consecutive recoverable errors exceeds this threshold, a warning message shall be issued to the operator.

7.9 Software Errors

Execution errors in on-line and maintenance functions that are not resolved by program logic internal to the function shall be considered fatal software errors. Examples of errors that may be resolved by internal program logic include failure of a study function to achieve a solution due to violation of an iteration limit or arithmetic errors (such as division by zero) which are caused by inconsistent input parameters or data. These errors shall produce an alarm informing the user of the error but shall not be considered fatal software errors. Fatal software errors shall result either in termination of the function or shall be handled as a fatal Server error. The action to be performed shall be defined by the programmer for each on-line function and each maintenance function. If the function is to be terminated, future executions of the function shall also be inhibited until the function is again initiated by the programmer.

On the occurrence of each fatal software error, Server and operating system error codes and messages shall be recorded in the SCADA/DMS/OMS system.

7.10 Server Redundancy and Configuration Management

Each server or server group supporting the CRITICAL functions described in the specifications, shall include at least one redundant server. The redundant server shall normally be assigned to the backup state and shall take the role of a primary server in the event of failure or upon user command.

When a failure of a primary server in a redundant group is detected, the SCADA/DMS computer system shall invoke the appropriate failover and restart actions so that on- line functions assigned to the failed server are preserved. The on-line functions of the failed primaryserver shall be assigned to the backup server by execution of a function restart within 30 seconds after detection of server failure, except for ISR function. For ISR server function the corresponding time shall be within 120 seconds after detection of server failure in case of failure of ISR sever, the ISR data shall be stored in the SCADA/DMS system till the failover of ISR server is completed to avoid data loss. This stored data shall be transferred to the ISR server automatically after restoration of ISR server.

If on-line functions are restarted in a backup server, the server's state shall be changed to primary. If backup servers are not available to perform the required functions, the SCADA/DMS computer system shall attempt to restart the failed primary server. A complete restart of the System, including full update from the field, shall not more than the stipulated time as specified above. No data shall be lost during the transfer of operation.

A failover (transfer of critical functions) to an alternate Server shall occur, as a minimum, under any one of the following situations:

- Non-recoverable failure of a server performing a critical function
- User request for a transfer of servers
- Failure of a periodic / scheduled function to execute on schedule.
- Violation of a configurable hardware device error counter threshold.

Failure of non-critical function shall not cause server failover. Functions assigned to a failed server in a non-redundant group may be lost until the failed server is restored to service. Failure of server operating in the backup state shall not initiate failover action.

Failed server shall be switched from down to any other state by user command only. All server reinstatement actions shall result in operator message. The messages shall identify the server(s) affected, all server state changes, and the success or failure of any restart operations.

7.11 Server Startup

Server startup shall be performed when commanded by a user, when server input power is interrupted and restored such that the operating environment of the server is established prior to restarting the on-line functions. Establishment of the operating environment may include execution of self-diagnostics, reloading the operating system and system services, and connection to and verification of communications with all nodes on the SCADA/DMS computer system LAN. Subsequent to server startup, a function restart shall bring the server(s)to the appropriate server state.

Server Startup requirements are as follows:

Cold Start: In which default values are used for entire database. A cold start would be used only to build the initial SCADA/DMS and to recover from extraordinary failure conditions. Server startup shall be completed within 15 minutes and all applications shall be operational within 20 minutes of applying power except for ISR server and its database initialisation, which can be up to 60 minutes.

Warm Start: In which a previously saved version of the database shall be used to initialise

all real time data values. Server startup shall be completed within 10 minutes and all applications shall be operational within 15 minutes of application of power.

Hot Start: In which the memory resident version of database shall be used for continued operation. No reload of saved data shall be performed, although application software restarts. The intent is that after hot restart, only the operations being performed at the time of failure may be lost. All on line applications shall be operational not more than failover time.

7.12 Peripheral Device Redundancy and Configuration Management

The device failover shall result in an orderly transfer of operations to a backup device in the event of failure of primary device. The device failover function may replace a failed device with an identical backup device or with a backup device that is different from the normal device.

Device failover actions shall be completed and the backup device shall be operating within 30 seconds of detection of the device failure. All device failures shall be annunciated by alarms.

7.13 System Configuration Monitoring and Control

Required displays shall be provided for the user to review the system configuration and to control the state of the equipment. The following operations shall be possible:

- Fail-over, switching of states and monitoring of Servers and peripheral devices.
- Control of the resource usage monitoring function and display of server resource utilization
- The user shall be provided with the capability to interact with all functions using displays. It shall be possible to atleast Stop, Start, inhibit /enable and Restart any of the functions.
- Displays to view and control the status of backup databases shall also be provided.

End of Chapter 7

CHAPTER 8: TESTING & DOCUMENTATION

8.0 General

This chapter describes the specific requirements for testing and documentation of the SCADA/DMS system. The general requirements of testing and documentation are covered in **chapter 18**. This chapter is applicable to Group A, B, C , U towns as per functional requirements**.**

8.1 Type testing –

Equipment wherever mentioned in the specification for type testing shall conform to the typetests listed in the relevant chapters. Type test reports of tests conducted in NABL accredited Labs or internationally accredited labs with in last 5 years/ or validity of test of certificate whichever is lower 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 before approval during design & engineering. Further, the equipment indicated in the MoP oder no 12/34/2020-T&R dtd 08.06.21 & CEA /PLG/R&D/MII/2021 dtd 11.06.21 and any amendment from time to time shall be adhered to. If there is a difference between the type test requirement mentioned above specification and type test requirement mentioned in the respective sections, the above shall prevail

8.2 Ad –doc testing

Utility may optionally ask SIA to stage ad-doc testing in presence of team comprising of PFC, utility. Other members may also be opted like, by like CEA, Discom , Nodal agency . for basic of prototype of SCADA/DMS /OMS functions of offered product with simulated offered at least 2 RTU & FRTUs.and balance by simulation for one sample project area . The same may be considered in design & engineering stage

8.3 Factory Acceptance Tests (FAT)

For each SDCC , ZSCC , SCADA/DMS/OMS system including DR center (DR is part of theproject area) shall be tested at the Contractor's facility. All hardware and software associated with the SCADA/DMS /OMS system and atleast two RTUs alongwith, LDMS, 1 type of numerical relays and one SCADA enabler each (if part of supply under this project) &10 FRTUs & all Remote VDUs, shall be staged for the factory testing and all remaining RTUs/FRTUs/FPIs shall be simulated for the complete point counts (ultimate size). The requirements for exchanging data with other computer systems like DR (if DR is not a part of the project area), data exchange with other envisaged shall also be simulated.

Each of the factory tests described below (i.e. the hardware integration test, the functional performance test, integrated system test and unstructured tests) shall be carried out under factory test for the SCADA/DMS system. The factory tests, requiring site environment, shall be carried out during the Field Tests after mutual agreement for the same from owner.

8.3.1 Hardware Integration Test

The hardware integration test shall be performed to ensure that the offered computer hardware, conforms to this Specification requirements and the Contractor- supplied hardwaredocumentation. All the SCADA/DMS system hardware shall be integrated and staged for testing. Applicable hardware diagnostics shall be used to verify the hardware configuration ofeach equipment. The complete hardware & software bill of quantity including software licenses & deliverables on electronic media shall also be verified

8.3.2 System Build test

After completion of hardware integration test, the SCADA/DMS system shall be built from thebackup software on electronic media (CDs/ Tapes) to check the completeness of backup mediafor restoration of system in case of its crashing/failure. The software deliverables shall includeone copy of backup software on electronic media.

8.3.3 Functional Performance Test

The functional performance test shall verify all features of the SCADA/DMS hardware and software. As a minimum, the following tests shall be included in the functional performance test:

a) Testing of the proper functioning of all SCADA/DMS & other software application in line with the requirements of various sections of technical specification.

b) Simulation of field inputs (through RTU/FRTU/FPI) from test panels that allow sample inputs to be varied over the entire input range

c) Simulation of field input error and failure conditions

d) Simulation of all type of sample control outputs

e) Verification of RTU /FRTU/FPI communication Protocol IEC-60870-5-104 /101 etc

f) Verification of MFT communication Protocol MODBUS etc

g) Verification of compliance of supporting interfaces such as IEC61850, IEC60870-5-103 etc.

h) Verification of Security & Encryption using SSL for all FRTU/FPI Connectivity.

i) Confirmation of cyber security compliance of products through software and RTU/FRTU and networking devices to be carried out by Cyber Crisis Management plan (CCMP) & its implementation during SAT by CERT.IN empanelled agency. CISO designated by DISCOM shall be available during these verification

j) Verification of Integration between GIS using adapter

k) Verification of data exchange with other systems

l) Verification of interoperability profile of all profiles of all protocols being used.

m) Verification of RTU /FRTU/FPI communication interfaces

n) Verification of LAN and WAN interfaces with other computer systems

o) Testing of all user interface functions, including random tests to verify correct database linkages

p) Simulation of hardware failures and input power failures to verify the reaction of the system to processor and device failure

q) Demonstration of all features of the database, display, and report generation and all other software maintenance features on both the primary and backup servers. Online database editing shall also be tested on primary server.

r) Logic verification of SAIDI/SAIFI reports and API for transfer of data to NPP

s) Demonstration of the software utilities, libraries, and development tools.

t) Verification that the SCADA/DMS computer system meets or exceeds employer's performance requirements (as per table for peak & normal loading in chapter 19 Verification of Design parameters as mentioned in chapter 19 & wherever defined in the specification.

u) Verification that ultimate expansion requirements are met.

v) Verification of DTS

w) Verification of Development system

x) Verification of data transfer of main to back up SCADA/DMS system. (s) Functions of DR /DRR system, if it is in the project area.

y) Unstructured testing of the SCADA/DMS system by employer. The unstructured tests shall include the test, which are not in the approved test procedures and may be required to verify the compliance to the specification.(Max 20% of total testing)

8.3.4 Continuous operation Test (48 hours)

This test shall verify the stability of the SCADA/DMS/OMS hardware and software after the functional performance test has been successfully completed. During the test, all SCADA/DMS functions shall run concurrently and all Contractor supplied equipment shall operate for a continuous 48 (forty eight) hour period with simulated exchange with other interconnected system IT system envisaged etc. The test procedure shall include periodic repetitions of the normal and peak loading scenarios defined**.** These activities to be tested may include, but shall not be limited to, database, display, and report modifications, configuration changes (including user-commanded processor and device failover), switching off of a primary server and the execution of any function described in this Specification. During the tests, uncommanded functional restarts or server/device failovers are not allowed; in case the problems areobserved, the Contractor shall rectify the problem and repeat the test.

8.4 Field Tests (Site Acceptance tests -SAT)

The SCADA/DMS system shall be tested at the site. All hardware and software associated with the SCADA/DMS system along with all RTUs/FRTUs/FPIs along with all field devices including MFTs connected shall be tested under the field tests.

8.4.1 Field Installation Tests

The equipment which has undergone the factory testing shall be installed at site and integrated with the RTUs /FRTU/FPI and other computer systems though the communication medium.

The field installation test shall include the following:

(a) Proper installation of all delivered hardware as per approved layout.

(b) Interconnection of all hardware

(c) Interconnection with communication equipment

(d) Interconnection with power supply

(e) Diagnostic tests to verify the operation of all hardware

(f)Random checking of SCADA/DMS/ software basic functions

The Contractor shall be responsible for performing the field installation tests and Employer may witness these tests

8.4.2 End-to-End Test

After the field installation tests, the Contractor shall carry out end-to-end test to verify:

a) the communication of RTUs/FRTUS/FPIs/MFTs with SCADA/DMS/OMS system

b) the RTU /FRTU/FPI communication channel monitoring in the SCADA/DMS /OMS system

c) the mapping of SCADA database with RTU /FRTU/FPI database for all RTU/FRTU/FPI points

d) the mapping of SCADA database with displays and reports

The Contractor shall provide the details of all the variances observed and corrections carried out during end to end test.

8.4.3 Field Performance Test

The field performance test shall concentrate on areas of SCADA/DMS/OMS operations that were simulated or only partially tested in the factory (e.g., system timing and loading while communicating with a full complement of RTUs/FRTU/FPI and data links and system reaction to actual field measurements and field conditions). Further the validity of factory test results determined by calculation or extrapolation shall be examined.

After the end to end test, the Contractor shall conduct the field performance test to verify the functional performance of the system in line with the technical specification which includes the following:

a) the communication of other system envisaged, if any e.g. IT , SLDC, DR system with SCADA/DMS/OMS system

b) Mapping of SCADA/ISR database with other system database e.g. IT , SLDC, DR system , NPP (SAIFI ,SAIDI data) with SCADA/DMS/OMS system

c) Verify that all the variances observed during the Factory test are fixed and implemented.

d) Conduction of the Factory tests deferred (tests requiring site environment)

e) Functional tests of SCADA/DMS /OMSsystem

f) Verify the execution rates of all SCADA/DMS/OMS application

g) Verify update rate & time for data update & control command execution as per specification requirements

h) Verify the response time of all SCADA/DMS/OMS applications.

i) Verify the response time for User interface requirements

j) Testing of all features of the database, display, and report generation and all other software maintenance features on both the primary and backup servers. Online database editing shall also be tested on primary server.

k) Conduction of unstructured tests as decided by the Employer

8.4.4 Cyber security compliance

Compliance of cyber security without threatening vulnerabilities by CERT.IN empaneled agency shall be carried out. DISCOM CISO shall also be available during this verification. Further, the equipment indicated in the MoP order no 12/34/2020-T&R dtd 08.06.21 & CEA /PLG/R&D/MII/2021 dtd 11.6.21 and any amendment from time to time shall be adhered to.

8.5 System Availability Test (360 hours)

Contractor shall provide & approve theoretical and practical figures used for this calculation at the time of detailed engineering. The calculation shall entail reliability of each individual unit of the System in terms of Mean Time between Failures (MTBF and a Mean time to Repair (MTTR) as stated by OEM. Reliability figures of existing equipment shall be supported by

evidence from operational experience at similar types of installation / figure given by OEM.

From those data, the unavailability of each sub-system shall be calculated taking in account each item redundancy. The global availability shall then be calculated from those different unavailability data. This calculation shall lead to the failure probability and equivalent global MTBF data for the control center system.

The overall assessment of System availability shall be provided in the form of an overall System block diagram with each main item shown, complete with its reliability data. The calculation of overall availability shall be provided with this diagram.

System availability tests shall be conducted after completion of the field tests. The system availability test shall apply to the SCADA/DMS/OMS system (hardware and software) integrated with its RTUs/FRTU/FPIs and legacy system envisaged However, the non-availability of RTUs/Data Concentrators/ FRTU/FPI , legacy IT system etc. & Communication System shall not be considered for calculating system availability. However, RTU/FRTU, communication equipment's auxiliary power supply shall be tested as per the provisions given in their chapters.

The SCADA/DMS system (hardware and software systems) shall be available for

99% of the time during the 360hours (15 days) test period. However, there shall not be any outage /down time during last 85 Hours of the test duration. In case the system availability falls short of 99%, the contractor shall be allowed to repeat the system availability test after fixing the problem, failing which the system shall be upgraded by the contractor to meet the availability criteria without any additional cost implication to the owner.

Availability tests of RTUs/FRTUs /FPI shall be conducted along with System availability test for 360 hours. Each RTU/FRTUs shall exhibit minimum availability of 98%. In case the RTU/FRTU availability falls short of 98%, the contractor shall be allowed to repeat the RTU/FRTU availability test (for failed RTU/FRTU/FPI only) after fixing the problem, failing which the equipment shall be upgraded by the contractor to meet the availability criteria without any additional cost implication to the owner.

In the event of unsuccessful reruns of the availability test, employer may invoke the default provisions described in the General Conditions of Contract.

The system availability tests will be performed by the owner by using the SCADA/DMS system and RTUs/FRTU/FPI for operation, control and monitoring of distribution system and using Contractor supplied documentation. The owner will also be required to generate daily, weekly and monthly reports. The supplied system shall be operated round the clock.

The SCADA/DMS/ OMS system shall be considered as available if

a) one of the redundant hardware is available so that all the SCADA/DMS/OMS applications are functional to ensure the design & performance requirement as envisaged in the specification

b) At least one of the operator console is available

c) At least one of the printers is available (off-lining of printers for change of ribbon, cartridge, loading of paper, paper jam shall not be considered as downtime)

d) All SCADA applications are available

e) All DMS, OMS applications are available

f) All SCADA/DMS/ OMS functions described in the specification are executed at periodicities specified in the specification. without degradation in the response times

g) Requests from available Operator Consoles & VPS are processed

h) Information Storage and Retrieval applications are available

i) Data exchange with other system is available

j) DC/DR data exchange and synch at defined periodicity

k) SAIDI/SAIFI and other performance (KPIs) related reports are available

However each device, including servers, shall individually exhibit a minimum availability of 98%.

The non-availability of following Non-Critical functions shall not be considered for calculations of system availability; however these functions should be available for 98% of the time.

(a) Database modification and generation

(b) Display modification and generation

(c) Report modification and creation

(d) DTS

During the availability test period, employer reserves the right to modify the databases, displays, reports, and application software. Such modifications will be described to the Contractor at least 48 hours in advance of implementation to allow their impact on the availability test to be assessed, except where such changes are necessary to maintain control of the power system.

The successful completion of system availability test at site shall be considered as **"Operational acceptance"** of the system.

8.5.1 Downtime

Downtime occurs whenever the criteria for successful operation are not satisfied. During the test period, owner shall inform the Contractor for any failure observed. For attending the problem the contractor shall be given a reasonable travel time of 8 hours. This service response time shall be treated as hold time and the test duration shall be extended by such hold time. The downtime shall be measured from the instant, the contractor starts the investigation into the system and shall continue till the problem is fixed. In the event of multiple failures, the total elapsed time for repair of all problems (regardless of the number of maintenance personnel available) shall be counted as downtime. Contractor shall be allowed to use mandatory spares (on replenishment basis) during commissioning & availability test period. However it is the contractor's responsibility to maintain any additional spares as may be required to maintain the required system availability individual device/ equipment availability. All outage time will first be counted but if it is proven to be caused by hardware or software not of Contractor's scope, it will then be deducted.

8.5.2 Holdtime

During the availability test, certain contingencies may occur that are beyond the control of either employer or the Contractor. These contingencies may prevent successful operation of the system, but are not necessarily valid for the purpose of measuring SCADA/DMS availability. Such periods of unsuccessful operation may be declared "holdtime" by mutual agreement of employer and the Contractor. Specific instances of holdtime contingencies could be Scheduled shutdown ofan equipment, Power failure to the equipment, Communication link failure.

8.6 Documentation

The complete documentation of the systems shall be provided by the contractor. Each revision of a document shall highlight all changes made since the previous revision. Employer's intent is to ensure that the Contractor supplied documentation thoroughly and accurately describes the system hardware and software.

The contractor shall submit the paper copy of all necessary standard and customized documents for SCADA/DMS in 2 sets for review/approval by the Employer for necessary reference which includes the following:

a) System overview document
b) Cross Reference Document
c) Functional design document
d) Standard design documents
e) Design document for customization
f) System Administration documents- software utilities, diagnostic programs etc.
g) Software description documents
h) Bill of Quantity & List of software and hardware deliverable
i) protocol implementation documents
j) point address document
k) IP addressing plan document
l) Software User document for dispatchers
m) Software Maintenance document
n) Training documents
o) Real time & RDBMS documents
p) Database settings, Displays and Reports to be implemented in the system
q) Test procedures
r) Test reports
s) Hardware description documents
t) Hardware User documents
u) Hardware Maintenance documents
v) Data Requirement Sheet (DRS) of all Hardware
w) Site specific Layout, Installation, GA, BOQ, schematics and cabling details drawings/documents
x) SCADA & IT Integration Plan Document using GIS Adapters & Messaging Interfaces.
y) Cyber Security Plan & Mitigation document (or Cyber Crisis Management Plan (CCMP)) for the system if Public Networks are used.
z) Interoperability profiles/ Tables

After approval two sets of all the above documents as final documents shall be

delivered to site by the Contractor. 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. Any software modifications/updates made at site shall also be documented and submitted in three sets to site and one set to Employer.

In addition to paper copies, two sets of final documentation shall be supplied on Electronic media to employer. The contractor shall also submit two sets of the standard documentation of Operating system and Databases in electronic media. Paper copies of these may be submitted, if the same are available from the OEM as a standard part of delivery. One copy of the software packages used for accessing & editing the final documentation in electronic media shall also be provided.

After successful completion of System availability test, the contractor shall take the software backup of complete SCADA/DMS/OMS system on electronic media and two copies of these backup software shall be submitted to the owner.

End of Chapter 8

CHAPTER-9: TECHNICAL REQUIREMENTS OF RTU

9.0 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. Further , the equipments indicated in the MoP order no 12/34/2020-T&R dtd 08.06.21 & CEA /PLG/R&D/MII/2021 dtd 11.6.21 and any amendment from time to time shall be adhered to. This chapter is applicableto Group A,B,C & new RTUs of Group U as per functional requirements

9.1 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. The RTU shall comply to IEC62351-3/ IEC62443 standard for cyber security

9.2 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 60870-5-104 protocol to communicate with the Master station(s) at least 2, 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 initialization 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 center

(g) Act as data concentrator on IEC60870-5-101/103/104/MODBUS(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/MPLS-4G/CDMA etc., therefore it mandatory to guard the data/ equipment f r o m intrusion/damage/breach of security & shall have SSL/VPN based security.

(j) Shall have SNMP

(K) Conformance to IEC62351-3/ IEC62443 standard for cyber security

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 or protocol converter & 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 IEC61850 /protocols & ability to act as a gateway for Numerical relays/ Smart Meters may have to be interfaced if need be

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 synchronization with GPS receiver which may be required future.

9.3 Communication ports

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

a) RTU shall have two TCP/IP Ethernet ports for communication with Master station(s) using IEC 60870-5-104.

b) 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.

c) In addition, if weather transducer & DC transducers are also having RS485

d) MODBUS port., the same can be also added in the daisy. However, total devices including MFT connected on one port shall not exceed

e) RTU shall have one port for connecting the portable configuration and maintenance tool for RTU.

f) RTU as a data concentrator, then RTU shall have additional communication ports Ethernet or serial for IEC60870-5-104/101 using SSL/VPN

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 MPLS/GPRS/MPLS-4G.

9.3.1 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)

9.3.2 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 /DLMS as legacy system . 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,

9.4 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 upto150% 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.

9.5 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.

9.6 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.

9.7 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 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

9.8 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.

9.9 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.

9.9.1 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 energizing 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.

9.9.2 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 selected/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.

9.9.3 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.

9.9.4 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.

9.10 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 For 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. 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.

9.11 Time facility

The internal RTU time base shall have a stability of 10 ppm. The RTU shall be synchronized through synchronization 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.

9.12 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 soft- ware shall check for memory, processor, and input/output ports errors and failures of other functional areas defined in the specification of the RTU.

9.13 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 .

9.14 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 chapter 14 of MTS. In place of 48VDC , Utility may opt any other voltage level such as 12, 24, 110 ,125 220 VDC etc. The permissible ranges as per applicable standards specified shall be adhered to accordingly . The interface components like CMRs , HDRs MFT etc. may also be selected accordingly.

9.15 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-20 to +60 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 -10 degree C. Utility may specify location with altitude more than 2000m above MSL for compliance of RTUs to be installed in that project area

9.16 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.

9.17 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.

9.18 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 color 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, ifapplicable 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 testas 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.

h) Armored Cables shall be used in the area where cable will pass through openarea which may experience loading.

i) The Communication cable shall be of shielded twisted pairs and of minimum0.22sq mm size.

9.19 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.

9.20 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 panelsand communicating with master station through communication port.
b) Distributed RTU design where distributed I/O modules /processor with I/Omodules 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. Thebidder shall asses the requirement of RTU panels for such design and supply panels accordingly. This is applicable for Numerical replay/BCPU concept

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

9.21 Local Data Monitoring System (LDMS)

The LDMS is a client workstation of main SCADA/ DMS control center 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.

End of Chapter 9

CHAPTER-10: TECHNICAL REQUIREMENTS OF FRTU

10.0 General

The Feeder Remote Terminal Unit (FRTU) shall be installed at Ring Main Units (RMUs), Sectionalizers locations FRTU shall also be used for control of switching devices such as breaker, isolator switches etc. inside RMU panel, Sectionalizers 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. Further, the equipments indicated in the MoP oder no 12/34/2020-T&R dtd 08.06.21 & CEA /PLG/R&D/MII/2021 dtd 11.6.21 and any amendment from time to time shall be adhered to. This chapter is applicable to Group A towns as per functional requirements

10.1 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. The FRTU shall comply to IEC62351-3/ IEC62443 standard for cyber security

10.2 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

c) Use of IEC 60870-5-104/101 protocol to communicate with the Master station(s) at least 2 Use of MODBUS over RS485 interface , Protocol to communicate with the MFTs.

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

e) 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.

f) Remote database downloading of FRTU from master station from SCADA/ DMS control center.

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

h) As the SCADA/DMS system will use public domain such GPRS/MPLS-4G/CDMA etc, therefore it mandatory to guard the data/ equipment f r o m intrusion/damage/breach of security & shall have SSL /VPN based security.

i) Shall support SNMP

j) Conformance to IEC62351-3/ IEC62443 standard for cyber security

k) 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 or protocol converter & using the same firmware at later date

l) Communication with at least two master stations simultaneously on IEC 60870-5-104 /101

m) 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.

10.3 Communication ports

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

a) 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

b) FRTU shall have required number of RS 485 ports for communication with

c) MFTs/ to be connected in daisy chain using MODBUS protocol . Minimum

d) 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.

e) FRTU shall have one port for connecting the portable configuration and maintenance tool for FRTU.

f) Support for /IEC61850 /protocols & ability to act as a gatewayfor Numerical relays/ Smart Meters may have to be interfaced if need be..

g) SSL/VPN ,NERC/CIP complaint

h) Ability to communicate over dual SIM modem

i) Ability to auto changeover incase configured for single SIM configuration at a time

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.

10.3.1 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)

10.3.2 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.

10.4 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.

10.5 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.

10.6 Sequence of Events (SOE) feature

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 asper IEC 60870-5-104 protocol. SOE buffer shall be maintained by FRTU on power supply interruption.

10.7 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.

10.7.1 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.

10.7.2 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.

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 FRTU.

10.7.3 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.

10.7.4 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.

10.8 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.

a) Power Frequency withstands 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-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.

10.9 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

10.10 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 soft- ware shall check for memory, processor, and input/output ports errors and fail- ures of other functional areas defined in the specification of the RTU.

10.11 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. Utility may opt any other voltage level such as 12, 24, 110 VDC etc. and permissible ranges and applicable standards specified shall be adhered to accordingly. The interface components like CMRs , HDRs MFT etc. may also be selected accordingly.

10.12 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 -20 to +60 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 -20 degree C. Utility may specify location with altitude more than 2000m above MSL for compliance of FRTUs to be installed in that project area

10.13 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.

10.14 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

(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.

10.15 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 color 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:

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.

The Communication cable shall be of shielded twisted pairs and of minimum 0.22sq mmsize.

10.16 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.

End of Chapter 10

CHAPTER-11: TRANSDUCER & MODEM REQUIREMNTS

11.0 Transducer & Modem Requirements:

All transducers shall use a 48 Vdc or 12/24/110/125VDC etc auxiliary power supply as provided for the RTU/FRTU and applicable values /limits/ permissible test values shall be considered as per nominal value of voltage. 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. Further, the equipments indicated in the MoP oder no 12/34/2020-T&R dtd 08.06.21 & CEA /PLG/R&D/MII/2021 dtd 11.6.21 and any amendment from time to time shall be adhered to. This chapter is applicable to Group A,B,C towns as per functional requirements.

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.

(a) Voltage:

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

(b) Impulse Withstand:

IEC 60688 or 60687 compliance is required.

(c) Electromagnetic Compatibility:

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

(d) Permanent Overload Protection:

IEC 60688 or 60687 compliance is required.

(e) Temporary Overload Protection:

IEC 60688 or 60687 compliance is required.

(f) 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)

11.1 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.

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.

11.2 DC Transducer

The DC transducer (DCT) are following types.

I. Voltage

II. Current

III. Winding Temp

IV. Oil temp

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 Output of the device shall preferably be 4-20ma or MODBUS in order to optimize the BOQ. However, as specific cases the output in

line ranges specified in analog input card in clause for analog input shall be selected. The accuracy of transducer shall be ±0.5%

11.3 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

11.4 Modems

- The modem shall have suitable interface facility to connect with the meter by using the RS232 /485cable. It shall have dual SIM facility
- The offered modems should be capable of operating on Threephase supply drawn from the FPI input itself. Auxiliary Power supply will not be acceptable form Modem at FPI The operating voltage range for the modem should be 90 V ac P-P to 440 V ac P-P. However the modem should also be capable of operating on single phase 230 V, 50 Hz power supply. The modemvoltage surges. Modem at FRTU locations should be capable of operating on dc voltage in line with FRTU voltage . The offered Modem should be capable to transfer the entire data as per the FRTU data requirement of FRTU/FPI at control center shall be suitably protected against
- The offered Modem should be capable to transfer the entire data as per the FRTU data requirement of FRTU/FPI at control center i.e. 4G /5G as per site signal condition
- The offered Modem should be supplied with power cable, antenna with co-axial cable of length, RS 232 /485connecting suitable cable, mounting adopter etc
- Sealing :- The modem cover and body should have arrangement for sealing. In addition to this, the SIM card holder cover should also have arrangement for sealing.
- Antenna :- The Modem should have flexible external antenna to enable placement of the antenna at the location of strongest signal inside the Metering Cubicle. Bidders are requested to quote separately for multiple gain antenna, such as OdBi/3dBi/10dBi with screw mount / Wall mount arrangement. The actual requirement of these Modem Antennas of various gains may vary as per the requirement at site. Bidder will be required to supply the exact requirement as per site conditions and will be paid as per the separate unit rated quoted for different Gain Antennas.
- Before supply of GSM/CDMA modem, the bidder is requested to ensure the availability of appropriate signal and operation of GSM/CDMA Modem in all the areas to be covered by making physical survey or otherwise. Before making the actual supply of Modems for FPI & FRTU locations , the Bidder is requested to assess the exact

requirement and should supply a high gain antenna or any other suitable alternate communication network for collecting data in such area.

- In the event of an outage, the modem should be able to initiate separate call or send SMS to predefined number to notify the outage event with data and time of occurrence and restoration
- The Modem should act a completely transparent channel i.e. the Commands received from SCADA/DMS Control center should be conveyed to FRTU/FPI and data from FRTU/FPI should be conveyed to SCADA/DM control center without any changes in the modem.
- Data collection from FRTU/FPI should take place only after connection is established between Control center and FRTU/FPI. Data should not reside in the modem before the time of transmission to Control center, to avoid chances of tampering of data at Modem end.
- The Modem should be capable of operating with SIMs of local GSM/CDMA Service provider in the area.
- Modem should be capable for continuous working for 24 hours every day under field conditions
- Modem should be a compact model housed in a polycarbonate /engineering plastic / Metallic enclosure. The modem should comply with IP55 degree of protection for FPI locations & IP41 for FRTU as the same shall be housed in the FRTU panel.
- Modem should be Dual Band modem capable of operating at 900 and 1800 MHz transmission. GSM Modem should support bothData and SMS transmission. It should have both GSM and GPRS/MPLS-4G/EDGE feature
- Modem should have an RS232 Interface through a 9 pin or 15 pin D type Connector for connection to FRTU/FPI. The SIM interface should be a 3 V Interface in accordance with GSM 11.12 phase 2 with a retractable SIM cardholder, which should be fully inserted inside the modem. The holder opening should have a sliding cover with provision for sealing after placing of the SIM card. The modem shall accept the standard SIM Card. Modem should have a SMA Antenna connector
- Storage Temperature : -20 degrees to +70 degree Celsius
- Operating Temperature: -10 degrees to +60 degree Celsius
- Humidity:- 95% RH (Non - Condensing)
- Utility may specify location with altitude more than 2000m above MSL for compliance of FRTUs to be installed in that project area
- Maximum Power Output should be 2 W at 900 MHz (Class 4) and 1W at 1800 MHz (Class 1).
- Sensitivity :- GSM 900 : <-100 dBm GSM 1800 : <-100 dBm
- Standard AT Command set (GSM 07.05, GSM07.07)
- TCP/IP stack access via AT
- Internet Services : TCP, UDP, HTTP, FTP, SMTP, POP3
- Max. Baud Rate: for GSM -9600
- GPRS/MPLS-4G Class B Multi slot class 12 or class B Multi slot class 10 Packet channel

support : PBCCH

- EDGE (EGPRS/MPLS-4G) Multi slot class12 or Multi slot class 10Mobile station Class B Modulating and coding schemes : MCS 1 to 9 Packet channel support : PBCCH
- **SMS Features: -** Text and PDU Point to point (MT/MO, Cell broadcast
- The Modem should have LED indications for transmit data, received data carrier detects and Power ON, etc. to indicate Power on position and to indicate the availability of signal at the place of installation.,

11.5 WAN router

RTU shall communicate with control center through MPLS network. The router specification shall be suitable to communicate with Control center. Industrial Grade Router should support QUAD core 1.2GHz CPU, DRAM of 2GB & usable Flash Memory of 2GB. Should support WAN port on Combo Gigabit Ethernet (RJ45/SFP slot)Gateway should have Four 10/100BASE-T Fast Ethernet LAN ports with 4KV isolation for Electrostatic Discharge (ESD) protection. Router should support 1 RS-232 serial ports Gateway should have mini Type B USB Console port, Dual SIM for 3G/4G/5G

The Router should have built-in security features like SSL VPN for remote access, Next gen encryption such as AES-256, SHA-384, and SHA-512, IP Sec tunells, NAT Transparency, VRF Aware Ipsec and Ipsec over IPv6.

Gateway should also have built in firewall features like Zone based policy firewall, VRF-aware stateful inspection routing firewall, Advanced application inspection and control, Dynamic and static port security

Router should have SDWAN so that dynamic path selection feature can be achieved to select the best available path out of multiple routes based on delay, jitter, and latency.

Router should support IPv6 name resolution, IPv6 DHCP and IPv6 NAT features, IP SLA, OSPFv2 and OSPFv3, BGP & EIGRP.

Router should support IEC 60870 T101, T104 protocol translations. Comply with IEEE 1613 and IEC 61850-3 standards

Router should be able to operate in the temperature range of -40 to 60 degree celcius. Gateway should support both In-band and out-of-band management using Telnet and SNMP, including MIB II and other extensions. Hazardous certification : ANSI/ISA ,EN

End of Chapter 11

CHAPTER –12

TEST EQUIPMENTS FOR RTU/FRTU

12.0 RTU/FRTU Configuration and Maintenance Tool

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

12.1 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.

12.2 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 analyzer 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 analyzer 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.

In case of usage of IEC 103/61850/ IEC62056 for data acquisition, the feature of the same also be provided with same or additional tool

12.3 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.

End of Chapter 12

CHAPTER –13: TESTING, TRAINING & DOCUMENTATION

13.0 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 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.

13.1 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

13.2 Documentation

The Contractor shall submit 3 sets of all the standard and customized 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

d) RTU/FRTU Operation & Maintenance document f) RTU/FRTU Training documentation

e) RTU/FRTU database document h) RTU/FRTU I/O list

f) RTU/FRTU Test procedures

g) Data Requirement Sheet (DRS) of all items

h) Protocol documentation including implementation profile etc.

i) RTU/FRTU installation and Layout, GA, BOQ, schematics and internal wiring drawings for each RTU/FRTU site

j) RTU/FRTU to C&R panels/ field device cabling details for each RTU/FRTU Site

k) Cyber security compliance certificate /document by manufacturer incl international agencies like KEMA / TuV etc.

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	√		√

Test Nos.	DESCRIPTION OF THE TEST	Type test	Routine test	Field test
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 sensor etc.	√		
25.	Test for functionality/parameters for bought items viz. CMRs, Heavy duty trip relays , MFT , weather sensor etc.	√	√	
26.	Test for test tools		√	√
27.	Test for LDMS functioning		√**	√**
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	√		

Test Nos.	DESCRIPTION OF THE TEST	Type test	Routine test	Field test
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	√		
E	**Other test**			
40	Product cyber security compliance IEC 62443 /IEC62351-3 certificate of RTU/FRTU from labs incl. international accredited labs like KEMA/TuV/ DNV etc	√		

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 Name	EUT Status	Test Level	Power Supply Points		I/O Points	Passing Criteria
			CM	DM	CM	
Surge Immunity Test (Test 28)	ON	Level 3	2 Kv	1 kV	2 kV	A
Electrical Fast Transient Burst Test (Test 29)	ON	Level 3	2 KV	-	1 kV	A
Damped Oscillatory Wave Test (Test 30)	ON	Level 3	2.5 kV	1 kV	2.5 kV	A
Electrostatic Discharge (Test 31)	ON	Level 3	+/- 6 kV in Contact discharge mode or +/- 8 kV in Air discharge mode			A
Radiated Electromagnetic Field (Test 32)	ON	Level 3	10 V/m electric field strength			A
Damped Oscillatory Magnetic Field test	ON	Level 3	30 A/m at 1MHz of magnetic field strength			A

(Test 33)				
Power frequency magnetic field (Test 34)	ON	Level 3	30 A/m of magnetic field strength (Continuous duration sine wave)	A
Power frequency voltage withstand (Test 35)	OFF	-	1 KVrms for 1 minute	No break down or flashover shall occur
1.2/50µs impulse voltage withstand (Test 36)	OFF	-	2 kVp	No break down or flashover shall occur
Insulation Resistance Test (Test 37)	OFF	-	Measure Insulation resistance using 500 V DC Megger before & after Power Freq & Impulse voltage withstand tests	As per manufacturer standard
Dry heat test (Test 38)	ON	-	Continuous operation at 55^0 C for 16 hrs	0
Damp heat test (Test 39)	ON	-	at 95% RH and 40^0 C	0

End of Chapter 13

CHAPTER 14: AUXILIARY POWER SUPPLY SYSTEM

14.0 General

This chapter describes the technical requirements for Auxiliary Power Supply System. The BOQ for Auxiliary Power Supply system equipments required for SCADA/DMS control center, RTU/Data Concentrator, FRTU Communication equipment & remote VDU locations The components of Auxiliary Power Supply system are Uninterruptible Power Supply (UPS), 48V DC power supply (DCPS), the batteries for UPS and DCPS. The technical requirements for all the above components are described in the various subsequent clauses.

The Bidder is encouraged to offer their standard products and designs. The UPS, DCPS, Battery shall be manufactured & tested as per the relevant IS/IEC/ EN/BS standards. However, the Bidder shall conform to the requirements of this specification and shall provide any special interface equipment necessary to meet the requirements stated herein.

All equipment except Batteries shall be designed for an operating life of not less than 15 years, however, batteries shall have a minimum expected operating life of 5 years under normal operating conditions or 1200 charge/discharge cycles (whichever is earlier). The Contractor shall demonstrate the functionality of the equipment during tests in the factory. After the equipment is installed, the Contractor shall demonstrate all of the functions during well-structured field tests. This chapter is applicable to Group A, B, C towns as per functional requirements

14.1 Uninterruptible Power Supply (UPS)

The technical requirements for the Uninterruptible Power Supply (UPS) System and associated equipments to be provided by the contractor are described below.

The UPS system shall include the following:

- UPS equipments supplying load at 0.8 lagging power factor
- VRLA batteries for UPS system with backup duration
- UPS input and output AC Distribution Boards.
- Power, control and network cables

14.1.1 UPS Functions

The UPS shall be designed for continuous-duty, on-line operation and shall be based on solid-state design technology to provide uninterrupted power supply for computer system and associated items. The control of the UPS system shall be microprocessor based providing monitoring and control of rectifier/charger, Inverter, static switches, firing and logic control.

Each UPS system provided by the Contractor shall include all of the following sub- systems as well as any other components and support hardware necessary for complete and proper operation of the UPS:

a) Rectifier/charger unit Inverter unit

b) Battery Low Voltage Disconnect device

c) Static bypass switches

d) Manual maintenance bypass switches

e) Isolation transformer

f) Load transformer and filters

g) Control panels including source selection equipment & ACDBs, automatic controls and protection

h) Hardware and software as required for parallel operation of two no of UPS

i) Systems

j) All necessary cables, MCCBs/MCBs/ switches/ fuses

In the event of a loss of AC source, the UPS equipment shall provide uninterrupted power to the critical loads from the output of the UPS inverter subsystems through batteries.

14.1.2 UPS Operation

The UPS systems with associated batteries shall operate in parallel redundant configuration sharing the connected load. The conceptual diagram for UPS is shown in figure 4-1.

The UPS shall primarily use the inverter subsystem to deliver AC power to the computer loads. In case of failure of any one of UPS, the other healthy UPS shall continuously supply the power to the computer loads without any interruption. If the other healthy UPS also fails then automatically Static bypass of UPS shall start supplying the connected load through AC mains without any interruption.

The Manual Maintenance Bypass shall be provided for each of the UPS separately to extend AC raw power supply to computer systems in case of complete failure or shutdown of UPS systems.

The facilities shall also be provided to manually control the UPS through its control panel.

14.1.3 4.1.3 UPS Equipment Design

The design of the UPS shall have the capability to isolate any failed piece of equipment viz. Rectifier/charger unit, inverter and battery for maintenance. UPS equipment design shall consider the following electrical parameters:

- UPS equipment shall comply with IEC 62040 or equivalent. EN/BS standards for design, performance and EMC requirements.
- The input mains AC supply to the UPS shall b e 415 volt AC, 3-phase, 4-wire 50 Hz. The input supply voltage may vary +10% to -15% from nominal and the frequency may vary from 47.5 to 52.5 Hertz.
- The UPS shall be suitable for operation on Mains input AC on phase sequence reversal. The UPS shall provide 3-phase four wire output plus ground. The UPS shall Supply power to the connected loads at 415 volt AC, 3-phase, and 50 Hz. 0.8-lagging power factor.
- The UPS shall provide continuous regulated sine wave AC power to the connected loads.
- The overall efficiency of the UPS, input to output, shall be a minimum of 90 percent with the batteries fully charged and operating at full load and unity power factor.
- Noise generated by the UPS under normal operating condition shall not exceed 78 dB measured five (5) feet from the front of the cabinet surface. The requirements of each sub-system of UPS are detailed below.