

# STANDARD BIDDING DOCUMENT

## FOR

### Full Turnkey Contract

### (Design Supply and Installation)

PVVNL

## Part – 4

## Technical Specifications (SCADA)

FOR

IMPLEMENTATION OF MSCL PROJECT NETWORK,  
STRENGTHENING, CAPACITY  
ENHANCEMENT, IMPLEMENTATION OF SCADA FOR POWER  
SUPPLY UNDER SMART CITY MISSION (SCM) IN MORADABAD  
CITY.

### Key Dates

Date of Release of RFB/ NIT	07 <sup>th</sup> November 2022
Date & Time of receiving Pre-bid queries via mail	19 <sup>th</sup> November 2022 till 16:00 Hrs E-mail Id: semmpvvn@gmail.com
Deadline for Submission of Bid	29 <sup>th</sup> November 2022 upto 16:00 Hrs
Date & Time of Opening of Technical Part of Bid	30 <sup>th</sup> November 2022 at 16:00 Hrs

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**Technical Specifications for Equipment**

All materials required to complete the work as per given specifications & drawings etc. must be manufactured and supplied using fresh raw material. Re-moulded, re-circulated materials are not acceptable. The procurement of materials must be made by the contractor directly from manufacturer or through authorized dealer/distributors. Documentary evidence to this effect is to be made available to Employer for necessary checks/verification of source of supply of materials. Secondhand materials/ partial used materials/ used materials would not acceptable.

Climatic condition details are given with various materials specifications however, bidder shall note that materials covered under project specific works shall be utilized in that particular project only. Hence, the geographical location of that particular project site and its associated climatic condition shall be applicable for all the materials of that particular project.

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## **SECTION -1**

### **SCADA FUNCTIONS**

#### **1.0 General requirements**

This section describes the functions to be performed by the SCADA applications for distribution system for the project area. Bidders are encouraged to supply standard, proven & tested products that meet or exceed the Specification requirements. This chapter describes the requirements of ISR functions also. Unless specified as optional functions/ features all functions/ features mandatory for the project area.

##### **1.1 Design requirements**

The software shall be modular in nature. The software shall be able to work platform based on minimum 64 bit architecture. All the variable parameters of SCADA/DMS applications, which require adjustment from time-to-time, shall be defined in the database and shall be adjustable by system personnel. All periodicities and time intervals contained in the Specification that define these parameters shall be considered as initial values to be used for performance purposes. The adjustments made to parameters by the user or programmer shall become effective without having to reassemble or recompile programs or regenerate all or portions of the database.

The specific requirements for output results are described along with the other requirements of each function. However, all results that the user deems to be important shall be stored in a form accessible for display and printing, whether or not explicitly specified in the particular subsection.

##### **1.1.1 SCADA/DMS Function Access**

Various application functions shall be designated as single user/ multi-user. For a single-user function, the user with access to the function must relinquish access to it before access can be granted to another user. For a multi-user function any number of users, up to the maximum designated for the function, may have access to the function simultaneously. All such actions shall be recorded as events in the event log

##### **1.1.2 Critical & non critical functions**

The functions defined in this specification shall be classified as Critical or as Non- critical. Every critical function must be supported by sufficient hardware & software redundancy to ensure that no single hardware & /software failure will interrupt the availability of the functions for a period exceeding the automatic transfer time defined in the specification.

Non-critical function may not be supported by hardware & software redundancy and can be suspended in case of non-availability of corresponding hardware.

Generally the following are to be classified as Critical functions

- a) All SCADA applications
- b) Information Storage and Retrieval (ISR)
- c) All DMS applications
- d) Data exchange among the contractor supplied SCADA/DMS system, IT system established under R-APDRP
- e) Web server applications , Security applications
- f) Network Management system (NMS)
- g) Data recovery function (DR)

The following are Non-Critical functions

- a) Dispatcher Training Simulator (DTS)
- b) Database modification and generation
- c) Display modification and generation
- d) Report modification and creation
- e) Data exchange with Remote VDUs ,if any

## **1.2 SCADA Functions**

The following SCADA functions are envisaged under this specification.

- Data Acquisition from RTUs at S/S , FRTUs at RMUs /sectionalizer & FPIs
- Time synchronization of RTUs, FRTUs & FPIs(if time synch is supported in FPI)
- Data Exchange among the contractor supplied SCADA/DMS system, IT system established under R-APDRP (in specified format (OPC / CIM-XML / ICCP / ODBC Format) Model & Data Exchange over IEC 61968-1 Enterprise SOA Based BUS), State load dispatch centre.
- Data Processing
- Continuous real-time data storage and playback
- Sequence of event processing
- Supervisory Control
- Failsoft capability
- Remote database downloading ,diagnostics & configuration
- CIM compliance IEC61968
- GIS adaptor (GIS Landbase data, network model using GIS engines/adaptors supporting Native Adapters , CIM/XML Model for Distribution / Power System, using Model Exchange & Data Exchange over IEC 61968-1 Enterprise SOA Based BUS)
- Information Storage & Retrieval (ISR)
- Data recovery (DR)

The System Design Parameters of SCADA/DMS functions ,The power system sizing, Performance requirements for complete SCADA/DMS system are specified are specified in DESIGN PARAMETERS AND PERFORMANCE given section 8 The SCADA system shall have capability to accept data from the following sources:

- (a) Telemetered data received from RTUs, FRTUs & FPIs
- (b) Data received from IT system established under R-APDRP
- (c) Data exchange
- (d) Calculated data
- (e) Pseudo-data (Manually entered data)
- (f) GIS land base data, network model using GIS engines/adaptors

All input data and parameters, whether collected automatically or entered by an user, shall be checked for reasonability and rejected if they are unreasonable. All intermediate and final results shall be checked to prevent unreasonable data from being propagated or displayed to the user. When unreasonable input data or results are detected, diagnostic messages, clearly describing the problem, shall be generated. All programs and all computer systems shall continue to operate in the presence of unreasonable data.

-  
Each of the SCADA functions is described below.

### **1.1.3 | Communication protocol.**

SCADA system shall use the following protocols to communicate

- a) for RTU - IEC 870-5-104 protocol also 101 to communicate when acting as data concentrator with slave devices
- b) for FRTU- IEC 870-5-101 /104 protocol
- c) for FPIs - IEC 870-5-101 /104 protocol
- d) for MFTs – MODBUS
- e) for DR & Other any other SCADA system - ICCP/TASE.2 in specified format (OPC / CIM-XML / ICCP / ODBC Format) Model & Data Exchange over IEC 61968-1 Enterprise SOA Based BUS)
- f) for IT Systems - (in specified format (OPC / CIM-XML / ODBC Format) Model & Data Exchange over IEC 61968-1 Enterprise SOA Based BUS)
- g) In case existing system uses DNP3.0 protocol, the same shall be used for integration of existing RTUs.

The protocol considerations shall be made in accordance to the system/ device to be interfaced. However, system shall have capability to interface using all necessary protocols as specified above for the devices that may be interfaced in future

### **1.2.2 Data Acquisition**

SCADA system shall acquire data from Remote Terminal Units (RTUs) ,FRTUs &FPIs

a) . RTU & FRTU

The type of data to be acquired through RTUs, FRTUs shall include analog values, digital status data (Double point and single point indications ) and SOE data from the substation, RMUs etc.

Analog values like P, Q, F, each phase V, each phase I, each phase pf, and energy values (Export/Import KWh and KVARh) shall be collected by the RTU, FRTUs from the MFTs .

Analog values such as station battery voltage, oil temperature, winding temperature , tap changer, weather transducer data etc. shall also be acquired through RTU using analog input modules & suitable transducer, if defined in the RTU BOQ.

b) FPIs

Digital status in the form Fault protection indication viz O/C & E//F & in case also analog data such as Fault settings are remotely .

The actual point counts & type of data acquired are given in the RTU, FRTU specification.

#### 1.2.2.1 Polling method

Digital status data from RTU shall be reported by exception and shall be updated and displayed within 4 seconds. Digital status data from FRTU & FPI shall be also be reported by exception and shall be updated and displayed within 6 seconds. Digital status data shall have higher priority than the Analog data. The system shall have dead band for data by exception.

All analog values except energy values shall be reported by exception from the RTU, FRTU & FPI . The analog value, when reported by exception, shall be updated & displayed within 5sec from S/S & 10sec from RMU/sectionlizer locations at the control centre. An integrity scan of all status & Analog values shall also be made every 10 minutes (configurable).

The provision shall also be made to report analog values & status data periodically at every 10sec (user configurable), if required by the user.

The time skew at SCADA/DMS control centre ,S/S , RMU,FPI shall not be more than 0.1sec at each location & latency shall not be more than 0.5sec for status. For analog data the time skew shall not be more than 1sec & latency shall not be more than 1sec for analog as per IEEE C37.1.

Energy values of 15 minute blocks shall be collected periodically from the RTU, FRTU at scan rate of 15 minute/1 hour (configurable upto 24 hours). Alternatively,

the energy values shall be calculated for each 15 minute/1 hour blocks at SCADA level from the acquired energy values of MFTs through RTU & FRTU.

The contractor must assess & take the network delay into consideration while designing the system so that the update time in normal & peak level of activities are met.

The SCADA/DMS computer system shall also be able to collect any and all analog & digital data from its RTUs/FRTU/FPI on demand. Apart from the periodic integrity scan, the integrity scan shall also be initiated automatically for an RTU/ FRTU/ FPI whenever the following situations arise:

- i. Upon start up of the system
- ii. RTU/ FRTU/ FPI status change is detected such as RTU/ FRTU/ FPI restart, Communication Link restoration
- iii. On demand by SCADA/DMS functions
- iv. On request by the user

The TCP/IP Communication for RTU,FRTU,FPI on public network shall be encrypted over SSL Security / VPN & the equipment should take control command from designated Master IP address only and no other IP. The RTU, FRTU, FPI & all TCP/IP devices that are on Public Network shall form a private VPN network with the SCADA Front End, through which encrypted data gets exchanged.

#### 1.2.2.2 Telemetry Failure

If data is not received from an RTU/FRTU/ FPI after a user-adjustable number of retries, each affected point in the SCADA system shall be marked with a **‘telemetry failure quality code’** and an alarm shall be generated. Telemetry failure of data can be due to failure of communication link, failure of complete RTU/ ,FRTU/FPI or RTU/ FRTU module or MFT etc. Only a single alarm shall be generated if an entire RTU/ FRTU or its communication channel fails.

In the event of telemetry failure, the last good value/status shall be retained in the database for each affected point. When telemetry returns to normal, the associated SCADA system shall automatically resume updating the database with the scanned data.

The user shall be able to substitute a value in the database for any point that is experiencing telemetry failure which shall be marked with **‘manual replaced’ quality code** in addition to the **‘telemetry failure’ quality code**. The user shall also be able to delete any point (or entire RTU/FRTU/FPI) from scan processing. All deleted points shall be marked with a **‘delete-from-scan’ quality code**.



## Acquisition Modes

The following modes of data acquisition shall be supported:

a) Enable

When RTU/FRTU/FPI is enabled, the data is scanned in normal fashion and control command execution is allowed.

b) Disable

When RTU/FRTU/FPI is disabled, the data scanning & control execution is disabled. This is equivalent to "delete from scan" of complete RTU.

c) Test /Maintenance

—Placing an RTU/ FRTU in test mode shall generate an appropriate event message. When an RTU/FRTU is in the test mode, the real-time database shall retain the last value from all points collected via the RTU/FRTU before it was placed in the test mode. The points shall be marked in the database with a quality code indicating that their source RTU/FRTU is in the test mode. All system displays, programs, data links, and other devices shall use this value. Supervisory control of points that are in the test mode shall not be permitted.

When an RTU/FRTU is removed from the test mode, a message shall be generated, the test mode quality code shall be removed from all points assigned to the RTU/FRTU, the database values shall resume updating on each scan, and any controls for the RTU/FRTU shall be enabled.

### 1.2.3 Time synchronisation of RTUs

The SCADA/DMS system will be synchronised from the GPS based Time and frequency system. The SCADA system shall synchronise the time of all connected RTUs/FRTUs/FPI every 15 minutes (user configurable from 5 minutes to 24 hrs ) using time synchronisation message in the IEC 870-5-104/101 protocol /NTP/SNTP. The servers /Workstations at SCADA/DMS control centre shall be synchronised using NTP/SNTP . The time of DR centre shall also be synchronised from the GPS based system installed in one of the SCADA/DMS control centre in the state.

### 1.2.4 Data Exchange

#### 1.2.4.1 SCADA/DMS system with IT system

The SCADA/DMS System shall exchange data with ISR System & ISR System shall be the nodal interface with all IT System. The Data Center, DR Center and Customer Care Center under IT System, shall exchange data with the ISR System, using Open Standards like CIM/XML & IEC 61968 Series Standards for Power System, OPC, ICCP/TASE.2., ODBC  
The GIS System shall exchange data with SCADA System over IEC 61968-1 SOA

based ESB/Bus using CIM/XML Models for Power System using GIS Engine / Adapters supporting the standard.

Direct SQL/ODBC interfaces should continue to be supported for report generation and ad-hoc queries.

If utility was having GIS/ billing/customer system prior to R-APDRP i.e. considered as legacy in IT –R-APDRP, then interfaces may be selected accordingly viz ODBC/DDE etc using ASCII files. However, they shall provide system in compliance of the data exchange requirement specified in this para.

Data to be exchanged with IT system is defined in ISR section. For DR & SLDC , it is given below:

#### **1.2.4.2 For data exchange between SCADA/DMS control centres & DR centre , SLDC :**

SCADA/DMS control centre shall also exchange data using ICCP with State Load Despatch Centre (SLDC) of the state..Data exchange shall also allow other information to be transferred report by exception but also configurable periodically, or on demand. . It shall be possible to exchange at least the following data:

- real-time telemetered data of the interconnected network,
- non-telemetered data of the interconnected network,
- calculated data of the interconnected network
- SOE data of the interconnected network
- historical data of the interconnected network
- scheduling data
- operator messages.
- Event /alarm lists

It is envisaged that the utility shall get the load forecasting & drawl schedules from SLDC & versa in order to execute planning of load distribution.. In addition , status /measurement of interconnected network shall be able exchanged in both directions.

The data exchange with DR is required all the data to be transferred from control centre to DR which is required for system build in order to build a system from scratch. ICCP . TASE.2 protocol or equivalent non proprietary / De-Facto protocol shall be used transfer network model / database changes on incremental /global basis automatically once a day & on demand –It shall transfer all data /information which is required for system build in order to build a system from scratch.

#### **1.2.5 Data Processing**

The SCADA/DMS system shall prepare all data that they acquire for use by the power system operations and other applications. The data processing requirements shall apply to data collected from all specified sources.

Data acquired from RTUs/FRTUs/FPI/IT system , as well as data received from the DMS and the existing control centers if any, shall be processed and placed in the Real-Time Database as soon as it is received.

Data processing involves a value which has been converted to internal form and analyzed for violations of limits. The data processing shall set various data attributes depending on the results of the checks and shall trigger any additional processing or calculation. The SCADA /DMS system shall prepare all the acquired data for use by the power system applications. The SCADA system shall have capability to accept data from the following sources:

- (a) Real-time (also referred as telemetered) data received from control centres /IT system (data centre, customer care ,DR centre and RTUs/FRTU/FPI etc)
- (b) Calculated data
- (c) Manually entered data
- (d) Sequence of events data
- (e) Alternate data sources

#### **1.2.5.1 Analog Data Processing**

Analog data processing shall be performed according to the requirements listed below.

##### **(i) Conversion to Engineering Units**

Analog points that are transmitted to SCADA system in raw data format shall be converted to engineering units before being stored in the database. This conversion function shall include, as a minimum, the capability to perform the following conversion algorithm:

$$\text{Value} = (A * \text{scanned valued}) + B ,$$

where A and B are programmer-adjustable constants assignable as database attributes on a per point basis.

##### **(ii) Zero dead band processing**

The SCADA system at control centre shall process each analog input for dead band zone processing. The acquired value, if falls between the dead band range around zero then it shall be considered as clamped zero value else the actual value shall be considered.

##### **(iii) Reasonability Limit Check**

The reasonability limits shall represent the extremes of valid measurements for the point's value. All analog values shall be compared against defined high and low reasonability limits. The comparisons shall be performed at the scan rates of the analog values. An alarm shall be generated the first time a reasonability limit

violation is detected. The last valid value of the variable shall be maintained in the database and marked with a quality code indicating the '**reasonability limit violation**'. When data returns to a reasonable value, the new value shall be accepted and a return-to-normal message shall be generated.

#### **(iv) Limit Monitoring**

For bi-directional quantities (positive or negative) there shall be a set of three limits for each direction. For unidirectional quantities there shall be a set of three limits in one direction. These limits will represent increasing levels of concern and shall be named as "**Operational**", "**Alarm**" and "**Emergency**" limits. These three limits shall be set within the boundaries of reasonability limit. Generally, any alarm can be assigned as audible alarm but emergency limit shall necessarily be assigned as audible alarm.

All telemetered and calculated analog point shall be compared against above sets of high and low limits each time the value is scanned or calculated. Whenever a monitored point crosses a limit in the undesirable direction a limit violation alarm message shall be generated. Whenever a monitored point crosses a limit in the desirable direction, an exit alarm message shall be generated. If multiple limits have been crossed since the last check, each limit crossed shall be reported.

All limit monitoring shall preclude annunciation of multiple alarms when a value oscillates about an alarm limit by utilizing a programmer-adjustable alarm dead-band for each point.

The user shall be able to temporarily override any of the above limits (which are in use) by entering a new value. When the user overrides a limit, it shall be marked with a '**limit override quality code**' on all displays. The override value shall be recognized, and any display, report, or log containing the value of the overridden limit shall include it as such. An override value shall be used instead of the permanent value until the user removes the override condition or system is re-initialised. Any change in alarm states resulting from a change in limit value shall be reported. Contractor shall finalise & take approval from utility for limit values.

#### **(v) Rate of change /Gradient**

All telemetered and calculated analog points shall be also processed for rate of change of / Gradient processing, if defined that point for such processing in the database. An Alarm for over shoot & event message for return to normal shall be generated.

The rate of change shall be calculated periodically for each assigned point, by dividing the point's values at the beginning and the end of the period into the length of the period. Filtering shall be applied so that single scan excursions do not cause an alarm. The result shall be saved as a non-telemetered database point. All the requirements that apply to calculated points, such as limit checking,

alarming and availability for display and processing shall apply to the ROC points. There shall be a positive limit and a negative limit to catch excessive rises in the analog value.

#### **vi) Sign Conventions**

The sign conventions for the display, data entry and reporting of active and reactive power flow shall be used universally by all SCADA/DMS functions. All imports to bus bars shall be represented with + sign and all exports from bus bars shall be with –ve sign.

#### **Vii ) Accumulator Processing**

The system shall be able to store accumulator history. Storing accumulator history shall be provided with a method in which that stores data only once per hour and in other method that stores data each time new data enters the system.

It shall be possible to use the two methods concurrently for any pulse accumulator, making it possible to maintain two records for data that are read more than once an hour.

### **1.2.5.2 Digital Input Data processing**

Each state of a digital input point shall be associated with the state of an actual device. The number of bits that will be used to define the state of a device is defined in the RTU/FRTU Specification. A status point shall be defined as being either legal or illegal, and normal or abnormal:

- Illegal state: The first check on a new input to a digital status point is the legality check. If the new state is illegal, then the old value shall be left in the database and marked old with relevant quality code such as telemetry failure etc .
- Abnormal state: If the new state is legal, it shall be checked to see if it is among the normal states defined for the point. If not, the status point shall be marked as abnormal. While abnormal, it shall appear in the summary display of abnormal conditions/ off-normal summary
- Alarm checking: Each new value shall be checked to see if transitions into that state are to be alarmed. If so, and if no control action is pending on the status point, then an alarm action shall be triggered.

The following digital input data types shall be accommodated as a minimum:

- (a) Two-state points: The following pairs of state names shall be provided as minimum :
  - (1) Open/Closed
  - (2) Tripped/Closed
  - (3) Alarm/Normal
  - (4) On/Off

- (5) Auto/Manual
- (6) Remote/Local
- (7) On Control/Off Control

Three-state points: Any of the state combinations listed in (a) above shall be supported with a third, typically, in-transit state which is the case for slow operating devices such as isolator. If a device remains in this state for a period more than a threshold value, the same shall be alarmed.

Momentary change Detection (MCD): The input to capture the states of fast acting devices such as auto recloser.

Commanded changes initiated by supervisory control shall not be alarmed but shall generate an event message. All other status changes in the state of telemetered, calculated digital input points & uncommanded changes shall be alarmed. Each CB, isolator switching device etc shall have normal & off normal positions states defined. In the event of off normal positions, the same shall be reflected in the off normal summary list

### **1.2.5.3 Calculated Data processing**

SCADA system shall be capable of performing calculations and storing the result in the database as calculated data available for display. The database variables to be used for arguments and the mathematical/statistical/logical functions to be used as operations shall be definable interactively at a console as well as by the programmer using database creation and maintenance procedures.

Calculated analog values shall use database points as the arguments and mathematical and statistical functions as the operations. Functions such as addition, subtraction, multiplication, division, maximum value, minimum value and average value, count, integration, square root extraction, exponentiation, trigonometric functions, logarithms and logical & comparative operators etc shall be provided.

It shall be possible to calculate running maximum value, minimum value and average value over a time interval (time interval configurable from 5 minutes to 60 minutes). The value shall be reset after the elapse of defined time interval. These values shall be stored with time of occurrence for maxima and minima and the time for averaging.

Calculated status values shall use database points as arguments and combinational logic functions that include the logical, comparative operators such as AND, inclusive OR, exclusive OR, NOT, Less Than, Greater Than, Less Than or Equal To, Greater Than or Equal To, and Equal To ,If , else if etc. Suitable

rules or operators (such as multi-level parentheses) shall be provided to indicate the sequence of operations in the calculation.

#### **1.2.5.4 Substation Topology Processing**

The SCADA /DMS system shall be provided with a Substation topology processor function. This function shall be capable of analyzing the open/closed status of switching devices, such as breakers and disconnectors, in order to define the configuration of the substation for display. The energization of lines, transformers, bus sections and generating units shall be determined so that the associated displays may correctly show the status of these power system elements. The configuration shall be re-evaluated and updated whenever a switching device status change & analog value change beyond deadband is detected.

#### **1.2.5.5 Alternate source for data:**

The system shall have capability to accept multiple data sources by defining as main & secondary . Normally, data from normal source will be considered . In the event of non availability of primary source , data from secondary source shall be considered & once primary source is healthy , it shall switch back to primary source. There shall be an indication for primary /secondary source in displays , reports etc. Suitable alarm shall be generated in the event to change from primary to secondary & vice versa. Alternate source of data can be defined for certain critical points in the database.

#### **1.2.5.6 Quality Codes**

Quality codes indicate the presence of one or more factors that affect the validity of a data value. All quality codes that apply to a data value shall be maintained in the database for that data value.

The quality of the calculated value shall be the quality of its "worst" component of its arguments. The presence of a quality code on any of the component data values shall not disrupt the calculation using that value . Results of calculations that are manually overridden by the user shall be denoted with a quality code that can be differentiated from the propagation of a manual replaced quality code from one of its component values.

At least the following data quality codes preferably as the following single letter code shall be provided. However, distinct symbols /shapes after approval from employer may also be used.

Quality code	Code	Reason
Telemetry Failure (RTU Link)	T	Telemetry has failed
Manual Replaced	M	Manual updation
Delete from Scan (RTU/point)	D	User disabled the scan of the of data/point
Questionable data	Q	Analog values of the de-energized elements
Calculated	C	Calculated data
Estimated	E	Estimated data from state estimator
Limit Override	L	Limits are overridden
Primary /secondary source	P/S	Primary or secondary source
Reasonability Limit Exceeded	R	Value beyond reasonability limit
Alarm Inhibit	A	Alarm processing is inhibited
Test or maintenance mode	X	Point is in test /maintenance mode

### 1.2.6 Continuous Real-time data storage and playback

All real-time data (Analog and status) shall be continuously stored in auxiliary memory for atleast two weeks as and when it is received in the SCADA database from the RTUs.

It shall be possible to playback above stored data on single line diagram and network diagram for a time window of at least 10 minutes (configurable in seconds /minutes) by defining Start and End date and time. It shall be possible to have tabular and graphical trends of the stored data. It shall be possible to set a different sampling rate for playback than the sampling rate for data storage.

The users shall be able to select the time window of interest for archival of data in the ISR system for future retrieval and playback in SCADA system. This archived data shall be transferable in RDBMS database tables of ISR system for generation of tabular displays and reports.

- The SCADA system shall be capable of being configured to provide a complete picture of the electrical system from the stored data. This includes playback of a previously recorded monitored data, calculated system parameters, sequence of events, and message log.
- SCADA shall include an Event Log, Playback Historian and Playback Console and shall utilizes archived data for root “cause and effect” investigations, improvement of system operations, exploration of alternative actions, and replay of “What if” scenarios.
- The event log shall be synchronized and displayed while the playback is in progress. It shall allow the operator to determine, at a specific time, what events were occurring in the



power system, what was being reported to the operator, and what operator action resulted, if any.

- The playback historian shall provide seamless retrieval of data from the SCADA system historian for any events from any real-time console. The playback data is stored in an ODBC/SQL database and can be transferred to any user with the appropriate authorization.
- The playback console shall allow the system operator to control playbacks to re-run at original or accelerated speeds, single-step, fast-forward, or rewind through the message log. Playback resolution is operator controlled and determined by the scan rate of field devices. Full simulation capabilities shall be available to the system operator at any point during the replay; the operator shall be able to explore the effects of alternative actions at any point of recorded data.
- The Operator Console shall provide a complete historical (archiving) subsystem providing the user the capability to capture and analyze historical data.
- The system shall allow selection of any point in the system to be added and configured for archiving.
- The archiving system shall utilize a Microsoft SQL real-time relational database for storage of all process related data. Flat file or internal proprietary databases will not be accepted.
- The archiving system shall be configured using standard tools provided by the system to facilitate the display and editing of archive rates, archive types, etc. from graphical and tabular data displays.
- The system shall support the online addition of new tags to the historical database without interrupting operations.
- The historical subsystem shall promote the visualization of historical data in both tabular and graphical form. This includes the capability to view historical data via a web-enabled interface.
- The historical subsystem shall provide the ability to define archiving rates in increments of seconds, minutes, hours, or days.
- The historical system shall allow an individual archive rate to be programmatically modified and/or utilized as part of the Control Logic/Scripting requirements specified above.
- The system shall support archiving of up to 20,000 different variables per historical server.
- The system shall supply tools for automatically backing up the database to removable media or to an alternate storage location. The backup utility shall execute the database backups automatically based on either of the following configurable criteria:
  - a) Based on the size of the database (e.g. after the size reaches 1 Mbyte)
  - b) Time-based (e.g. every 24 hours)

### **1.2.7 Sequence-of-Events data**

Sequence-of-events (SOE) data shall be chronological listings of „status change events with time stamp" acquired from RTUs /FRTUs/FPIs. The SOE data shall be collected from all RTUs/FRTU/FPI either in normal polling or periodically/on demand . SOE data collection shall have lower priority than supervisory control actions and normal data acquisition. The SOE data collected from different RTUs/FRTU/FPI shall be merged for chronological listings and stored for subsequent review. Atleast latest 1000 SOE data shall be available for display.

The SOE resolution of RTU/FRTU is defined in respective sections for RTU/FRTU. SCADA/DMS system at control centre shall have 1ms SOE resolution. However, as SOE time stamping is done at RTU/FRTU/FPI level , the same shall be in line with resolution defined for RTU/FRTU/FPI.

All SOE data collected from all RTU/ FRTU/FPIs shall be stored in daily RDBMS database of ISR system.

#### **1.2.8 SCADA language**

The SCADA system shall have capability to write various programs using IEC 61131-3 SCADA language or C/C++ or any non proprietary language . It will facilitate user (programmer) to write various programs/ logics using points defined in the database .

#### **1.2.9 Supervisory Control**

The operator shall be able to request digital status control, set-point control and raise/lower control on selected points and analogs using Select check before operate (SCBO) Sequence.

Supervisory control shall allow the SCADA system to remotely control switching devices. A control action shall require a confirmation-of-selection-prior-to-execution response. Initiation of the control execute step shall occur after the dispatcher confirms that the correct point and control action have been selected.

After the dispatcher/DMS function initiates control execution, the RTU/FRTU shall be addressed for verification that the correct point has been selected at the RTU/FRTU and then the control action shall be executed. It shall also be possible to reset the flag in FPI through a command.

It shall be possible to issue control commands as a group control from SCADA where switching devices pertaining to different RTUs/FRTU or a RTU/FRTU may be controlled as a group. The SCADA system shall send the control commands sequentially (without dispatcher intervention), if the commands pertain to switching devices in the same RTU/FRTU, using the Selection Check before operate (SCBO) of prior-to-execution. The control commands pertaining to different RTUs /FRTUs may be executed in parallel.

If, after selecting a point, the user does not execute the control action within a programmer-adjustable time-out period, or if the user performs any action other than completing the control action, the selection shall be cancelled and the user be informed. If the communication to the RTU /FRTU is not available, the control command shall be rejected and shall not remain in queue.

The user shall not be prevented from requesting other displays, performing a different supervisory control action, or performing any other user interface

operation while the SCADA/DMS system waits for a report-back on previously executed control actions.

The system shall process supervisory control commands with a higher priority than requests for data from the RTU /FRTU /FPI data acquisition function.

Functional requirements for the various types of supervisory control are given below. A supervisory control request shall be sent from control centre only after the controlled point was checked for proper conditions. The request shall be rejected by the System if:

1. The requested control operation is inhibited by a tag placed on the device;
2. The device or S/S in local manual control mode
3. An Uninitialized, Telemetry failure, delete from scan, manual replaced , Test/maintenance , or Manually Entered data quality indicator is shown for the device;
4. The Operating Mode/ user permission of the workstation/console attempting control does not permit supervisory control
5. The device is already selected for control request or control execution is from another workstation / user/window /console or control request is progressing
6. Time out after selection
7. The device is not subject to supervisory control of the type being attempted

Rejection of a control request from control centre shall occur before any transmission is made for control purposes. A control rejection message shall be displayed for the Dispatcher.

### **1.2.9.1 Digital Status Control**

A digital control output results in the activation of an output relay in a RTU. Different commands shall be possible for these digital status controls:

Successful completion of the control request shall be recorded as an event. Failures to complete shall be handled as specified in UI section. Control requests shall be canceled and the selection of the point shall be terminated when the user cancels a request, does not perform the next step of the control procedure within the selection time-out period from the previous step of the procedure, or the request is rejected.

#### **1.2.9.1.1 Breakers**

The user shall be able to select and operate the two state controllable switching device i.e. Circuit breakers/ isolators (in case of RMUs)

#### **1.2.9.1.2 Capacitor Banks**

The user shall be able to control capacitor devices. The procedure for controlling these devices shall be the same as that of a switching device except that any supervisory control action must be inhibited for a programmer-adjustable time period after the capacitor/ reactor device has been operated. A message shall appear if an attempt is made to operate the device prior to expiration of that time period & dispatcher is required to give command after expiration of inhibited time period.

#### **1.2.9.1.3 Tap Changing Transformers**

SCADA system shall have the capability to raise and lower the on load tap position of the transformers from SCADA control centre through supervisory commands.

Depending on system conditions, the user may raise or lower the tap positions of On Load Tap Changing (OLTC) transformers. OLTC's tap position need to be monitored if supervisory control action is to be exercised. OLTC tap position input shall be acquired as an analog value. Tap excursions beyond user-specified high and low limits shall cause the master station to generate an alarm.

Supervisory control of OLTCs shall only be permitted when the transformer's control mode is Supervisory. All attempted invalid control actions shall be rejected.

For supervisory operations, the initial selection and control of the transformer for a raise/lower operation shall follow the (SCBO) Sequence. Upon receipt of the raise/lower command, the RTU will immediately execute the control action. It shall not be necessary for the user to re-select the transformer for additional raise/lower operations; the user shall only have to repeat the desired number of raise/lower commands, which shall be executed immediately. Normal scanning functions shall not be suspended between the times that repeated raise/lower commands are issued.

The user shall be able to cancel the operation or have it automatically cancelled by the master station after a programmer-adjustable time period elapses after the last raise/lower command. This multi-step procedure as described below

1. The RAISE and LOWER pushbuttons shall be displayed.
2. The command shall be launched as soon as RAISE or LOWER is selected. The Raise and Lower buttons shall not be replaced by a single Execute button. The RAISE/LOWER pushbuttons shall continue to be displayed, and it shall be possible to initiate these controls repeatedly without reselection of the controlled point, provided that the execution of the previous control command has successfully been completed.
3. The RAISE/LOWER pushbuttons shall remain available until either (a) the dispatcher clicks the CANCEL button or (b) the control times out due to inaction by the dispatcher.

4. A separate timeout period, adjustable in the range of upto 120 seconds, shall be provided for incremental control. The timer shall be reset and start counting again whenever a RAISE or LOWER command is issued.

Successful completion of incremental control shall be recorded as an event . However failure of incremental control, including failure to achieve the intended result, shall be alarmed.

#### **1.2.9.2 Set point Control**

The SCADA/DMS shall provide the capability to issue set point control using SCBO procedure to field equipment The SCADA/DMS shall transmit a numerical value to the device being controlled, to indicate the desired operational setting of the device.

#### **1.2.9.3 Auto execution sequence /Group control**

The Auto execution sequence function shall permit multiple supervisory control commands to be programmed for automatic execution in a predefined sequence. The dispatcher shall be able to execute this sequence. Commands to be supported shall include:

- Time delayed
- Pause & until a user commanded restart or step execution
- Jump to other sequence on certain conditional logic
- Manual Entry.

After executing a supervisory control action, the SCADA/DMS shall pause to obtain an indication of a successful control completion check . If the control completion check is not received, or does not have the expected value, the SCADA/DMS shall terminate the execution of the sequence and shall declare an alarm. Apart from waiting for control completion checks, and unless there is an explicit command for a delay, such as a "Pause" or "Stop" command, the SCADA/DMS shall not introduce any other delays in the execution of an sequence. No limit shall be placed on the number of Auto execution sequences, which may execute in parallel.

At any time during the execution of a list, the user shall be able to stop further execution via an cancel feature.

#### **1.2.9.4 Control Inhibit Tag**

A user shall be able to inhibit or enable supervisory control on any device. A tag symbol indicating the control inhibit conditions shall be displayed next to the device on all displays where the device is presented.

The programmer shall be able to define up to 4 tag types with the following attributes for each:

- (a) Type of controls that shall be inhibited by the tag (e.g., open only (Green tag) close only (Yellow tag), open and close (Red tag), or information only - no control inhibit (White tag). Tags shall be preferably identified by colours. However, distinct symbols /shapes after approval from employer may also be used.
- (b) Tag priority

Further the user shall be able to place atleast 4 tags per device. Only the highest priority tag shall be displayed. Any combination of tags shall be supported, including multiple tags of the same type. The combined effect of multiple tags shall be to inhibit a type of control if it is inhibited by any of the tags.

When a tag is placed on a device, the user shall be prompted to enter tag number and comment. An event message shall be generated each time a control inhibit tag is placed or removed with information on user ID, type of tag, time of placement or removal of tags.

#### **1.2.9.5 Control Permissive interlocks**

It shall be possible to define the interlocks at SCADA level as necessary for control actions. It shall also be possible for operator to bypass the interlock which shall be recorded as an event message with user ID information.

#### **1.2.9.6 Control Action Monitor**

The response to all control actions shall be verified by monitoring the appropriate feedback variable. A report-back timer (the duration dependent on the type of device) shall be initiated when the command is issued. At least ten timer periods of 1 to 60 seconds (adjustable in steps of one second) shall be supported, any of which may be assigned to any device.

The user shall be provided with an indication that a control action is in progress and, subsequently, a report of the result. If the control was unsuccessful, an alarm shall be generated that states:

- (a) the control message exchange was not completed successfully,
- (b) the device failed to operate, or
- (c) the device operated but failed to achieve the desired result (e.g., following a close control action, a three-state device operates from the open state, but remains in the transition state).

If the control was successful, an event message shall be generated.

For commands issued as part of a group control, DMS applications etc., the successful completion of all device control actions shall be reported via a single message. If the operation is unsuccessful, the user shall be informed of those devices in the group that failed to operate.

#### **1.2.10 Failsoft capability**

The SCADA system shall be able to manage & prevent system from total shutdown / crash etc in the event of system crosses mark of peak loading requirements through graceful de-gradation of non –critical functions & also relaxing periodicity / update rate of display refresh & critical functions by 50%..

#### **1.2.11 Remote database downloading ,diagnostics & configuration :**

The SCADA/DMS system shall be able to download database run diagnostics & create/modify /delete configuration/ parameterisation from centralised control centre locations to RTU/FRTU/FPI etc using ASDU/ messages of respective protocols or file transfer.

#### **1.2.12 CIM & IEC61850 , SMART GRID interface, requirements**

The system shall utilize an IEC 61968 and IEC 61970 compliant interface. The system shall enable export of all data via a CIM-XML interface and shall utilize modeling from IEC 61968 as appropriate. The profiles supported should be CDPSM (Common Distribution Power System Model) and CPSM (Common Power System Model). Messaging interfaces shall be based on model neutral interfaces based on the IEC 61970-40X series for access to real-time and historical data and use the IEC 61968-3 and IEC 61968-9 standards for messaging interfaces that are model dependent for network operations and metering respectively.

Further the above Interfaces shall be used for Integrating with the R-APDRP IT Systems being deployed for real-time & historical data exchange to and from the SCADA/DMS & IT Systems. The IT Systems Interface & the SCADA/DMS Systems Interface shall be so provided using CIM/XML & IEC 61970/61968 standards such that, a 3rd Party application service provider can integrate the two systems, or add a 3rd IT or SCADA/DMS System easily, without having to know specific Database Tables / Information of the other system.

Any Change in the electrical network system which will be captured in GIS database (through IT system being procured under separate package under R-APDRP) of the utility shall be automatically added/modified to SCADA system. eg: A new asset addition, should be able to be exchanged through Model Information between the IT System, and SCADA/DMS System without programming or configuration effort automatically & adjust and accept the Model and re-configure its databases, and should provide updated results.

SCADA/DMS Vendors shall provide CIM/XML Adapters for ICCP, OPC or ODBC for their System and CIM/XML Model repository for data and model exchange with IT Systems.



Further, system shall be able to interface with IEC61850 (GOOSE & GSSE Models) & provide an Independent 3rd Party modeling tool that can support multiple vendor IEC 61850 IED's and create IEC 61850 SCD files.

To enable to Migrate to Smart Grid, the SCADA/DMS Systems shall support the following:

- ☐ Security – The SCADA/RTU/FRTU Network has to be secure over SSL secure layer, and should be implemented as a VPN. Secure adapters between end nodes on public networks should be considered with IPsec or VPN.
- Interface to AMI/AMR System where-by DSM can be implemented over CIM/XML Interfaces
- ☐ The SCADA CFE should be able to integrate with Smart Grid gateway that support IEC 61850 / IEC 60870-5-101/104// DNP3, DLMS & ANSI C12.18/21 & IEEE C37.118 .

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### **1.3 Information Storage and Retrieval**

Information Storage and Retrieval (ISR) function shall allow collection of data from real-time SCADA/DMS system and storing it periodically in a Relational database management system (RDBMS) database as historical information (HI) data. This includes storing of data such as SOE, status data, Analog values, calculated values, Energy values etc. Programmer shall also be able to set storage mode as by exception in place of periodic storage.

Subsequently, the data shall be retrieved for analysis, display, trending and report generation. All stored data shall be accessible from any time period regardless of changes made to the database after storage of that data (e.g., it shall be possible to retrieve stored data for a variable that no longer exists in the SCADA/DMS computer system through back ups on storage medias viz. tapes /MO disks etc and initialise study-mode DMS functions with stored data on the corresponding power system model).

The addition, deletion, or modification of data to be collected and processed shall not result in loss of any previously stored data during the transition of data collection and processing to the revised database.

It should be able to compress data, and should have 100% retrieval accuracy. However, the retrieval of compressed historical streams should be of the same performance levels as normal SCADA retrieval. The ISR should be able to interface over IEC 61850, OPC, ODBC and CIM/XML to external systems for analytics over SOA / ESB for Integration with IT Systems, over the Enterprise Services Bus & SOA Architecture provided as part of IT SRS. The ISR system shall act as the real interface between SCADA and IT System, where-by the real-time operational system is not affected with a transaction processing system like IT, and the IT Integration efforts will not in any way effect the real-time operationally of SCADA/DMS System.

In ISR should also support ad-hoc queries, and define display and report formats for selected data via interactive procedures from operator workstations. Formatted reports and responses to user queries shall be presented in alphanumeric or graphical format on either operator workstations or printers at the option of the user. Procedure definition facilities shall be provided for activities that will be frequently performed. SQL-based language shall be used for selecting, retrieving, editing, sorting, analysing, and reporting ISR data stored. The selection and sorting criteria shall include time tags and ranges, station names, point names, equipment types, status values, text string matches on selected data fields etc and combinations of these criteria.

It shall be possible to reload any IS&R archival media that has been removed from IS&R and access the archived data without disturbing the collection, storage, and retrieval of IS&R data in real-time .

The ISR system shall also be used for mass storage of data/files such as DMS application save-cases, Output results of DMS applications, Continuous real-time data of selected time window etc.

The System Design Parameters of ISR system is given in the **section 8**

### 1.3.1 **Circuit breaker status Table**

The ISR function shall maintain a table in RDBMS database where real-time status of all Circuit breakers , in case of RMU isolators also along with the associated quality codes shall be stored. The change of status of any breaker shall be updated in this table as soon as the change is detected by the SCADA system. This table shall contain additional information\_ such as date & time of tripping, cause of tripping, Expected duration of outage etc. Some of the causes of tripping could be Supervisory control by user, Protection tripping, Tripping / closing by DMS applications. Information on expected duration of outage shall be taken from schedules for DMS application such as Load shed application etc. For expected duration of outages due to protection tripping, the same shall be user enterable field.. Such daily tables for two months duration shall be stored on auxiliary memory. Tables for the previous day shall be backed up to Magnetic tape by the user at 10AM daily.

The ISR function shall transfer the information available in the "Circuit breaker status table" as defined above, to the Customer Care centre under R-APDRP IT implementation / legacy system using SOA/Enterprise Service Bus supplied by ITIA, over CIM/XML Models, or CIM/XML OPC/ICCP Adapters / Interfaces. The complete Circuit Breaker Information shall be transferred to Customer care centre on demand & by exception along with the associated quality codes and additional information associated with the CB .

### 1.3.2 **Real-time Database Snapshot Tables**

At the end of each 5 minutes, the following real time snapshot data shall be stored in RDBMS in **Real-time Database Snapshot tables**:

- a) All telemetered analog values and Calculated values for all telemetered analog points (atleast maxima & minima with associated time and average values). Energy values are not envisaged for storage in Data snapshot tables.
- b) All status values with time stamp

All the above values as specified above in (a) & (b) shall be stored alongwith their associated quality code. The periodicity of the snapshot shall be user adjustable to include 5, 15, 30, and 60 minutes. **Data Snapshot tables** shall be created on daily basis. Such daily tables for two months duration shall be stored on auxiliary memory. Tables for the previous day shall be backed up to Magnetic tape/ MO disk by the user at 10AM of every day. The ISR function shall prompt the user through a pop-up window to inform the user for taking the backup. The pop-up window shall persist till user acknowledges the same. In addition to that data can be stored on offline storage device .

The user shall also be able to initialize the study-mode power system analysis functions from stored snapshot data.

### 1.3.3 Hourly Data tables

At the end of each hour information as defined below shall be included in the hourly data tables, in RDBMS database form:

- (a) Selected analog values alongwith their associated quality codes
- (b) Selected status values alongwith their associated quality codes
- (c) Results of hourly calculations for selected analog points (atleast maxima & minima with associated time and average) alongwith their associated quality codes.
- (d) In addition to above a separate hourly energy data table exclusively for energy values (Export and Import Active and reactive Energy values for each feeder) shall be created in ISR alongwith their associated quality codes.

**Hourly data tables** shall be created on daily basis. Such daily tables for two months duration shall be stored on auxiliary memory. Hourly data table for the previous month shall be backed up to Magnetic tape /MO disk by the user on the 10<sup>th</sup> of every month. The ISR function shall prompt the user through a pop-up window to remind the user for taking the backup. The pop-up window shall persist till user acknowledges the same.

#### 1.3.3.1 Missed Hourly Data Storage

The programmer shall be able to independently assign any one of the following processing for each hourly value to be executed when the value is missed and cannot be acquired prior to the storage of hourly values.

- a) Store zero and a telemetry failure quality code for each missed hour.
- b) Store the last good data value, with a questionable data quality code, for each missed hour.
- c) Temporarily store zero with a telemetry failure code for each missed hour. When the next good hourly value is obtained, divide that value by the number of hours since the last good value was obtained and insert this value, with a questionable data quality code, for all hours with missed data and the first hour that good data was obtained as is the case for energy values.

#### **1.3.3.2 Hourly Data Calculations**

The programmer shall be able to define calculated values using stored hourly data and constants as operands. The calculations shall allow the carry-forward of data from one day, week, or month to the next. The results of all calculations shall include quality codes derived from the quality codes of the operands. The following calculations shall be provided:

- (a) Addition, subtraction, multiplication, and division
- (b) Summation of an hourly value by day, week, and month: The running total of the summation for the current day, week, and month shall be updated each hour and made available for display.
- (c) Maximum and minimum of a value over a programmer-definable time period, and the time the maximum or minimum occurred
- (d) Average of a value over a programmer-definable time period

#### **1.3.4 Daily Energy Data table**

The daily energy data table shall be generated for storage of daily energy values for 15 minute blocks / one hour blocks of a day & shall be stored for each feeder on daily basis alongwith quality codes. This daily energy data shall be exchanged with the Billing system in Data centre & DR Under R-APDRP IT implementation/ legacy master billing centre on daily basis and on demand. This table shall be created on daily basis. Such daily tables for two months duration shall be stored on auxiliary memory. Daily Energy data table for the previous month shall be backed up to Magnetic tape by the user on the 10<sup>th</sup> of every month.

#### **1.3.5 Load priority table**

ISR system shall maintain a Load priority table containing information such as breaker name, number of consumers connected to each Breaker and Load priority of each Breaker. This table shall be updated by the Billing system in Data centre. Under R-APDRP IT implementation/ legacy master billing centre .

SCADA /DMS control centre operator can also assign priorities in load priority table & the priorities assigned by the Billing system in Data centre & DR Under R-APDRP IT implementation/ legacy billing system may be accepted/ rejected by him. There shall be suitable alarm/event message including user ID for such activity. The table information shall be used by various DMS applications.

### **1.3.6 SOE data table**

ISR system shall maintain SOE data table which shall store the SOE data for complete distribution system . It shall be possible to sort the table by Time, Date, Substation name, feeder/line name, device name etc. using SQL commands. This table shall be made on daily basis. Such daily tables for two months duration shall be stored on auxiliary memory. For the purpose of sizing of table, daily 4 changes per SOE point may be considered. All CBs, protection and alarm contacts shall be considered as SOE. Tables for the previous day shall be backed up to Magnetic tape/ MO disks by the user at 10AM of every day.

### **1.3.7 Data exchange with Billing system (Data centre & DR centre) Under R-APDRP IT implementation**

The ISR function shall provide daily energy values along with associated quality codes to Billing system Under R-APDRP IT implementation or any legacy master billing centre once in a day and on demand. SCADA/DMS System shall have the provision to import/export energy values with Billing system at data centre/DR Under R-APDRP IT implementation. This information of Load priority in ISR system shall be updated by Billing system at data centre /DR Under R-APDRP IT implementation shall be used by DMS applications. Further data from snapshot table shall be transferred to IT system in R-APDRP

This data exchange shall be done using SOA / Enterprise Services Bus already provided by ITIA, over Open XML Models like CIM/XML, or over ICCP / OPC/ODBC.

### **1.3.8 Data Exchange with Customer Care System Under R-APDRP IT implementation**

The ISR function shall transfer the information available in the "Circuit breaker status table" as defined in this chapter, to the Customer Care centre under R-APDRP IT implementation / legacy system using SOA/Enterprise Service Bus supplied by ITIA, over CIM/XML Models, or CIM/XML OPC/ICCP /ODBC Adapters / Interfaces. The complete Circuit Breaker Information shall be transferred to Customer care centre on demand or Changed Information shall be send along with the quality codes and additional information associated with the CB.

### 1.3.9 Data Exchange with GIS system:

SCADA Systems over CIM/XML Models using GID to IEC 61968-1 will be used by SCADA/DMS & other IT Systems for getting network information, customer and interconnection information.

The GIS will interface using CIM/XML adapters to other applications. SCADA will have model aware adapters to read from GIS network model repository, and update its own models. The system shall utilize an IEC 61970 and IEC 61968 compliant interface. The system shall enable export of all data via a CIM-XML interface per IEC 61970-452 and IEC 61970-552-4 and shall utilize modeling from IEC 61968-11 as appropriate.

Data exchange shall be over model neutral messaging services and CIM/XML data exchange for real-time or RDBMS will be used. The following standards as applicable will be used to achieve the above requirements:

Messaging interfaces shall be based on model neutral interfaces based on the IEC 61970-40X series for access to real-time and historical data and use the IEC 61968-3 and IEC 61968-9 standards for messaging interfaces that are model dependent for network operations and metering respectively

The Graphic data import from a GIS systems shall support native formats of GIS systems which shall be potentially used for data import. All Technological addresses (TAs) shall be automatically assigned within the system to the tags linking the graphic data to the attribute data in the GIS, the attribute data shall be loaded into the SCADA data base and the display diagrams shall be generated. The Graphics exchange between GIS and SCADA should happen over IEC-61970-453 Scalar Vector Graphic based XML representation

The complete network model including data of electrical network e.g. line (i.e. length, type of conductor, technical particular of conductor & transformer etc, land-base data . Suitable GIS interface adaptor to enable the compatibility with GIS software/ data format /model shall be provided . The Graphic data import from a GIS systems shall support native formats of GIS systems which shall be potentially used for data import. The data shall be transferred on global & incremental basis on manual request & automatically, once in a day The DMS shall automatically move elements that overlap one another in congested areas so that the operator can clearly see each segment of the network in the geographic view. In addition, the system shall automatically move and scale annotation text that come from GIS so that it is visible the user's current display SCADA/DMS in the geographic view. The system shall include tools to edit annotations /text & symbology placements in geo –referenced displays , substation and distribution network. It shall be possible to import related reference layers such as streets , buildings, poles etc and other background information.

All Technological addresses (TAs) shall be automatically assigned within the system to the tags linking the graphic data to the attribute data in the GIS, the attribute data shall be loaded into the SCADA /DMS data base and the data /text shall be displayed on SCADA/DMS diagrams if viewed in GIS mode shall display GIS in background with zoom ,pan , scaling & UI navigation techniques in synch with SCADA/DMS system displays. The GIS Network Model shall be exposed to the IT and SCADA Systems over CIM/XML Models using GID to IEC 61968-1 Enterprise Bus. This model repository will be the single model authority for the entire Utility network to be used by both IT & SCADA/DMS Systems under R-APDRP. This repository is maintained by the GIS System, and will be used by SCADA/DMS & other IT Systems for getting network information, customer and interconnection information.

#### **1.3.10 Historical Information (HI) Data Retrieval**

The data stored in the ISR system shall support the following retrieval capabilities:

- (a) The user shall be able to view and edit HI data on displays/Forms and reports. The user shall be able to edit HI data, request recalculation of all derived values, and regenerate and print any daily, weekly or monthly HI report for the current and previous month.
- (b) The user shall be able to view tabular trend and graphical trend of multiple data points simultaneously by specifying the start date and time, the end date and time, and the time period between displayed samples. The duration of viewable tabular trend and graphical trend could be upto 24 hours. The features of Tabular/graphic trend is mentioned in the specification for User interface.
- (C ) The HI retrieval shall expose the ISR Data over SOA / Enterprise Services BUS Supplied by ITIA, over CIM/XML, ICCP or OPC ODBC Interfaces / Adapters.
- (D ) The retrieval shall provide 100% accuracy and fidelity of data

#### **1.3.11 System Message Log Storage and Retrieval**

System message log, which shall consist of the chronological listing of the SCADA/DMS computer system alarm messages, event messages and user messages shall be stored for archival and analysis. Each entry shall consist of time tag and a text containing user and device identification as displayed on the Alarm Summary or Event Summary displays. The System message log data storage shall be sized for up to 20,000 entries per month.

System message log data shall be stored in daily tables & shall be available for minimum two months on auxiliary memory. System message log data for previous months shall be Backed up on Magnetic tapes/ MO disks by the user for which ISR

function shall prompt the user every hour with suitable message to remind user for taking the backup on the 10<sup>th</sup> of every month. This message shall be disabled once the backup is taken.

Facilities to sort and selectively display and print the contents of the system message log shall be provided. The user shall be able to select the display of system message log entries based upon Alarm type, Events, User generated messages, Device, and Time period.

### **1.3.12 Mass storage of data/files**

The ISR system shall be sized for mass storage of data/files for atleast the following :

- a) 10 save-cases for each DMS application
- b) 10 Output results of each DMS applications

### **1.3 Thin Clients/Web HMI Visualization**

- A XAML / WPF based Thin Client software for dynamic graphical representation and access to data at the monitored site.
- The Thin Client design shall be such that no special software or application is required to be installed on any user workstation/computer, rather the system shall use off-the-shelf and commercially available web browser technology.
- No special software shall be required to create, edit or modify the thin client browser based displays regardless of the physical location of the PMS server serving the thin client displays as long as proper authorization is validated and the workstation/computer is connected to the server either over the Internet, or is on a private Intranet.
- Standard, off-the-shelf Microsoft services shall be utilized.
- There shall be no limit inherent in the software to the number of Thin Client simultaneously connected to the Server.
- The Thin Client shall communicate to the Server over an IP network. Ethernet, LAN/WAN, Intranet or Internet, or direct TCP when the thin client is running on the same computer as the server.
- Any Thin Client shall be capable of communicating with the Server on these networks requiring only authorization and a URL or IP address.
- Any individual computer shall be able to view the Server simultaneously (multiple WPF windows) with other users. This action shall be transparent to the all users.
- The thin client shall provide for dynamic data updates which means data is updated upon any change in value/status without requiring a screen refresh or other page related function, in other words as data updates the individual data shall update directly.



- The thin client shall be capable of displays that include graphs and data based on accessing information from the Server (both actual and derived data).
- SCADA shall support Web-Based solution which offers an extended thin-client web based application that allows users to visualize, simulate and manage their electrical systems remotely from the web.
- Web based real time simulation shall be capable for below features,
  - a) Predictive “What-if” Simulation using existing operating condition
  - b) Remote Scenario Execution
  - c) Review results on the One-Line Diagrams & Reports
  - d) System Monitoring & KPI Views
  - e) Geographical Power Distribution Views
  - f) Alarms & Events
  - g) Load Shedding Systems Views
  - h) Generation Monitoring
  - i) Switching Sequence Management
  - j) Customizable User Interface & Reporting
  - k) Development Console
  - l) Safe and Secured Communication
  - m) User and Machine access Management
- The Web client is designed with authentication, authorization, encryption and data integrity via signatures which permit secure server-client conversation. The user can control who can access their data. Multiple layers of security protect the information from unauthorized access.
- Real time web application can access anywhere through the use of a tablet or smart phone.

#### **1.4 Access control and Authorization Requirement**

- The SCADA system shall be protected against illegitimate use by restriction of access to various levels.
- Access to the SCADA system should be restricted by authorization validation and the access shall be archived for future tracking. This validation should occur at the application level of the SCADA system communication profile and should support the concept of access privileges, which includes:
  - a) Monitoring  
In this mode, the system is validated to monitor attributes/values from the SCADA system. However, it is not authorized to perform any action that affects the operation of the SCADA system viz. control or configuration changes.
  - b) Control  
In this mode, the system is validated to control the operation of the SCADA system. This privilege should be granted in conjunction with Monitoring. However, this privilege should not allow making any configuration changes.
  - c) Configuration  
In this mode, the system shall allow configuration changes to be made to the SCADA system. This Privilege should always be granted in conjunction with Monitoring.

d) Security Administration

In this mode, the system shall allow to change/retrieve security related attributes/values/configuration.

- The security requirement shall be in accordance with ANSI/ISA 99.02.01. Unless otherwise specified there shall be three levels of permissions/authority to ensure the security of the system, as detailed below

- a) System Administrator/Engineer
- b) Supervisor
- c) Operator

### **1.5 Energy Tracking & Accounting**

- The software shall be capable of providing energy usage analysis and cost allocation for individual generation units, areas, and the entire system.
- The software shall track and create energy billing reports based on user-definable energy cost functions and energy tariffs.
- For any onsite generators and utility feeders, the software shall be capable of creating the energy cost / profit analysis and energy production / consumption billing reports. The Energy Accounting software shall include the following features:
  - a) Predict system-wide energy usage & cost allocation
  - b) User-definable cost functions & generator heat rates
  - c) Track energy related costs
  - d) Avoid unnecessary peak demand charge & penalties such as PF penalty
  - e) Implement and track effectiveness of cost savings programs
  - f) Implement billing based on business units or tenants
  - g) Energy cost / profit analysis report
  - h) Energy production / consumption billing

### **1.6 Human Machine Interface (HMI) for Centralized E-SCADA**

- Centralized SCADA is comprising of redundant server, non-redundant historian server, operator workstation (OWS), Engineering Workstation (EWS), Printer, firewall, Gateway (if required) etc. to meet the specification requirement.
- SCADA shall be capable of performing all monitoring/controlling/displaying of various function envisaged from the system described in this Standard and project document.
- The centralized SCADA shall provide general substation information, giving an overview of all substation main components, general system information with overview of all substations, power distribution (all voltages levels) with status of breakers/other equipment's as applicable. This shall include but not limited to the following,
  - a) Single Line Diagram
  - b) Graphics and Trend Displays
  - c) Alarm Summary and History
  - d) Report Generation from any historical or real time measurement
  - e) Sequence of events
  - f) The various monitoring/control/alarm/ status displays as mentioned in the specification
  - g) Devices displays
  - h) System configuration displays
  - i) Communication network displays
  - j) Menu/Navigation Displays

- k) System Status Displays
- l) System Diagnostics and Maintenance Displays
- m) Links to document station, Symbol templates/libraries, printing etc.

- The EWS and OWS shall be 32'' LED monitor; rugged keyboard and functional keys. The color printer shall be laser type suitable for printing graphics/sequence of events etc.
- The display and graphics shall be in multicolor to show the operating condition of the network, energized/earthed status of breakers, voltages levels of various buses etc. with pan/Zoom facility. The display shall be large enough to provide an overview of the entire power network and enable the operator to identify at a glance any condition that requires their immediate attention.
- Central control SCADA shall be capable of retrieving data from the SCADA systems at various substations. In such cases EWS and accessories provided shall be suitable for handling the input from the several SCADA Systems located at various substations.
- Central control SCADA shall also accommodate a group devoted to daily operation and mainly dealing with data which changes frequently. This second group will concentrate on the GUI which encompasses all the tasks of real-time operation, and predictive simulation using real-time and/or archived data.
- Central control SCADA shall calculate the topology model based on real-time operating conditions such as meter readings, status of sources & loads as well as status of circuit breakers, switches, etc. The real-time network topology processor shall represent a base upon which state estimator and other electrical network analysis programs will operate.
- Network topology shall be recomputed and updated on the GUI single-line diagram each time the Central control SCADA scans the SCADA system.
- Network topology processor shall include a prediction comparator that provides error flags categorized based on the following such that the network topology used as a base for other applications is correct and reliable.

Raw Data Checking (RDC)

Bad Data Detection (BDD)

OPC Quality Flags (OPC)

### 1.8 Predictive Simulation

The SCADA software should be capable of real-time predictive simulation. SCADA shall contain integrated analytical tool or It should Integrate with System that have Simulation capability over OPC or with other protocol.

The Predictive Simulation system shall consist of all requisite hardware such as servers, OPC connectivity for interface with the SCADA system for real time data acquisition and representation on the electrical network. At any point of time, it shall be possible to use the real time data for offline simulation of Electrical System through simulation software.

Simulation shall provide prediction of system behavior in response to operator actions and events via the use of real-time and historical / archived data.

I. The system shall demonstrate analytical techniques and allow for prediction of vital electrical information at relevant locations on all buses:

- a) Predict the strength and resilience of electrical system.
- b) Predict the security of the electrical system including how adequate the protective devices are (in real-time) against predicted fault currents.
- c) Predict the adequacy of the facility power system in startup of heavy consumers of power in order to maintain adequate voltage to support the sudden impact of the startup of such heavy loads on the system and associated critical processes.
- d) Predict critical clearing time of circuit breakers so that facility stability is maintained.
- e) Automatically provide an impact assessment of a number of different disturbances such as loss of loads, loss of generators, and transfer of loads from one source to another.
- f) Predict the present power delivery capabilities of the electrical distribution system and remaining capacity available.
- g) Predict the reliability of the power distribution system and its components including availability at all critical locations.
- h) The above analytics shall be performed periodically (a user defined time period) or automatically should a switching event occur (connection to distribution is lost, chiller failure, sudden facility load increase).
- i) Predictive simulation shall provide overall system health and an indication of vital power indicators in a real time environment permitting immediate management of a complex power system through modeling and simulation. Predictive simulation cannot be an off-line or snapshot function and shall be fully integrated into the overall real-time solution.

II. The Simulator functions shall include the following features and capabilities:


- a) The single line diagram should be on intelligent one-line diagram and all the device physical attributes shall be shown on the system. This will help to have one integrated and unified model from design, analysis to operation and maintenance
- b) Data Acquisition, Advance Monitoring
- c) Alarms, Events & Trending
- d) Advanced Monitoring with State & Load estimation
- e) Network Topology builder & processor
- f) Real Time Power flow with direction, percentage of loading of bus etc. at each branch & buses
- g) Tabular Dashboard views
- h) Bad Data identification& isolation
- i) Real Time Load Flow, Short Circuit& Relay Coordination Analysis
- j) What-if analysis
- k) Event Play back with visualization and root cause analysis
- l) Switching Sequence Management
- m) Reliability Analysis
- n) Collection, upload, display and archiving of the time stamped data
- o) Capable of obtaining snap-shots of real-time data for the purpose performing simulation at any time under various system configurations.
- p) Allow the system operator to perform "what if" studies by simulating any system event and running calculations to determine subsequent system parameters.
- q) Simultaneous Monitoring, Simulation, & Control.

- r) Simulate the operation of system equipment such as relays, fuses, circuit breakers, etc.
- s) Graphically display system responses to faults or disturbances.
- t) Allow for simulator playback of previously recorded events to run at original or accelerated speeds, single-stepping, fast forward, or rewind through the message log.
- u) Real-Time Operation of System Components
- v) Complete Display of Real-Time & Estimated Data
- w) Predict System Response to Operator Actions
- x) Full spectrum network analyses modules
- y) Get online data on demand
- z) Retrieve archived data for system analysis
- aa) Graphical display of simulation results
- bb) Unlimited study case / solution parameter editor
- cc) Intelligent interactive graphical user interface
- dd) Online / offline simulation alerts
- ee) Emulate response of protective devices
- ff) Evaluate protection & control systems
- gg) Customizable reports via Crystal Reports
- hh) Automatic scenario simulation using project wizards
- ii) Multiple power analysis methodologies and techniques

## **SECTION -2**

### **DMS FUNCTIONS & Supporting functions**

#### **2.1 General Requirements**

This Section describes the Distribution Management System (DMS) applications & Other supporting applications that are required for SCADA/DMS System . The DMS applications shall utilise the data acquired by the SCADA application. Distribution management System Software shall include the following applications. Utilities shall select /all or certain applications according to the need & characteristic / profile of the electrical network & future part of SMART GRID in the project area, 

##### **2.1.1 DMS functions**

- Network Connectivity Analysis (NCA)
- State Estimation (SE)
- Load Flow Application (LFA)
- Voltage VAR control (VVC)
- Load Shed Application (LSA)
- Fault Management and System Restoration (FMSR)
- Loss Minimization via Feeder Reconfiguration (LMFR)
- Load Balancing via Feeder Reconfiguration (LBFR)
- Operation Monitor (OM)
- Distribution Load forecasting (DLF)

##### **2.1.2 Other Supporting functions**

- Dispatcher training Simulator (DTS)

##### **2.1.3 Contractor's Standard product**

The bidders are encouraged to supply standard, unmodified products that meet or exceed the Specification requirements. These products may be

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provided from the bidder's in-house baseline offerings as standard products from other established suppliers. Bidders shall describe all standard, unmodified products proposed and shall highlight those features that exceed the Specification requirements. Although the bidder is encouraged to use as much standard hardware and software as possible, the proposal will be judged by its conformance to the Specification. Hence, a minimum level of customisation in order functional requirement is permitted. The product CIM based interfaces to other enterprise applications shall be available.

#### **2.1.4 Graphical & Tabular display requirements for DMS functions**

A network overview display of the distribution system with substations, feeders colour coded by voltage shall be provided. This display shall present the distribution system in a graphic format. Telemetered and calculated values like active and reactive power flows etc shall be displayed with direction arrow. Lines, Loads, transformers etc that have exceeded their loading limits shall be highlighted. Stations shall be depicted by suitable symbols which reflect the presence of alarms. Cursor selection of a station symbol shall result in display of the associated Single line diagram for that station. “ What if “analysis shall be included to visualise network & verify the impact before an action is taken by dispatcher. For all switching actions which dispatcher have to execute manually/step by step shall have the option to simulate switching operations in order to visualise the effect on the distribution network using what if analysis

All DMS result tabular displays shall have capability for sorting by name and calculated parameters.

The solution prescribed by DMS application shall consider & identify & sort the following as minimum

- 1: Remote controllable circuit breaker with capability to interrupt fault currents
- 2: Non-remote controllable circuit breaker with capability to interrupt fault currents
- 3: Remote controllable circuit breaker with no capability to interrupt fault currents
- 4: Non-remote controllable circuit breaker with no capability to interrupt fault currents .
- 5: Remote controllable disconnecter
- 6: Non remote controllable disconnector .
- 7: Fuse
- 8: Ground/ Earth switch etc
- 9.Sectionizer

## **2.2 Network Model**

The DMS applications shall have a common model for the project area comprising of primary substation feeders, distribution network and devices with minimum 10 possible islands, which may be formed dynamically. All DMS applications shall be able to run successfully for the total distribution system with future expandability as envisaged under the specification. The following devices shall be represented in the model as a minimum:

- a) Power Injection points
- b) Transformers
- c) Feeders
- d) Load (balanced as well as unbalanced)
- e) Circuit Breakers
- f) Sectionizers
- g) Isolators
- h) Fuses
- i) Capacitor banks
- j) Reactors
- k) Generators
- l) Bus bars
- m) Temporary Jumper, Cut and Ground
- n) Meshed & radial network configuration
- o) Line segments, which can be single-phase, two-phase or three-phase and make up a distribution circuit.
- p) Conductors
- q) Grounding devices
- r) Fault detectors
- s) IEDs
- t) Operational limits for components such as lines, transformers, and switching devices

All DMS applications shall be accessed from graphic user interface through Operator consoles as defined in this specification. Reports, results and displays of all DMS application shall be available for printing at user request.

Population and maintenance of the distribution network model should be possible by using the database maintenance tools to build the database from scratch. In case the required data already exists within the Employer's corporate Geographic Information System (GIS) as a part of R-APDRP scheme or otherwise, the DMS database functions should leverage this effort by providing an interface/adaptor to extract GIS data using the CIM international standard IEC 61970/61968 and automatically generate the complete Network Operations Model. The data extracted should include network device information, connectivity, topology, nominal status and non-electrical data such as cable, landbase data etc. Further Land base data



can be sourced from GIS in Shape files or DXF.

The extraction process should comply with the international standard CIM data descriptions. The CIM standard is maintained by the IEC (Technical Committee 57, Working Group 14 ) and is used for a wide range of purposes. The extraction process should be independent of the real-time network management system. Any GIS model should be extractable to build the network model regardless of the supplier or internal schema.

The extraction should also allow incremental updates & global transfer with no need to bring the system down or even fail over. The model should support extraction on a per-station basis and must be fully scalable from a single zone substation to the largest distribution networks. SCADA/ DMS should be able to present geospatial data even when the link to the source GIS at the data center/DR is not available

The user interface supporting the database will provide updated data directly to display geographic and/or schematic views of the network.

The model should support multiple geographic coordinate sets for each device so that, if available, the network can be displayed in custom geo-schematic formats. The network views may also include various levels of detail depending on the zoom level. Information such as land-base data (provided as a dxf file, shape file etc ) may also be displayed as required.

An interface with the already existing Geographical Information Systems shall be developed using interoperability features between the DMS and the installed GIS.

Each of the two systems shall keep its own specificity, and shall be used for what it has been designed: the SCADA for the real-time data acquisition ,control and processing, the GIS for the maintenance of the network construction and geographic data.

The interface shall be developed in order to obtain a maximum benefit of the two systems use. It shall be implemented while maintaining the SCADA/DMS and GIS integrity as individual systems. It is of the utmost importance that the two systems remain able to operate separately.

The required functionalities for this interface shall cover the two following aspects:

The transfer of specific real-time data from the DMS into the GIS data-base  
The possibility to navigate easily from one system to the other through the user's interface

Data exchanges shall be made through the Control Center LAN/WAN.. Bidder shall demonstrate its incorporation capability to the main GIS Vendors through

a dedicated reference list or provide and support standard interfaces to GIS.

## 2.3 Network Connectivity Analysis (NCA)

The network connectivity analysis function shall provide the connectivity between various network elements. The prevailing network topology shall be determined from the status of all the switching devices such as circuit breaker, isolators etc that affect the topology of the network modelled.

NCA shall run in real time as well as in study mode. Real-time mode of operation shall use data acquired by SCADA. Study mode of operation will use either a snapshot of the real-time data or save cases.

NCA shall run in real time on event-driven basis. In study mode the NCA shall run on operator demand.

The topology shall be based on

- (a) Tele-metered switching device statuses
- (b) Manually entered switching device statuses.
- (c) Modelled element statuses from DMS applications.

It shall determine the network topology for the following as minimum.

- (a) Bus connectivity (Live/ dead status)
- (b) Feeder connectivity
- (c) Network connectivity representing S/S bus as node
- (d) Energized /de-energized state of network equipments
- (e) Representation of Loops (Possible alternate routes)
- (f) Representation of parallels
- (g) Abnormal/off-normal state of CB/Isolators

The NCA shall assist operator to know operating state of the distribution network indicating radial mode, loops and parallels in the network. Distribution networks are normally operated in radial mode; loops and/or parallel may be intentionally or inadvertently formed.

A loop refers to a network connectivity situation in which there exist alternative power flow paths to a load from a single power source. A parallel refers to a topological structure in which a load is fed from more than one power source. Parallel paths often result in circulating currents and such operating conditions need to be avoided. All loops/parallels in an electrical network shall be shown by different colours in such a way that each is easily identifiable.

Abnormal state of CB/Isolators means these devices are not in their Normal OPEN or CLOSED position.

Alarms shall be generated when presence of abnormal switches, De-energized components of network and of Network loops / parallels is detected.

### **2.3.1 Tracing**

NCA function shall also have the capabilities of network tracing when requested by the dispatcher. Dedicated colours shall be used for feeder and circuit tracing and also when information available is not complete or inconsistent.. The trace shall persist through subsequent display call-ups, until the operator explicitly removes it or requests another trace. In addition, at the bottom of the geographic view the number of transformers and customers passed by the trace are shown.

- (a) Feeder tracing - This feature shall aid dispatcher to identify the path from a source to all connected components by same colour.
- (b) Circuit tracing- This feature shall enable operator to select any device and identify the source and path by which it is connected through the same colour.
- (c) Between Tracing : This feature shall enable the operator to select any two components of the network and shall able to trace all components connected in between them.
- (d) Downstream Trace – from a selected circuit element the trace identifies all devices that are downstream of the selected element. In the case where a downstream trace is performed on a de-energized section of the network, the trace highlights all devices electrically connected to the element.

### **2.3.2 Temporary Modifications:**

The NCA will allow temporary modifications at any point in the distribution network to change the network configuration, to isolate faults, restore services or perform maintenance. A Summary shall list the jumpers, cuts and grounds that are currently applied. The function is performed by the NCA and is implemented locally within the client software and has no effect on the operations model or other clients viewing the network.

#### **2.3.2.1 Cuts:**

Cuts facilitated in any line segment in the network. The cut may be applied to one or more available phases of the conductor. The cut could also be applied as a temporary switch inserted in the line.

- The cut must be given a name or id number for identification, which is displayed as a label on the geographic network view.
- It should be possible to select the position of the label relative to the cut symbol.
- The position can be altered after the cut has been placed.

Once placed the cut symbol can be selected and switched on and off by the operator in the same way as a standard disconnect switch. Cuts can also be tagged.

### **2.3.2.2 Jumpers**

Jumpers are a means of providing a temporary, switchable connection between two points on the network. The operator should be able to select two points and place the jumper with relevant details. The initial state of the jumper may be set to open or closed. The jumper popup automatically defaults to show the phases available for connection between the two points but other partial or cross-phase connections may be made if required. The popup shall warn the operator about abnormal connections such as not all phases being connected or the nominal voltage being different at the two connection points. Once the jumper has been placed the switch symbol in the center can be selected and switched open or closed. The topology of the network model is updated accordingly. There is no restriction on the placement of jumpers between lines connected to different feeders or different substations.

Temporary connections between phases on the same line segment, known as a phase jumper shall be supported. This can be used in conditions where one phase is deenergized and it is desired to restore customers by energizing the dead conductor from one of the live phases.

### **2.3.2.3 Temporary Grounds**

Temporary grounds should only be placed, for obvious reasons, on de-energized sections of a line. These grounds represent the mechanical grounding of lines for safety purposes during maintenance or construction.

A temporary ground may be placed on one or more of the available phases. It must be given a name and additional information can be included in the description field.. If a line segment is re-energized while a temporary ground is still applied, the ground will be automatically removed.

### **2.3.3 Reports and Displays**

The reports and displays shall be generated indicating the followings as a

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minimum:

- (a) Abnormal switches in tabular display
- (b) De-energized components of network in tabular display
- (c) Presence of loops & parallels on network displays
- (d) Un-served/ disconnected loads (loads affected due to tripping of CBs) in tabular displays
- (e) List of temporary jumpers/cuts /grounds

## 2.4 State Estimation

The primary function is to determine network state where SCADA system monitoring is directly envisaged. The State Estimation (SE) shall be used for assessing (estimating) the distribution network state. It shall assess loads of all network nodes, and, consequently, assessment of all other state variables (voltage and current phasors of all buses, sections and transformers, active and reactive power losses in all sections and transformers, etc.).

Firstly, the symmetrical (per phase) and asymmetrical (three-phase) load of all nodes in the radial or weakly meshed MV network, which are not remotely monitored, that is not directly covered by the SCADA System shall be using evaluated Load Calibration. **SE** represents the basic DMS function, because practically all other DMS Analytical Functions are based on its results.

This is the unique function dealing with the unobservable load of the actual network, which is not directly covered by the SCADA System. Function is used for balanced and unbalanced networks.

The function is based on an algorithm specially oriented towards distribution networks, with low redundancy of real time, remotely monitored data, The deficiency of real time data has to be compensated with historical data.

Beside the parameters of network elements, the real time data consists of:

- Actual topology, transformers tap changer position, etc.
- Voltage magnitudes of supply point and other nodes in the network.
- Current magnitudes (active and reactive power) at feeder heads.
- Current magnitudes (active and reactive power) from the depth of the network.

The historical data of the network consists of:

- Daily load profiles – current magnitudes and power factors, or active and reactive powers for all load classes (types, for example: industrial, commercial, residential), for all seasons (for example: winter, spring, summer, autumn), for e.g. four types of days (for example: weekday, Saturday, Sunday and holiday).
- Peak-loads for all distribution transformers and/or consumers (peak-currents and/or peak powers) and/or monthly electric energy transfers across all distribution transformers (consumers).

**SE** function shall run in all cases from the range of networks where all historical data

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are known, but also in networks with no historical data available (based on parameters of the network elements).

Also according to users setting, the **SE** function shall be able to run:

- With or without verification of telemetered measurements.
- With manual or automatically processing unobservable parts of network.
- With or without fixed measurements.

This shall have real time & Simulation mode both . In the first one, the function shall be used for estimation of the current state. In the Simulation mode, the function is used for estimation of the desired state (e.g. any state selected from the saved cases).

The **SE** algorithm shall consider into account the non availability of real time data and compensates them with historical data, pseudo and virtual measurements, to achieve the minimal set of input data necessary for running a consistent Load Flow.

The **SE** algorithm shall consist of the next important steps:

- Pre-estimation – It shall be based on the historical data of the network: daily load profiles, peak-loads for all distribution transformers and/or consumers, etc. This step shall give pre-estimated states of considered MV networks.
- Verification of measurements– It shall be obtained from artificially redundancy of measurements (too small number of measurements and notable main number of pseudo measurements obtained from first approximation). This step shall consider two sub-steps: (a) in sighting evidence bad measurements, (b) verification and/or correction all permanent measurements. In this step, incorrect measurements shall be corrected or discarded.
- Load calibration – The function shall distribute the load to the busbars of the MV network on the basis of the set of verified measurements and historical data. Also, Load calibration shall deal with consumers specified directly through their current/time diagrams i.e. load curves as well as with consumers with constant consumption. The function shall run even any of these data are not available. It shall be designed in such a way that the quality of results of the function running increases directly with the amount of given data.
- Load Flow calculation – This shall be the next function in the specification based on the loads assigned in the previous step.

#### 2.4.1 Input/Output

Beside the network element parameters, main inputs for the functions consist of above noted real time and historical data. In the case of the function running in the Simulation mode, the real time data must be replaced with the corresponding data from the saved cases or forecasted ones.

Main outputs of the function are estimation of:

- Voltage magnitudes in the entire network.
- Current magnitudes and power factors for all network elements.

- Loads of all MV and LV consumption buses.
- Losses of active and reactive powers in the entire network, by each supply transformer or feeder.

Beside those results, output of **SE** function is tabular report, also. In this report measurement verification results are presented those results are:

- Pre-estimated and estimated values of measurements.
- Minimal and maximal expected values of measurement.
- Quality of each measurement.
- Deviation measured values from estimated and pre-estimated values.

## 2.5 Load Flow Application (LFA)

The LFA shall utilize information including real-time measurements, manually entered data, estimated data together with the network model supplied by the topology function, in order to determine the best estimate of the current network state.

The Load Flow Application (LFA) shall determine the operating status of the distribution system including buses and nodes

The LFA shall take the following into consideration:

- a. Real time data
- b. Manual entered data
- c. Estimated data
- d. Power source injections
- e. Loops and parallels
- f. Unbalanced & balanced loads
- g. Manually replaced values
- h. Temporary jumpers/ cut/ grounds
- i. Electrical connectivity information from the real-time distribution network model
- j. Transformer tap settings
- k. Generator voltages, real and reactive generations
- l. Capacitor/reactor bank ON/OFF status value.
- m. Save case data

System shall include real-time power flow analysis as part of predictive simulation. Real-Time Load Flow software shall perform power flow analysis and voltage drop calculations and include built in features such as automatic equipment evaluation, alerts and warnings summary, load flow result analyzer and customizable result annotations.

- a) Power flow simulation shall accommodate multiple loading & generation conditions
- b) Power flow simulation should automatically adjust transformer tap & LTC / voltage regulator settings
- c) User-controlled load flow calculation convergence parameters
- d) Compare & analyze multiple reports using load flow result analyzer
- e) Include effect of phase-shifting transformers
- f) View power flow results graphically
- g) Evaluate critical & marginal limit violations
- h) Simultaneously solve three-phase & single-phase system load flow
- i) Solve parallel power operation as well as looped system with unlimited elements

#### **2.5.1 General Characteristics of LF application:**

The following general characteristics/ capabilities shall be provided as



minimum:

- The LF model shall support the different kind of lines such as cable feeders, overhead lines and different kind of transformers having various vector groups & winding configurations.
- Unbalanced & balanced three phase loads connected in radial and non-radial modes.
- Compute voltages and currents and power factor for each phase for every node, feeder and network devices.
- Compute each phase active and reactive loads and technical losses for the distribution system as a whole, for individual substations and feeder wise with in telemetered zone.
- Use previous save-case to make new save case or use new snapshots to set the base case for LF.
- The results of the LF application shall reasonably match with the operating condition in which the distribution system is stable.
- The LFA function shall be executed in real time & study mode.
- It shall be possible to model load either as a percentage of system load or profile base load modelling
- It shall be possible to model individual component of load i.e. Active and Reactive parts

### **2.5.2 Real Time Load Flow Execution:**

The Real-Time LF function shall be executed:

- on event trigger
- on periodic basis
- on demand basis
- on initiation by other DMS Applications functions
- On placement of Temporary Jumper, Cuts and Ground

The Event Triggered LF execution shall always have the highest priority. The study mode LF function shall be executed on a snapshot or save case with user defined changes made to these cases. The study mode execution of LF Function shall not affect the Real-time mode execution of LF function.

#### **(a) Event Triggered Real Time LF Execution:**

The LF function shall be executed by pre-defined events that affect the distribution system. Some of the events the dispatcher may choose for triggers shall include:

- Power system Topology Change i.e. Alteration in distribution system configuration.

- Transformer Tap Position Change / Capacitive/reactor MVAR Change
- Feeder Over loadings
- Sudden change in feeder load beyond a set deadband

**(b) Periodic Real Time LF Execution:**

The real-time distribution system load flow application shall be executed periodically as configured by the dispatcher. The function shall be executed periodically even if there are no significant changes in the operating conditions, as some of the power flow outputs shall be required to provide aggregate summaries (losses, etc.)

**(c) On Demand Real Time LF Execution:**

Dispatchers may initiate the real-time LF function at any time through dispatcher command.

**(d) Real Time LF Execution initiated by other DMS Applications:**

Other DMS functions may initiate the real-time LF function at any time as desired for the execution of the respective functions.

**2.5.3 Study Mode Load Flow Execution:**

It shall provide dispatchers with estimates of kW, kVar, kV, Amps, power losses and the other information on the distribution system, but not necessarily reflecting its real-time state. In study mode the application should use the same data model and have direct access of the real time data as necessary. Study mode load flow shall be used to study contingency cases.

It shall be possible to prepare and store at least fifty cases along with the input parameters, network configuration and output results.

The dispatcher shall be able to select the saved Case to be used as a Base case for LF execution and modify the base case . Possible changes, which the dispatcher shall be permitted to make, shall include:

- (a) States of individual power system elements
- (b) Values of specific parameters including nodal loads, bus voltages, connected kVA, power factor etc.

The Study Mode shall calculate various values for each feeder and prepare summaries as LF output.

The Load Flow function shall provide real/active and reactive losses on:

- Station power transformers
- Feeders

- sections
- Distribution circuits including feeder regulators and distribution transformers, as well as the total circuit loss

#### **2.5.4 Load Flow Output:**

The following output capability shall be provided:

- (a) Phase voltage magnitudes and angles at each node.
- (b) Phase and neutral currents for each feeder , transformers, section
- (c) Total three phases and per phase KW and KVAR losses in each feeder, section , transformer ,DT substation & for project area
- (d) Active & reactive power flows in all sections, transformers List of overloaded feeder, lines, busbars, transformers loads etc including the actual current magnitudes, the overload limits and the feeder name, substation name
- (e) List of limit violations of voltage magnitudes, overloading.
- (f) Voltage drops
- (g) Losses as specified above

#### **2.5.5 Display and Reports**

All input and output data shall be viewed through tabular displays and overlay on the one line network diagram. Tabular displays shall consist of voltages, currents (including phase angles), real and reactive powers, real and reactive losses as well as accumulated total and per phase losses for each substation, feeder and project area . All the overloaded lines ,busbars, transformers, loads and line shall start flashing or highlighted

The LF outputs shall be available in the form of reports. The report formats along with its contents shall be decided during detailed engineering.

#### **2.5.6 Alarms**

The LFA shall warn the Despatcher when the current operating limits are exceeded for any element or when lines are de-energized. It shall also warn the Despatcher when any abnormal operating condition exists.

Alarms generated during Study Mode shall not be treated as real-time alarms but shall be displayed only at Workstation at which the LF application is running in study mode.

### **2.6 Volt –VAR control (VVC)**

The high-quality coordination of voltages and reactive power flows control requires coordination of VOLT and the VAR function. This function shall

provide high-quality voltage profiles, minimal losses, controlling reactive power flows, minimal reactive power demands from the supply network.

The following resources will be taken into account for voltage and reactive power flow control:

- TAP Changer for voltage control
- VAR control devices: switchable and fixed type capacitor banks.

The function shall propose the operator solution up on change in the topology of the network switching. The function shall consider the planned & unplanned outages, equipment operating limits, tags placed in the SCADA system while recommending the switching operations. The functions shall be based on user configurable objectives i.e. minimal loss , optimal reactive flow , voltage limits, load balancing . These objectives shall be selectable on the basis of feeder , substation & group of substations or entire network. The despatcher shall have the option to simulate switching operations and visualise the effect on the distribution network by comparisons based on line loadings, voltage profiles, load restored, system losses, number of affected customers. The solution shall identify /sort the different type of switches that are required for operation i.e. remote /manual etc.

### **2.6.1 Modes of operation**

The VVC function shall have following modes of reconfiguration process:

- (a) Auto mode
- (b) Manual mode

The despatcher shall be able to select one of the above modes. These modes are described below:

#### **2.6.1.1 Auto mode**

In auto mode, the function shall determine switching plans automatically and perform switching operations upon despatcher validation automatically.

#### **2.6.1.2 Manual mode**

In manual mode, the function shall determine switching plans automatically and perform switching operations in step-by-step manner.

A filter for remote operable & manual switches shall be provided with switching plan ,

### **2.6.2 Reports**

Detailed reports of complete switching sequence for VVC operation , including voltage / VAR levels before switching & after switching shall be presented.

### 2.6.3 Displays

The User interface for VVC function shall have following summary displays as minimum:

- (a) Network & tabular display to VVC switching
- (b) Tabular display giving chronological sequence for VVC operation

## 2.7 Load Shed Application (LSA)

The load-shed application shall automate and optimize the process of selecting the best combination of switches to be opened and controlling in order to shed the desired amount of load. Given a total amount of load to be shed, the load shed application shall recommend different possible combinations of switches to be opened, in order to meet the requirement. The Control Centre Engineer is presented with various combinations of switching operations, which shall result in a total amount of load shed, which closely resembles the specified total. The Control Centre Engineer can then choose any of the recommended actions and execute them. The recommendation is based on Basic rules for load shedding & restoration.

In case of failure of supervisory control for few breakers, the total desired load shed/restore will not be met. Under such conditions, the application shall inform the Control Centre Engineer the balance amount of load to be shed /restore. The load-shed application shall run again to complete the desired load shed/restore process. The result of any Load Shed operation shall be archived in Information storage and retrieval (IS&R) system.

SCADA,DMS bidder should provide intelligent & User-Defined Knowledge Base (UDKB) load shedding system. UDKB will be created for each individual Substation based on goals and priorities provided by utility. The intelligence built in the UDKB tables will be based on 70% transient stability analysis and 30% load flow and optimum power flow studies. Hence the SCADA,DMS vendor to conduct the transient Stability & Load Flow analysis to create the load shedding priorities. utility required not only frequency or voltage based load shedding but also the above defined load shedding system.

SCADA,DMS bidder should provide intelligent & User-Defined Knowledge Base (UDKB) load shedding system. UDKB will be created for each individual Substation based on goals and priorities provided by utility. The intelligence built in the UDKB tables will be based on 70% transient stability analysis and 30% load flow and optimum power flow studies. Hence the SCADA,DMS vendor to conduct the transient Stability & Load Flow analysis to create the load shedding priorities. utility required not only frequency or voltage based load shedding but also the above defined load shedding system.

The real-time (operating values) generation, loading, and configuration of the system Load Priority Table – user- definable from the study case Controllers will be programmed to initiate the load shedding process immediately after receiving trigger signals from the system. Possible system contingencies

The system will be capable of fast load shedding that can dynamically manage the stability of the system. It shall calculate the minimum required MW to be shed for the entire electrical network and per each islanded subsystem according to the

type and location of the disturbance, loading, configuration, load distribution, and process and operator priority.

The intelligent load shedding shall be capable of selecting the best combination of loads (CBs) that will satisfy this requirement. System response to a disturbance shall be no more than 100 milliseconds unless configured by the system engineer due to process constraints. Steady-state conditions such as overloads shall be handled after user-defined time delays as configured.

The intelligent load shedding will continuously predict system response if they were to happen at that particular instant of time. Its predictions will be monitored continuously from any of the SCADA/DMS consoles. Data will be displayed through the load shedding HMI as well as through the one-line diagram.

The intelligent load shedding shall be capable of providing the operator the capability to change the load shedding priority, logic, and schedules directly from the DMS Consoles with user-friendly interfaces when having the correct access rights. For these changes, it will not be required to update the Load Shedding Controller/RTU programs.

In a case of a communication failure between the load shedding Server and the controllers, the controllers will activate intelligent load shedding logic and tables that will take over the load shedding system until the load shedding Server is activated

**Load Shedding Validation Application:** The intelligent load shedding should be capable of providing the operator a method to Verify and Validate (V&V) the Intelligent Load Shedding logic and operation before uploading a new schedule to the Master controller, at any time during normal operation, and/or after a load shedding event has occurred.

The intelligent load shedding should be capable of providing:

- Reliable load preservation
- Fast response to disturbances
- Operator alerts for marginal operating conditions
- Display required minimum MW & selected loads
- Trigger & time dependent load shedding
- User-definable control logics & macros
- User-definable system triggers
- Operator-friendly interface
- Display operating & recommended spin reserve
- Display monitored data on the one-line diagram
- Predict system response after load shed
- Log & view load shedding actions & recommendations
- User-defined load priority & groups
- Option to simulate & test Load Shedding recommendations

### **2.7.1 Basic rules for load shedding & restoration**

The load shall be shed or restored on the basis of following basic rules:

**(a) By load priority**

The LSA shall have a priority mechanism that shall allow the user to assign higher priorities for VIP or any other important load. The load assigned with the higher priorities shall be advised to be shed later and restore earlier than load with relatively lower priorities. Each load priority shall be user definable over the scale of at least 1-10.

**(b) By 24 Hrs load shed /restore history**

The loads of equal priorities shall be advised for restoration in such a way that loads shed first shall be advised to be restored

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first. The application shall ensure that tripping operations is done in a cyclic manner to avoid the same consumers being affected repeatedly, however, priority loads shall be affected least.

**(c) By number of consumers affected**

The consumer with equal priority and similar past load shed history shall be considered by the application in such a way that minimum number of consumers are affected during the proposed load shed. The data for number of consumers connected to a feeder /device shall be taken from computerised billing system.

**2.7.2 Modes of operation**

The load-shed application shall operate in the following modes:

- (a) Manual load shed
- (b) Manual load restoration
- (c) Auto load shed
- (d) Auto load restoration

Each mode of operation can be enabled or disabled by operator independently. The load can be shed & restore in possible combination i.e. manually shed & auto restore vice versa or both operations in the same modes.

**2.7.2.1 Manual Load Shed**

In this mode operator specifies a load to be shed in a project area. The software shall determine & propose all the possible combinations of switches to be operated for the requested load shed considering the basic rules for load shed & restoration.

In case more than one options are possible, then the application shall identify all such options with the priority of consumers along with the number of consumers are likely to be affected for the particular load shed option. The despatcher shall select & execute one of these options for affecting the load shed.

**2.7.2.2 Manual Load Restoration**

In this mode operator specifies the desired load to be restored. The software shall determine the switches to be operated for the requested load restore considering the basic rules for load shed & restoration.

In case more than one options are possible, then the application shall identify all such options with the priority of consumers along with the number of



consumers are likely to be restored for the particular load restore option if chosen by despatcher. The despatcher shall select & execute one of these options for effecting the load restoration.

The Load shed Application shall maintain a load restore timer, which shall automatically start after tripping of CB due to manual load shedding. An alarm shall be generated to remind the operator to restore the loads when this timer expires. For manual mode of operation the dispatcher shall enter the value of load restore timer.

#### **2.7.2.3 Auto Load Shed**

This shall have two modes namely frequency based load shed & time of day based load shed as described below.

##### **(a) Frequency based Load Shed**

The function shall execute the tripping of breakers based on the system frequency automatically considering the basic rules for load shed & restoration.

The software shall automatically execute the switching operations as soon as system frequency reaches at load shed start (LSS\_str) frequency threshold and it shall continue to do so unless system frequency crosses the load shed stop (LSS\_stp) frequency limit. The frequency limits shall be despatcher assignable up to single decimal points. Once frequency crosses below LSS\_stp limit, then load shed can only be started again when frequency attains LSS\_str. Limit LSS\_str shall be lower than LSS\_stp & suitable protection to ensure that shall be provided in user interface such as discard, forbidden etc if user accidentally enters LSS\_str higher or equal to LSS\_stp or LSS are entered higher than LSR.

##### **(b) Time of day based Load Shed**

The function shall operate to shed load at the predefined time of the day & load to be shed. The software shall automatically execute the switching operations considering the basic rules for load shed & restoration.

#### **2.7.2.4 Auto Load Restoration**

This shall have two modes namely frequency based load restoration & time of day based load restoration as described below:

##### **(a) Frequency based restoration**

The function shall execute the closing of breakers based on the system frequency automatically considering the basic rules for load shed &

restoration.

The software shall automatically execute the switching operations as soon as system frequency attains load restore start frequency limit (LSR\_str) and it shall continue to do so as long as system frequency is crosses below the mark load shed restore stop frequency limit (LSR\_stp). The frequency limits shall be despatcher assignable up to single decimal points. Once frequency crosses below LSR\_stp limit, then load shed can only be started again when frequency attains LSR\_str. Limit LSR\_str shall be higher than LSR\_stp & suitable protection to ensure that shall be provided in user interface such as discard, forbidden etc if user accidentally enters LSR\_stp higher or equal to LSR\_str or LSR limits or LSS\_str higher or equal to LSS\_stp or LSR limits, lower than LSS. The sequence of frequency limits shall be permitted as LSR\_str > LSR\_stp > LSS\_stp > LSS\_str. Adequate protection as mentioned above shall be given if user tries to violate the same.

#### **(b) Time of day based restoration**

The function shall operate to restore load at the predefined time of the day & load to be restored. The software shall automatically execute the switching operations considering the basic rules for load shed & restoration.

### **2.7.3 Alarms/Events**

All Load shed & restore operations executed shall be logged in the system as events. In case the supervisory control fails during the operation in predefined time, an alarm shall be generated with the possible reason for the failure.

### **2.7.4 Summary Report**

Load shed application shall generate Summary Reports for project area on daily basis. These reports shall be available online for minimum period of two days. The following reports shall be made.

- (a) Daily Load shed report indicating, substation name, feeder/device name, date/time, duration of load shed and amount of load shed, Number of consumers affected based on consumer indexing information, mode of load shed including planned outages of feeders/network equipments.
- (b) Daily Alarm summary pertaining to LSA, substation wise.
- (c) Substation wise daily Served, un-served power & energy for every 5 minute time block
- (d) Served & un-served power for last seven days for every 5-minute time block to calculate Load forecast for the next day. The report shall contain a column to define weightage factor (multiplier) by despatcher to calculate Load forecast for the next day. The weightage factor is

required to consider the type of the day such as holiday, festivals, rainy day, etc. Separate report for total load forecast of complete project area shall also be generated from above two reports.

## **2.8 Fault Management & System Restoration (FMSR) Application**

The Fault Management & System Restoration application software shall provide assistance to the despatcher for detection, localisation, isolation and restoration of distribution system after a fault in the system. The FMSR function shall be initiated by any change in the network connectivity due to any fault. It shall generate automatic report on switching sequence depicting analysis of fault, location of fault & recommendations for isolation of faulty sections & restoration of supply.

### **2.8.1 Functional Requirement**

The FMSR function shall include the following characteristics:

- 1) FMSR shall be capable of handling phase-to-ground and phase-to-phase faults and shall not be restricted by their time of occurrence on one or more feeders. Thus, the ability to handle multiple faults of different types, on multiple feeders, shall be provided. It shall be capable to carry out restoration of large area after a occurrence wide spread faults amounting to substantial outages in the town.
- 2) FMSR shall be capable of allowing the substitution of an auxiliary circuit breaker or line recloser that may temporarily function in place of a circuit breaker or line recloser that is undergoing maintenance.
- 3) The Operator shall be able to suspend FMSR restoration capabilities by activating a single control point. Otherwise, FMSR shall continue to operate for fault detection and isolation purposes. The Operator shall be able to resume FMSR's normal operation by deactivating the same point.
- 4) FMSR shall be capable of isolating faulty sections of network by opening any available line Circuit Breaker that may be necessary, however operating limitations on device such as control inhibit flag shall be respected.
- 5) FMSR application shall utilize the results of LF for recommendations of switching steps for restoration where in it should guide the operator for amount of overloading in lines ,bus voltage violations and amount of load that can be restored for various options of restorations ,the operator shall have the privilege of selecting the best restoration option suggested by FMSR before it starts restoration .The operator shall also be to simulate the LF for the recommended switching actions ,so that the necessary violations can be displayed on graphical display also.  
If an overload condition is expected as a result of the proposed

switching, it shall be displayed to the operator on a graphical display and proposed alternative switching sequence to avoid or minimize the overload.

- 6) FMSR shall be capable of using data derived from substation RTUs/FRTUs /FPIs to recognize faults in substation transformer banks , any fault on the primary side of these banks that cause loss of outgoing feeder voltage and current or any fault occurred on 11KV network.
- 7) FMSR shall be capable to make Restoration plans with identification name and respective merit orders & its execution of Restoration plan using network Display and single line diagram of substation.
- 8) FMSR shall be capable to find delay in the restoration of network beyond specified time (Despatcher configurable) and shall be able to report separately in the form of pending restoration actions.

### **2.8.2 Detection of fault**

FMSR function shall detect the faulty condition of the network causing CB tripping due to protection operation or FPI indication. The Circuit breakers having auto-reclose feature, the FMSR application shall wait for programmer specified(setteable for individual feeders) duration before declaring the network as faulty. On detection of fault in the network, an alarm shall be generated to draw attention of the dispatcher.

Switching device tripping caused by SCADA/DMS applications shall not be considered as a faulty condition. FMSR application shall also not be initiated if the quality flags such as, manually replaced value, Out of scan are set for a switching device.

To avoid potential difficulties during severe storm conditions, the Operator shall be able to suspend FMSR switching sequence of restoration capabilities by activating a single control point. Otherwise, FMSR shall continue to operate for fault detection and isolation purposes. The Operator shall be able to resume FMSR's normal operation by deactivating the storm-mode control point. When this occurs, FMSR shall be ready to restore power as well as detect and isolate faults following the next outage event. The same shall be recorded as an event.

### **2.8.3 Localisation of Fault:**

Wherever protection signal or FPI indication is not available , FMSR function shall determine the faulty section by logically analysing the telemetered data (status of CBs, , analog values etc) as acquired through SCADA system. Besides this, for such cases an iterative method for determining fault shall be used e.g. In case of fault, upstream breaker is tripped & long stretch of multiple sections are having no intermediate fault indicators & intermediate switches are not capable to trip on fault upto the closest NO(Normal open)

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point, the dispatcher can open the last switch before NO point & try to close breaker , if trips again fault is on further upstream & the same method is to be repeated else fault is located in the downstream section only. For the sections where protection signal or FPI indication is available , the same shall be derived through these telemeterd signals. Network diagram identifying the faulty sections/components shall be displayed identifying the relevant section. and various configurations of switch type etc) Minimum of following switch types shall be considered by FMSR system:

- 1: Remote controllable circuit breaker with capability to interrupt fault currents
- 2: Non-remote controllable circuit breaker with capability to interrupt fault currents
- 3: Remote controllable circuit breaker with no capability to interrupt fault currents
- 4: Non-remote controllable circuit breaker with no capability to interrupt fault currents.
- 5: Remote controllable disconnecter
- 6: Non remote controllable disconnector .
- 7: Fuse
- 8: Ground/ Earth switch etc

#### **2.8.4 System isolation & restoration**

Once faulty section is identified, the FMSR function shall determine the switching plan to isolate healthy area from unhealthy area . FMSR function shall suggest switching plans for restoration of power to the de-energized healthy sections of the network. It may done be by closing NO switch to allow the power from alternate source. In case more than one feasible switching plans exist, the despatcher shall be guided for most optimum plan based on the merit order ie minimum switching operations, minimum loss path, system operation within the safe limits of various network elements. The despatcher shall have the option to simulate switching operations and visualise the effect on the distribution network by comparisons based on line loadings, voltage profiles, load restored, system losses, number of affected customers. The FMSR function shall have feature to attain the pre-fault configuration on despatcher's request after repair of faulty sections.

The FMSR function shall have following modes of restoration process:

- (a) Auto mode of restoration
- (b) Manual mode of restoration

The despatcher shall be able to select one of the above modes. These modes are described below:

(a) Auto mode of restoration

In auto mode, the FMSR shall determine switching plans automatically upon experiencing fault & proper isolation of unhealthy network from healthy part of the network and perform restoration actions upon despatcher validation automatically.

(b) Manual mode of restoration

In manual mode, the FMSR shall determine switching plans upon experiencing \_faulty state & proper isolation of unhealthy network from healthy part of the network. The switching plans shall be presented to despatcher for step by step restoration. Despatcher shall be allowed to introduce new steps.

A filter for remote operable & manual switches shall be provided with switching plan ,

### **2.8.5 Reports**

Detailed reports of complete switching sequence from outage to restoration, feeder-wise outage duration with Date & Time stamp, quantum of served & un-served load, number of consumers interrupted & restored and network parameters limits violations shall be generated by FMSR application

### **2.8.6 Displays**

The User interface for FMSR function shall have following summary displays as minimum:

- (c) Network & tabular display to identify faulty network
- (d) Network & tabular display to identify remotely controllable devices
- (e) Network Display to show plan for Isolation of faulty sections from the network using single line diagram of substation or network as selected by the despatcher.
- (f) Tabular display for Restoration plans with identification name and respective merit orders & execution of Restoration plan using network Display, and single line diagram of substation
- (g) Delay in the restoration of network beyond specified time (Despatcher configurable) shall be reported separately in the form of pending restoration actions in Tabular display.
- (h) List of sections not restored with the reasons for non-restoration such as overloading and voltage limit violations etc shall be shown in tabular display.

## **2.9 Loss Minimization via Feeder Reconfiguration (LMFR)**

This function shall identify the opportunities to minimize technical losses in the distribution system by reconfiguration of feeders in the network for a given load scenario. The technical losses are the losses created by characteristic of equipments & cable such as efficiency, impedance etc.

The function shall calculate the current losses based on the loading of all elements of the network. The telemetered values, which are not updated due to telemetry failure, shall be considered by LMFR application based on recommendations of LF Application.

Function shall advise the transfer of load to other elements of the network with an aim to minimize the loss. All such advises shall indicate the amount of loss reduction for present load condition. The LMFR application shall consider the planned & unplanned outages, equipment operating limits, tags placed in the SCADA system while recommending the switching operations. The despatcher shall have the option to simulate switching operations and visualise the effect on the distribution network by comparisons based on line loadings, voltage profiles, load restored, system losses, number of affected customers.

LMFR application shall run periodically at every 15 minutes and on demand. Short duration Power Interruption to the consumers during suggested switching operations may be permitted.

### **2.9.1 Modes of operation**

The LMFR function shall have following modes of reconfiguration process:

- (a) Auto mode
- (b) Manual mode

The despatcher shall be able to select one of the above modes. These modes are described below:

#### **2.9.1.1 Auto mode**

In auto mode, the function shall determine switching plans automatically for minimal loss condition in the network and perform switching operations upon despatcher validation automatically.

#### **2.9.1.2 Manual mode**

In manual mode, the function shall determine switching plans automatically for minimal loss condition in the network based on which despatcher can perform switching operations in step-by-step manner.

A filter for remote operable & manual switches shall be provided with switching plan ,

### **2.9.2 Displays & Reports**

At the defined periodicity or on demand, the despatcher shall be presented with the tabular & graphical displays indicating feeder-wise, substation-wise, project area wide technical losses in % before & after the feeder reconfiguration.

The summary report shall also be generated periodically to display technical losses and possible reduction in losses if despatcher follows the LMFR recommended switching operations. The report shall also highlight violations that are occurring in the network with display layers before and after reconfiguration."

### **2.10 Load Balancing via Feeder Reconfiguration (LBFR)**

The load-shed application shall automate and optimize the process of selecting the best combination of switches to be opened and controlling in order to shed the desired amount of load. Given a total amount of load to be shed, the load shed application shall recommend different possible combinations of switches to be opened, in order to meet the requirement. The Control Centre Engineer is presented with various combinations of switching operations, which shall result in a total amount of load shed, which closely resembles the specified total. The Control Centre Engineer can then choose any of the recommended actions and execute them. The recommendation is based on Basic rules for load shedding & restoration.

In case of failure of supervisory control for few breakers, the total desired load shed/restore will not be met. Under such conditions, the application shall inform the Control Centre Engineer the balance amount of load to be shed /restore. The load-shed application shall run again to complete the desired load shed/restore process. The result of any Load Shed operation shall be archived in Information storage and retrieval (IS&R) system.

SCADA,DMS bidder should provide intelligent & User-Defined Knowledge Base (UDKB) load shedding system. UDKB will be created for each individual Substation based on goals and priorities provided by utility. The intelligence built in the UDKB tables will be based on 70% transient stability analysis and 30% load flow and optimum power flow studies. Hence the SCADA,DMS vendor to conduct the transient Stability & Load Flow analysis to create the load shedding priorities. utility required not only frequency or voltage based load shedding but also the above defined load shedding system.

SCADA,DMS bidder should provide intelligent & User-Defined Knowledge Base (UDKB) load shedding system. UDKB will be created for each



individual Substation based on goals and priorities provided by utility. The intelligence built in the UDKB tables will be based on 70% transient stability analysis and 30% load flow and optimum power flow studies. Hence the SCADA,DMS vendor to conduct the transient Stability & Load Flow analysis to create the load shedding priorities. utility required not only frequency or voltage based load shedding but also the above defined load shedding system.

The real-time (operating values) generation, loading, and configuration of the system Load Priority Table – user- definable from the study case Controllers will be programmed to initiate the load shedding process immediately after receiving trigger signals from the system. Possible system contingencies

The system will be capable of fast load shedding that can dynamically manage the stability of the system. It shall calculate the minimum required MW to be shed for the entire electrical network and per each islanded subsystem according to the type and location of the disturbance, loading, configuration, load distribution, and process and operator priority.

The intelligent load shedding shall be capable of selecting the best combination of loads (CBs) that will satisfy this requirement. System response to a disturbance shall be no more than 100 milliseconds unless configured by the system engineer due to process constraints. Steady-state conditions such as overloads shall be handles after user-defined time delays as configured.

The intelligent load shedding will continuously predict system response if they were to happen at that particular instant of time. Its predictions will be monitored continuously from any of the SCADA/DMS consoles. Data will be displayed through the load shedding HMI as well as through the one-line diagram.

The intelligent load shedding shall be capable of providing the operator the capability to change the load shedding priority, logic, and schedules directly from the DMS Consoles with user-friendly interfaces when having the correct access rights. For these changes, it will not be required to update the Load Shedding Controller/RTU programs.

In a case of a communication failure between the load shedding Server and the controllers, the controllers will activate intelligent load shedding logic and tables that will take over the load shedding system until the load shedding Server is activated

Load Shedding Validation Application: The intelligent load shedding should capable of providing the operator a method to Verify and Validate (V&V) the Intelligent Load Shedding logic and operation before uploading a new schedule to the Master controller, at any time during normal operation, and/or after a load shedding event has occurred.

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The intelligent load shedding should be capable of providing:

- Reliable load preservation
- Fast response to disturbances
- Operator alerts for marginal operating conditions
- Display required minimum MW & selected loads
- Trigger & time dependent load shedding
- User-definable control logics & macros
- User-definable system triggers
- Operator-friendly interface
- Display operating & recommended spin reserve
- Display monitored data on the one-line diagram
- Predict system response after load shed
- Log & view load shedding actions & recommendations
- User-defined load priority & groups
- Option to simulate & test Load Shedding recommendations

#### **2.10.1 Modes of operation**

The function shall have following modes of reconfiguration process:

- (a) Auto mode
- (b) Manual mode

The despatcher shall be able to select one of the above modes. These modes are described below:

#### **2.10.1.1 Auto mode**

In auto mode, the function shall determine switching plans automatically for load balancing in the network and perform switching operations upon despatcher validation automatically.

#### **2.10.1.2 Manual mode**

In manual mode, the function shall determine switching plans automatically for load balancing in the network based on which despatcher can perform switching operations in step-by-step manner.

A filter for remote operable & manual switches shall be provided with switching plan ,

#### **2.10.2 Displays & Reports**

The summary report shall cover the followings:

- (a) Loadings of feeders and transformers before and after reconfiguration.
- (b) Voltage profile of the feeders before and after reconfiguration.

The report shall also highlight violations that are occurring in the network with display layers before and after reconfiguration."

### **2.11 Load Forecast –**

#### **2.11.1 Short-Term Load Forecasting (STLF)**

Short-Term Load Forecasting (STLF) analytical function will be used for assessment of the sequence of average electrical loads in equal time intervals, from 1 to 7 days ahead.

As noted above, the STLF function shall be based on different forecasting methods such as:

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- Autoregressive.
- Least Squares Method
- Time Series Method.
- Neural Networks.
- Kalman filter
- Weighted Combination of these method

In the first step, training module is executed using load data series from the historical database and weather conditions. After appropriate training, Forecast module is executed for up to next 7 days including weather forecast. Results are available in tabular and graphical form. The user shall be able to make adjustments to the active forecast. The adjustments can also be done through weather conditional data parameters i.e. temperature, humidity, precipitation level, wind speed, wind direction acquired through telemetered sensors or manually.

STLF will be used for forecasting of loads for the next short-term period (up to 7 days), to provide planning of the (optimal) network operation at the daily level. in periodic time (15 min to 1hr) The user shall be able to save forecasts in save cases, one of which shall contain the active forecast that shall be available for study functions.

### **2.11.2 Similar day forecasting**

A similar day forecast shall be used that is based on the normalized half-hourly load values stored for each of seven-day types. Provision shall be made for storing day types for the last 24 months. The storage shall be updated each day by replacing the oldest of the same day type with the most current actual load curve.

The similar day forecast shall search the 24-month file for the same day type whose weather conditions best match. It shall then present the user-entered and best-matched conditions, for user comparison, together with the chosen day's loads as the suggested forecast. The user shall be able to modify any of the forecast's loads manually. In addition, the user shall be able to scale the entire forecast by simply specifying an appropriate peak load value.

Multi-day forecasts shall be constructed by permitting the user to define the input data for each forecast day.

The results of the previous forecasts will be compared with the actual load realization. The performed differences will be used for updating the forecasting procedure parameters.

### 2.11.3 Long Term forecasting

In addition to the above , Long term load forecasting shall also be available for at least 1 year . The same shall be calculated based on the peak load values or energy consumptions on weekly/monthly basis for atleast two preceding years, Array of forecasted peak loads imported from STLF/ entered manually.

The user shall be able to print and display the forecasts in both tabular and graphical form. This shall include the ability to display the active forecast with the actual loads of current and past days superimposed ,energy consumption/peak load curves in the forecasting period . .

### 2.11.4 Results of Function

A) Main input data for the LF will be:

- Historical Load measurements for specified network points, associated with corresponding weather conditions.
- Daily load curves & energy consumption from the past, for all type of days and seasons.
- Weather prognosis for the forecasting period.

B) Main output data of the STLF will be:

- Forecasted load for the forecasting period

### 2.12 Operation Monitor

The Operations Monitoring function shall track the number of operations made by every breaker, capacitor switch, recloser, OLTC , isolator and load break switch that is monitored by the System. Devices shall be identified by area of responsibility, substation, feeder, and device ID to provide the necessary information for condition-based maintenance of these devices.

Each monitored device shall be associated with a total operations counter. This counter shall be incremented whenever the associated device changes state. When a multiple change (such as a trip-close-trip sequence) is reported by an RTU/FRTU, each transition shall be counted separately. In addition, a fault operations counter is required. This counter shall be incremented only for uncommanded trip operations. The date and time of the last operation shall be saved for each device when one of the counters is incremented.

An Operator with proper authorization shall be able to enter a total operations and fault operations limit for each counter. An alarm shall be generated when a counter exceeds its limits. No additional alarms shall be generated if the counter is incremented again before it is reset. For each counter, the System shall calculate the present number of operations expressed as a percent

(which may exceed 100%) of the corresponding limit.

The ability to reset individual counters shall be provided. In addition, a user shall be able to inhibit operations counting for individual devices. Such devices shall be included in summaries based on areas of responsibility. Resetting and inhibiting counters shall be permitted only for devices that belong to the areas of responsibility and resetting shall require the console to be assigned to an appropriate mode of authority. The user info , date and time , when each counter was last reset shall be saved.

The counters and other related information shall be available for display and inclusion in reports. The user shall be able to view the date and time of a device's last operation together with its accumulated operations data by simply selecting the device on any display where it appear

## 2.2 Real Time Short Circuit

- a) SCADA shall include real-time short circuit analysis as part of predictive simulation. Real-Time Short Circuit software shall analyze the effects of 3-phase, 1-phase, line-to-ground, line-to-line, and line-to-line-to-ground fault currents on electrical power systems.
- b) Fault current short circuit duties should be calculated and compared in compliance with the latest editions of the ANSI/IEEE Standards (C37 series) and IEC Standards (IEC 60909 and others).
- c) Short circuit software shall determine fault currents and automatically compare these values against manufacturer short circuit current ratings. Overstressed device alarms should be automatically displayed on the one-line diagram and included in short circuit study reports.
- d) Automatic 3-phase device evaluation based on total or maximum through fault current
- e) Automatically adjust conductor resistance & length (both lines & cables)
- f) Global or individual device impedance tolerance adjustments for maximum & minimum fault currents
- g) Include / exclude fault impedance modeling for unbalanced faults
- h) Include / exclude shunt admittance for branches & capacitive loads (unbalanced faults)
- i) Graphical or tabular bus fault selections
- j) Automatically determine fault currents at motor terminals without the need to add additional buses
- k) Consider effect of phase-shifting transformers
- l) Grounding models for generators, transformers, motors, & other loads
- m) Motor contribution based on loading category, demand factor, or both
- n) Short Circuit software shall extract manufacturer published data from the libraries for thousands of devices
- o) Short Circuit result analyzer shall compare and automatically determine the worst fault current values and/or violations.

## 2.3 Switching Sequence Management

SCADA software shall be capable of building a complete switching program using a

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graphical user interface and execute the switching plan all in one step. The switching sequence shall contain a list of switching devices and time of execution for circuit breakers, load disconnects, and ground disconnects.

Before any switching sequence is executed, the application verifies whether the sequence is compliant with safety switching procedures and requests confirmation during execution of each step before proceeding to the next step in order to avoid inadvertent switching.

The software shall be capable of configuring switching plans for automatic transfer of bus loads on double-ended bus configurations thus replacing the step-by-step method of switching for double-ended bus configurations that require manual bus load transfer. Switching sequences shall be ranked based on de-energized time, non-delivered energy, and the order of switching allowing easy comparison between different variations of the plan.

The switching management software shall include the following features:

- a) User-friendly switching plan builder
- b) Point & click selection of switching device from the one-line diagrams
- c) Graphical display of selected switching devices
- d) Multi-level switching request approval
- e) Assignment of user-definable & interlock logic per each switching device
- f) Checking of selected switching plans against forbidden or potentially hazardous actions
- g) Unlimited switching plans each with an unlimited number of switching actions
- h) Switching order reports include switching mode, start / stop time, & nature of work
- i) Simulate & evaluate switching plans in all states prior to execution

Offline Simulation Capability in the form of a digital Twin to enable testing and Simulation including the planning, Practice and validation of safe Switching routines

## **2.13 Disptacher Training Simulator (DTS)**

A Dispatcher Training Simulator (DTS) shall be provided for SCADA/DMS system for training of operators/ dispatchers during power system normal, emergency/ disturbance and restoration activities. The DTS shall be installed at the SCADA/DMS control centre where it shall be used to train employer and other utilities dispatchers. The major DTS features shall include:

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- (a) The DTS model shall simulate the distribution power system in a realistic manner, including its response to simulated events, Instructor actions, and Trainee actions. The response shall be identical to the response observed by the dispatcher in the actual computer system environment.
- (b) The consoles shall be assignable as trainee or instructor consoles. The DTS shall support at least one instructor & two trainees
- © Instructor control features shall include the ability to set up, control, participate in, and review the results of a training session.
- (d) Dispatcher control feature shall facilitate dispatchers to train dispatcher to use all SCADA , dispatcher & DMS functions under normal & disturbed conditions.
- (e) An ability to obtain data from the SCADA/DMS systems automatically for DTS initialization. The initialization data shall include save cases, predefined & instructor defined scenarios.
- (f) It shall prevent actions & keep insulated the actions performed by the Instructor and Trainee using the DTS from affecting the real-time system database or the actual power system.



- (g) An ability to simulate actual system disturbances from historical data "snapshots" stored by the real-Time database Snapshots .
- (h) DTS function shall have ability to establish the following training conditions as a minimum:
  - (1) Normal steady state
  - (2) Disturbed network conditions for distribution network
  - (3) High & Poor Voltage conditions
  - (4) Poor VAR conditions
  - (5) Indiscriminate tripping
  - (6) islanding
  - (7) System blackout
  - (8) System restoration
  - (9) Conditions/functions included for SCADA/DMS real time system
- (i) Following features as minimum:
  - (a) All SCADA/DMS functions as envisaged in the specification
  - (b) Cry wolf alarms
  - (c) Record/ Playback /slow/realtime/fast forward
  - (d) Record trainee actions

DTS Model features , functions & user interface shall be true replica of SCADA/DMS system model for that project area. The DTS can be used in the following modes as minimum :

1. Instructor Control
2. Trainee Control

### **2.13.1Instructor Control:**

The Instructor shall be able to perform pre-session, session, and post-session activities. Each training session shall consist of executing a scenario (tailored to the simulated SCADA/DMS system) starting from a base case. The base case shall consist of a solved network output case from the NCA or load/power flow and one or more load curves..

Pre-session activities consist of scenario building and development of events that occur during the training scenario. A load/power flow function shall be provided in the DTS to support this feature.

Session activities performed by the Instructor include initiation, control, and participation in the training session.

Post-session activities shall consist of session review and evaluation of Trainee performance. The DTS shall maintain records of the training session so that the base case, scenario, Trainee actions, and other session activities may be

reviewed. Instructor shall have all rights of trainee mode also as mentioned below:

### **2.13.2 Trainee control :**

All activities ,features, functions, user interfaces, which dispatcher can perform or use in real time shall be available to trainee in trainee control mode.

### **2.13.3Pre-Session Activities**

The Instructor shall be able to create a base case and to execute a power flow if desired to initialize the base case. The Instructor shall be able to build groups of events scheduled to occur during the training session. A training session shall be built by combining one or more event groups with a base case.

### **2.13.4 Scenario Construction**

The following features shall be provided for building a training session:

- (a) Base Case Construction: shall allow Instructor to set conditions, parameters, and limitation for equipment in the network database. It shall be possible to initialize a base case from the following sources:
  - (1) A stored base case created in the DTS
  - (2) A power flow solution obtained in the DTS
  - (3) A power flow or NCA /SE solution obtained from real-time system.
  - (4) Output of real time DMS executed functions
- (b) Base Case Store: shall allow instructor to save a base case for future use. It shall be possible to transfer saved base cases to auxiliary memory (e.g., magnetic tape) and to reload saved base cases from auxiliary memory.
- (c) Base Case Select: shall allow instructor to select a specific base case for modification or further processing. Base case selection may be indexed by title or subject.
- (d) Base Case Review: shall allow instructor to display the contents of the base case.
- (e) Base Case Editing: shall allow instructor to modify a base case and to store the updated version.
- (f) Event Group Construction: shall allow instructor to construct event groups containing one or multiple events. The Instructor shall be able to define the events within the event group to occur simultaneously or

according to other parameters of time or system conditions. Checks shall be performed to assure that each event entered is one of the predefined set of events and that the equipment and parameters associated with the event are valid for the event specified.

The system shall provide an interactive means for specifying the device or point associated with each event.

- (g) Event Group Store: shall allow the Instructor to save the event group constructed for future use.
- (h) Event Group Select: shall allow the Instructor to select one or more event groups for incorporation into a training scenario.
- (i) Event Group Review: shall allow the Instructor to display events within an event group.
- (j) Event Group Editing: shall allow the Instructor to modify an existing event group and to store the updated version.

#### **2.13.5 Event Types**

The Instructor shall be provided with a set of permissible event types that can be scheduled as part of a scenario. As a minimum, the following event types shall be included:

- i. Change of bus load
- ii. Change of system load
- iii. Fault application/FPI indication
- iv. Circuit breaker trip/close
- v. Circuit breaker trip with successful reclosure
- vi. Circuit breaker trip with unsuccessful reclosure
- vii. Isolators switchings
- viii. Supervisory control disable/enable for specific device
- ix. Relay status enable/disable
- x. Loss of RTU /FRTU due to telemetry failure for specified period of time
- xi. Loss of single RTU /FRTU point
- xii. Replace value of telemetered point
- xiii. Messages to Instructor
- xiv. Pause simulation
- xv. Demand snapshot.
- xvi. Cry wolf alarms

#### **2.13.6 Event Initiation**

Events shall be executed at an Instructor-specified time, when Instructor-

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specified conditions occur, upon Instructor demand, and when protective relays operate. Event initiation shall include:

- (a) Time Dependent Events: These events shall be scheduled by the Instructor to occur at a specified simulated clock time or at time intervals relative to the start time of the scenario.
- (b) Conditional Events: Conditional events shall be based on simulated power system conditions obtained from DTS model . The Instructor shall be able to specify a conditional event by specifying a permissible events and a boolean equation for the power system condition that will trigger the event. The boolean equation shall allow the following triggers to be incorporated separately or in combination:
  - (1) A status variable equal to a defined state
  - (2) An analog variable above or below a defined threshold
  - (3) Change in analog variable from one DTS cycle to the next by more than a defined amount (positive or negative).
- (c) Demand Events: The Instructor shall be able to demand the immediate execution of an event without having to insert it in the events list.
- (d) Relay Initiated: The operation of a relay shall result in the execution of one or more Instructor-specified events.

#### 2.13.7 Session Activities

The Instructor shall be able to monitor the training scenario and guide it toward a specific objective by inserting new events omitting scheduled events, and performing other actions. The following commands shall be provided to control a Trainee scenario:

- (a) Pause/Resume: Shall allow the Instructor to suspend or resume the training scenario without affecting the scenario. While in the Pause mode, the Trainee and Instructor shall be able to call all displays but perform no other functions. The Resume command shall resume the simulation from the point at which the pause occurred.
- (b) Slow/Fast Forward: shall allow the Instructor to move a training scenario forward at a Instructor-specified speed slower/faster than real-time.
- (c) Event Insertion: shall allow the Instructor to add new events when a training scenario is in progress without the need to interrupt the

training scenario.

- (d) Event Demand: shall allow the Instructor to demand the immediate execution of an event.
- (e) Event Omission: shall allow the Instructor to omit a scheduled event from the training scenario in progress without interrupting the training scenario.
- (f) Periodic Snapshot: shall allow the instructor to create a historical file that is periodically updated with session data necessary to resume simulation as it occurs during the simulation. The DTS shall not pause while the snapshots are being collected and saved. The snapshot save area shall be circular in nature where the oldest snapshot will be overwritten each time a new snapshot is saved when the save area is full.
- (g) Demand Snapshot: shall allow the Instructor to create a historical file, identical to that created by a periodic snapshot, on demand during the simulation. The DTS shall not pause while the snapshots are being collected and saved.

#### 2.13.8 Post-session Activities

The DTS shall provide the following capabilities to assist the Instructor in reviewing a training session with the Trainee:

- (a) Snapshot Review: shall initialize the DTS with a snapshot saved during a training session. After a snapshot has been loaded, the Trainee and Instructor shall be able to call displays to examine any data available during a session.
- (b) Snapshot Resume: shall resume the simulation from a snapshot in the same manner as it would resume from a Pause.
- (c) Evaluation report : Based on the actions performed , timeliness & An evaluation report shall be created to review performance of trainee.

#### 2.13.9 DTS Performance and Sizing

The DTS shall be sized the same in all respects as the SCADA/DMS control system. In addition, the capabilities of the DTS shall include the following items as minimum:

- (a) 20 DTS base cases
- (b) 20 scenarios

- (c) 250 event groups
- (d) 50 events per group
- (e) 50 session snapshots
- (f) 5-minute snapshot periodicity
- (g) 100 conditional events
- (h) 1000 variables in conditional events.
- (i) 2 Trainee (according to no. of DTS consoles) & 1 instructor

#### **2.13.10 DTS Database and Displays**

The DTS SCADA and Network model database must have the same functionality & displays as the real-time system database & displays. It must be possible to initialize the DTS with a copy of the database of real-time system in addition creation of database locally.

## SECTION -2

### User interface Requirements

#### 3.0 General Requirements

This chapter describes the User Interface requirements for the SCADA/DMS system. All SCADA/DMS functions shall have common user interface as user interaction shall be performed from Operator Consoles envisaged in this specification. All user interactions shall be from full graphics display. The sizing requirements are given in **the appendices in section 8**

#### 3.1 System Users

The term "user" is applied to the personnel interacting with the SCADA/DMS system. These users shall be required to login in one or more of following **user modes**, which include:

- (a) Supervisor Personnel responsible for SCADA/DMS system administration and management such as assigning the access area to users, creating users etc.
- (b) Dispatcher Personnel responsible for real-time Power system operations including real-time study.
- (c) Engineer Personnel having access to certain SCADA/DMS system functions and maintenance of database/ displays and responsible for support activities such as post fault analysis , report generation, regular backup of database
- (d) Programmer Personnel responsible for continuing development and maintenance of the SCADA/DMS system functions, databases, displays and report formats. Security system
- (e) Remote VDU user : Personnel having only monitoring access of real-time power system from SCADA/DMS system , reports..
- (f) DTS ( Instructor & Trainee modes): The Consoles dedicated for DTS shall have instructor & trainee modes . The requirements are defined in section 2

The role, accessibility for each mode is defined as above, However, the Utility with login as supervisor shall be able to assign the operation of certain functions, or features of functions, to specific user modes. Utility shall maintain the privileges as specified to each user mode .Each individual user shall be assignable to anyone or more user modes. User access to all SCADA/DMS functions shall follow a consistent set of common user access guidelines. A

mechanism for defining and controlling user access to the SCADA/DMS system shall be provided.

Password security shall be provided for access to the SCADA/DMS system, its operating system, layered products, and other applications. Each password shall be validated against the corresponding user information in the database. Users shall have the ability to change their own passwords.

### **3.2 Function and Data Access Security**

After a user has successfully logged on, access to the SCADA/DMS functions, displays, reports, and databases shall be restricted by pre-assigned operating jurisdictions. These operating area assignments shall be made when the function, display, report, or database element is defined.

The access security function shall compare the user's assigned operating jurisdiction against the operating jurisdictions assigned to the function, display, report, or database element each time a user attempts a console action, such as:

- (a) Calling a display
- (b) Entering or changing display data
- (c) Viewing, editing, or printing a report
- (d) Executing a supervisory control action

There shall be no restrictions on the assignment of multiple jurisdictions to a console & user or the assignment of a jurisdiction to multiple consoles & users. The access security function shall ensure that each jurisdiction is at all times assigned to a least one console. If a console failure or manual reassignment of jurisdiction results in one or more jurisdictions not being assigned to at least one console, the unassigned jurisdictions shall be automatically assigned to a pre-assigned default console and suitable alarms shall be generated.

SCADA/DMS users shall not required additional login (user name and password) to the other facility allowed as per operating jurisdictions such as ISR. "Single Sign-On" (SSO) technology be employed (i.e., a user logs on once to the SCADA/DMS using individually defined user name and password which permits appropriate level of access to all SCADA/DMS facilities, including IS&R. Further, the facility should be compatible with enterprise-wide SSO capabilities.

Each log-on and log-off shall be reported as an event. Unsuccessful attempts to log-on shall also be reported as events.

### **3.3 Windows Environment**

The user interface for SCADA/DMS system shall be web enabled. The SCADA/DMS system displays shall operate within a windows environment and shall conform to the standards contained in the X Consortium's Inter-Client Communications Conventions Manual (ICCCM). The window system shall work with the graphical user interface provided and shall allow windows created on the



workstations to communicate with processors equipped with X Windows-compatible software on their respective local area networks (LANs) and with future remote applications over the wide area network (WAN).

Alternatively, the SCADA/DMS system can have the user Interface based on Microsoft Windows. The functionality in technical specification related to the GUI features of X-windows, shall be met by available features of Microsoft Windows.

It shall be possible to save window configuration in Rooms. Rooms shall allow each user to configure and save a preferred layout, size, and location of windows and displays. The World Display Features shall provide two-dimensional graphic world displays that a user shall be capable of panning, zooming and rubber banding.. The world display features such as Layers, Declutter levels, Overlays shall be supported. Displays & navigation on VPS shall be same as on the operator workstations.

The user interface software shall be based on state-of-the-art web-based technology to present interactive, full-graphics views of system data via LAN, corporate intranet or the internet. The same displays shall be used.

It is essential that the same web-based user interface (same navigator, same tools) be available to the operator either for local use in the dispatching center or remotely.

The web technology shall be natively supported by the DMS product, which means that having the displays shown in the web browser shall not bring additional work to the maintenance engineer at display building time. Nor shall it require additional third-party software products like specific plug-ins.

The web user interface shall support and enforce all security features described in the following sections.

### **3.4 Display interactions**

Rapid, convenient, and reliable display requests shall be provided using the following methods:

#### **3.4.1 Display Requests**

- (a) Selection of a display from a menu display
- (b) Cursor target selection on any menu, graphic, or tabular display
- (c) Selection of an alarm : in this case, it shall call up the one-line display containing the alarm's location,
- (d) Selection of an alarm or event message on a summary display followed by a display request command

- (e) Selection of display by Entering a display name or number
- (f) Forward and reverse paging in a page-based display.
- (g) Selecting a previous display by re-call command.
- (h) Selecting a point of interest from an Overview display for viewing on full screen (such as viewing a SLD of a substation by selecting the Substation node from a Network diagram).
- (i) Selecting function keys or cursor targets dedicated to displays.

### **3.4.2 Display navigation**

Display navigation methods shall provide a consistent approach for moving within a display. The following methods shall be provided:

- (a) Panning with cursor positioning device or scroll bars
- (b) Zooming with cursor positioning device
- (c) Navigation window for rapid movement between portions of a world display
- (d) Rubber-band zooming.
- (e) Tool tip
- (f) Find & locate
- (g) Drag & drop

Zooming shall affect the magnification level of the data displayed. Panning shall move the viewed portion of a world map space. The size of the viewed portion of the map relative to the whole display shall be indicated by the width of the sliders in the scroll bars of the window displaying the sector. When a display is first called up in a window, it shall be automatically scaled as per default zoom level.

Both continuous and discrete panning and zooming control shall be provided. Continuous panning and zooming shall be done in a convenient and intuitive way using the mouse; and the resulting changes in the screen contents shall be “smooth” and instantaneous without any noticeable delay. Discrete panning and zooming in larger steps shall be possible by dragging the mouse, using the keyboard, and clicking on pushbuttons on toolbars.

When only a part of the display is shown in the active window, the user shall be able to request a “navigation” window for orientation. This window shall show a small replica of the complete display, with the displayed sector of the display highlighted. The user shall be able to move the navigation window anywhere on the screen, and shall be able to close it.

A decluttering mechanism that defines the visibility of a graphic construct as a function of its magnification shall be provided. As zooming changes the magnification of data displayed, the declutter mechanism shall cause levels of detail to be shown or suppressed.

The magnification range corresponding to each declutter level shall be defined as system configuration parameter. Static and dynamic element within a display shall have associated with it a visibility designation as yes or no for each  
In addition to reaching the various decluttering levels through zooming, users shall also be allowed to request a specific level from a dialog menu.

The user shall be able to scale (zoom) the image of a world co-ordinate space or display in a smooth fashion to any convenient scale factor. The scale factors shall allow the presentation of an entire world co-ordinate space or display on the full screen or a window.

Static and dynamic data shall be displayed and updated during a scaling operation, and display text shall be scalable to be consistent with the scaled image. At defined scale factors, levels of de-clutter shall be invoked.

The user shall be able to select an area of a world co-ordinate display by cursor manipulation ("rubber-banding") and cause the display to be redrawn with the selected area centered in the display and with the selected area magnified to best fit the full window. The window dimensions shall not be changed by such an action.

A tool tip or equivalent method shall be provided for displaying information in English text & numeral upon moving cursor on the device etc.

Find & locate feature to take the user to the oneline/ network display where the particular component exists.

### **3.4.3 Permanent Indicators**

Several indicators, including those listed below, shall be permanently shown on each SCADA/DMS Display screen as minimum:

- Date and Time: Date shall be presented in the format DD/MM/YY. Time shall be presented in the format HH:MM:SS with a resolution of one second, and shall be updated once per second.
- Username: Name of the user logged in the SCADA/DMS
- Name of the active server
- Name of the SCADA/DMS display accessed
- Name of the display window

### **3.4.4 Default Screen Layout**

It shall be possible for each user to define a personal layout (Rooms) for the screens displayed on the screen(s) of the workstation, i.e. to define a personal default setup of the position, size, and contents of the screens.

The user's default layout shall appear when the user logs on to a workstation. When a dispatcher takes over a new shift by logging on without the previous dispatcher logging off first, the current screen layout shall be preserved. It shall be possible to go to another room layout of the logged on user at any time.

### **3.4.5 Display Note pad**

An user shall be able to place and edit a note on bays , devices etc on any display. A symbol shall appear on the display indicating the presence of Note on that display. The content of the note shall be callable using a cursor target.

### **3.4.6 Quality Code and Tag Indication**

All displays and reports containing telemetered analog values, device status and calculated values shall have a data quality code associated with each data field. The quality code shall reflect the condition of the data on the display or report. When more than one condition applies to the data, the symbol for the highest priority condition shall be displayed.

A separate indicator shall identify the devices that have supervisory control inhibit tags. When more than one tags are present on a device, the highest priority tag shall be displayed.

## **3.5 User Interaction Techniques**

The user's interaction with the SCADA/DMS system for power system operations shall primarily be accomplished using a menu item selection technique. The first step in the interaction will be selection of the item to be operated upon. The user shall then be provided a menu of operations applicable to the selected item. The required operation alternatives include:

- (a) Supervisory control
- (b) Data entry
- (c) Device status entry
- (d) Scan inhibit/enable
- (e) Tag placement/removal
- (f) Trend.

A set of parameters shall be presented appropriate to the item type and operation to be performed. For example, selecting a device for control shall cause a menu of control actions to be presented. Selecting an analog value for trending shall cause a menu of parameters, such as range and trend rate etc., to be presented.

As appropriate for the data and function requested, a menu containing output destinations such as screen, printer, or file shall be presented. When the destination is selected by the user, the requested action shall begin. It shall not be necessary to select an execute command to complete the interaction except for supervisory control actions.

The user shall be able to end the interaction sequence at any time by selecting a cancel command. The progress of all user operations shall be monitored. If the user does not complete to a step within a multi-step operation within a pre-defined time, the process shall reset, and the user shall be informed of the reset. A partially completed action shall be reset if the user begins another non-related sequence. A programmer-adjustable time-out cancel shall also be provided.

### **3.5.1 User Guidance**

The SCADA/DMS system shall respond to all user input actions indicating whether the action was accepted, was not accepted, or is pending. For multi-step procedures, the systems shall provide feedback at each step. User guidance messages shall be English text and shall not require the use of a reference document for interpretation. User shall be guided for multiple options. The use of mnemonics is prohibited, unless the mnemonics are industry-accepted or approved by employer. Provisions are required for administrators to edit the toolbars and menus ,user guidance messages and to construct new ones through an interactive procedure and without programming.

### **3.5.2 User Help**

In addition to the user guidance, general and specific context-sensitive on-line help shall be available to the SCADA/DMS user. Context sensitive means that the help information provided shall be applicable to the next step or steps in the sequence being performed. The Help menu shall present a list of topics available for reference. The topics shall refer to the SCADA/DMS user documents. The ability to scroll through the topic's explanatory text shall be supported.

The Help button in a dialog box and help key shall present the text of the user documents where use of the dialog box is explained. The user shall be able to scroll through this text. Exit from the help facility shall return the user to the same point in the sequence for which help was requested.

Context sensitive help facilities shall be provided for each application software package and operator display. The capability to easily edit or add additional help facilities in the future shall be provided.

The provided help facility shall also support:

- search mechanism
- navigation links between related topics within the help documents
- select/copy mechanism
- print facilities

### **3.5.3 Overlapping user access**

The ability to queue multiple commands from different consoles shall be provided. In this regard, however, interlocks shall be provided to avoid overlapping user access to certain functions such as data entry and supervisory control as follows:

- (a) Data Entry: Although the same data entry field , device status entry or fields (in the case of full-page data entry) may appear concurrently in multiple windows at multiple consoles, data entry

for the field or fields shall be restricted to one window at one console at a time. An attempt to initiate data entry for the field or fields from another window shall result in a user guidance message. Concurrent data entry on different areas of a world display, however, shall be allowed.

- (b) Supervisory Control: Although the same power system device, such as a circuit breaker, may appear concurrently in multiple windows at multiple consoles, control of the power system device shall be restricted to one window at a console at a time. An attempt to initiate control of the power system device from another window shall result in a user guidance message.

#### **3.5.4 Function Key Usage**

Special functions shall be assigned to the 12 function keys on a standard keyboard. With extensions (e.g., Shift, Alt, Esc) this shall result in a minimum of 48 function key actions.

#### **3.5.5 Trend**

Trend shall be a display of series of values of parameters on a time axis. Both graphical trend and tabular trends shall be supported. The attributes of the trend display shall be user configurable. The trend application shall be able to show trends for any measurement type from more than one source, at least from real-time, historical and forecast sources. It shall be possible to combine this data showing data for comparison using a shared timeline simultaneously comparing for example yesterday (historic) and today (historic, actual and forecast) as two curves on the same time axis. It should be possible to trend different types of parameters (P, Q, V, I, F etc.) with associated Scales on the same display. The user shall be able to select a trend rate different than the sampling rate.

##### **3.5.5.1 Graphical Trend**

The user shall be able to select and configure trending on Graphical displays enabling user for entry of the following parameters:

- (a) Data value name
- (b) Trend header
- (c) Trend direction (horizontal or vertical)
- (d) Scale (unidirectional and bi-directional)
- (e) Zero offset
- (f) Trace number, colour & texture
- (g) Trend data rate
- (h) Trend start time and date (historical data only)
- (i) Total trend duration (historical data only)

- (j) Reference lines or shading axes ( With default to restrictive alarm limits)
- (k) Windows/chart to be used
- (l) Simultaneous trending of different parameters with associated scales.

Trending of at least four values simultaneously, on a common axis or separate axes shall be supported. All scales corresponding to the values selected shall be visible on the Trend Display simultaneously. There shall be automatic movement of data down or across the screen as new values are generated. When the number of real-time trend samples reaches the limit that can be displayed, the oldest value shall automatically be removed as the display is updated.

The magnitude & time of all the trended quantities at a particular time instant shall be displayed when the cursor is placed on the timescale on the trend display.

When historical data is selected for trending, the user shall be able to page forward and backward, or scroll by the use of a scroll bar, through a non-updating snapshot of the data within the constraints of the data stored in the historical files.

Shading between each trend value and user-definable axes shall be provided. Trend colour shall be changeable based on a comparison of the trend value against associated alarm limits.

It shall be possible to have at least data samples corresponding to 2 months on line storage for each of the trended variable. The user shall be able to print the trend without interfering with the continuing trending process.

### **3.5.5.2 Tabular Trending**

Tabular trending shall be a listing of the time-sequential values of a variable/ variables. The tabular trend shall present the data in a tabular form with one column for Date/time and additional columns for each of the trended variable. The tabular trend shall contain at least rows for samples corresponding to 2 months on line storage. Each row shall contain the values of the trended variables. It shall be possible to scroll up and down to see the rows. The sampling rate shall be individually definable for each tabular trend.

The historical tabular trends, which shall be produced from the previously stored values in trend files, it shall be possible to choose the start time, the end time, and the sampling rate independently of the sampled rate of historical data.

It shall also be possible to save trend output to an ASCII file. The file output shall be in ASCII format, with date and time information and the engineering unit value of the trended variables for each collection interval. The user shall be able to print the trend on a user-selected printer without interfering with the continuing trending process.

### **3.6 Alarms**

Alarms are conditions that require user attention. All alarms shall be presented to the user in a consistent manner. Alarm conditions shall include, but not be limited to, the following:

- (a) Telemetered or calculated value limit violations
- (b) Values returning to normal from a limit violation state
- (c) Uncommanded changes of a power system device state
- (d) SCADA/DMS application program results
- (e) Data source communication errors resulting in loss of data
- (f) SCADA/DMS system hardware or software failures.

Each alarm shall be subjected to a series of alarm processing functions. A device or value's alarmable conditions shall be assigned to an alarm category and alarm priority levels. Alarms shall also be subjected to advanced alarm processing. The results of the alarm processing shall determine the console(s) that will receive and be authorized to respond to the alarm and the associated actions with the alarm.

All alarm messages shall be recorded on auxiliary memory of SCADA/DMS system and archived in chronological order & reverse chronological order. It shall be possible to sort, display and print user selected alarm messages from any console by the user.

#### **3.6.1 Alarm Categories**

An alarm category provides the logical interface that connects an alarm condition to a specific Area of Responsibility (AOR) or operational jurisdiction as defined and accordingly alarm shall be reported to user. Every alarm shall be assignable to a category. Each category shall, in turn, be assignable to one or more users. A means shall be provided for changing operating shifts without reassignment of alarm categories at a console. Each log-on and log-off shall be reported as an event.

#### **3.6.2 Alarm Priority levels**

Each alarm shall be assigned to an alarm priority level. Up to 8 alarm priority levels shall be supported. Each alarm priority level shall be presented in separate display. For each alarm, it shall be possible for the programmer to independently configure the following actions:

- (a) Audible alarm tone type selection and its enabling/disabling
- (b) Alarm messages to be displayed on an alarm summary
- (c) Alarm message deleted from alarm summary when acknowledged
- (d) Alarm message deleted from alarm summary when return-to-normal alarm occurs



- (e) Alarm message deleted from alarm summary when return-to-normal alarm is acknowledged
- (f) Alarm message deleted by user action.

This assignment shall determine how the alarm will be presented, acknowledged, deleted, and recorded.

### **3.6.3 User Interaction for Alarms**

The User shall be able to perform the alarm interactions described below.

#### **3.6.3.1 Alarm Inhibit/Enable**

Inhibiting alarms for a value or device, including a complete RTU /FRTU/FPI or other data source, shall cause all alarm processing of that value or device to be suspended. The action shall be recorded in the event log. However, Scanning of the value or device shall continue and the database shall be updated.

#### **3.6.3.2 Alarm Acknowledgment**

An alarm shall be acknowledged by selecting an alarm acknowledge command when the item in alarm is selected on:

- (a) Any display showing the item in alarm
- (b) Any display showing the alarm message.

User shall be able to acknowledge alarm individually, by page, user selected manner. It shall be possible for the user to distinguish persistent & reset alarms under acknowledged & unacknowledged conditions. All alarms shall be stored by the system

#### **3.6.3.3 Audible alarm silencing**

User shall be able to silence alarm without acknowledgement and shall remain until the user enable the audible alarm. The silencing & enabling shall be recorded as event. The tones shall be definable on the console basis. For each console, multiple tones shall be available. Tones shall be of continuous & short duration type both. The former shall be of high priority condition & require operator intervention to stop. In case of short duration tone, it shall go off at it's own.

#### **3.6.3.4 Change Alarm Limits**

The user shall be able to change the alarm limits.. When the user selects an item to change its alarm limits, a menu showing the alarm limits currently in use and a data entry field for the revised limits shall appear. All changes to alarm limits shall be subjected to data entry error checking and recorded as events. The alarms

shall be annunciated according to the changed alarm limits. The user shall be able to reset alarm limits to the limits set in the SCADA database. However, these shall be treated as temporary changes & if the system is re-initialised, the original limits defined in the SCADA database shall be operationlised.

#### **3.6.3.5 Alarm Presentation**

Alarm presentation shall be determined by the alarm's category and priority. Displays shall highlight every alarm condition using a combination of colour, intensity, inverse video, blinking and audible sound. The alarm condition highlighting shall show whether the alarm has been acknowledged. The highlighted alarm condition shall appear on all displays containing that device or value at all consoles regardless of the alarm's category.

Alarm messages shall be a single line of text describing the alarm that has occurred and the time of occurrence. The alarm message shall be English text and shall not require the use of a reference document for interpretation.

### **3.7 Events**

Events are conditions or actions that shall be recorded by the SCADA/DMS system but do not require user action. Events shall be generated under the following conditions

- (a) User initiated actions
- (b) Conditions detected by application functions that do not require immediate user notification, but should be recorded.

Events shall be recorded in the form of an event message. The event message format shall be similar to the alarm message format. The same message format shall be used for displaying and printing events. Event messages shall be displayed on an events summary.

Event messages shall be stored on auxiliary memory of SCADA/DMS system and archived in chronological order and reverse chronological order.. It shall be possible to sort, display, and print event messages from any console.

### **3.8 Hardcopy Printout**

The SCADA/DMS system shall have features to produce a print out of a display, reports, Alarms, Events etc. from a menu. Any of the available printers shall be selectable by the SCADA/DMS users from menus for taking printout.

It shall be possible to print a complete display or a selected portion of a display. The options for printing shall include at least choice for orientation, background colour, page size, colour/ black & white and print preview. Also any of the available printers shall be selectable from the print Menu.

### **3.9 Report Generation**

The contractor shall be required to generate the Daily, Weekly, Monthly reports formats for SCADA/DMS system. The report formats shall be finalised during detailed engineering stage. The user shall be able to schedule periodic generation of reports, direct report to display, print report, and archive report using report-scheduling display. The report scheduling display shall enable entry of the following parameters, with default values provided where appropriate:

- (a) Report name
- (b) Report destination (printer or archiving device)
- (c) Time of the system should produce the report.

The user shall be able to examine and modify the contents of reports for the current period and for previous report periods using displays. Any calculation associated with the revision of data in a report shall be performed automatically after data entry has been completed.

The report review displays shall accommodate formatted report pages up to 132 characters in width and 66 lines in length and shall contain headings that correspond to the printed report headings. For reports containing more columns or rows than the display, the system shall include a means to view the entire report in a graphic format. The report view and editing displays shall function with the initially supplied reports and all future reports added by employer.

### **3.10 System Configuration Monitoring and Control**

The user shall be provided with the capability to review SCADA/DMS computer system configuration and to control the state of the configuration equipment using displays. The following operations shall be possible:

- (a) Failover of each server
- (b) Monitoring of servers, device, including workstations, RTUs, FRTUs, FPIs, status & loading of WAN LANs etc.
- (c) Monitoring of the processor resource, hard disk & LAN/WAN utilization
- (d) Control & monitor of SCADA/DMS functions

### **3.11 Dynamic Data Presentation**

It shall be possible to present any item in the database on any display. All supervisory control and data control capabilities shall be supported from any window of a world display. Device status or data values shall be displayable anywhere on the screen, excluding dedicated screen areas such as the display heading.

Only standard X Window system or Microsoft windows standard fonts shall be provided with the SCADA/DMS. All fonts supplied shall be supported on the user interface devices and all printers supplied with the system. The types of fonts to be used in a particular display shall be selected at display definition time.

Status and data values shall be presented in the following formats as appropriate:

- (a) Numerical text that presents analogue values shall have the provision for the format definition of the text shall include the number of characters, number of decimal places, and the use of positive /negative sign or flow direction arrows, etc.
- (b) Normally the telemetered MW/Mvar values alongwith the sign/direction shall be displayed on the Single line diagram and Network diagram. However the user shall also be able to display all other telemetered and calculated/ estimated analog values (I, V, pf etc. for each phase) on the Single line diagram (SLD) and Network diagram. All the displays shall be suitably designed to view 12 telemetered and 12 estimated/calculated values simultaneously for each feeder.
- (c) Symbols, including alphanumeric text strings for an item, based upon state changes e.g., circuit breaker (OPEN/CLOSE/INVALID).
- (d) Symbols, including alphanumeric text strings for indicating the data quality flags.
- (e) Colours, textures, and blink conditions based upon state or value changes or a change of data quality, e.g., alarm limits.

### **3.12 Element Highlighting**

Element highlighting techniques shall be provided to draw the attention of Dispatcher to critical state of the system. The highlighting technique shall include change of colour, colour intensity, blinking, Character inversion, Line texture, appended symbols etc. This feature shall be used to highlight alarms, power system device and measurement status, data quality, data entry locations on a display and error conditions.

### **3.13 Display Types**

The following list describes the types of displays that are to be included in the SCADA/DMS system. The user interface shall support the capabilities of all displays as specified. The User mode, Current Time and date shall be displayed on a screen-basis, not on a display basis, and shall be always visible.

#### **3.13.1 SCADA/DMS System Display**

A display shall be provided that lists all SCADA/DMS system directory displays. The displays shall be listed in alphabetical order with suitable separation in the list to enhance readability. Each entry in the list shall have a cursor target for display selection.

#### **3.13.2 Distribution System Network Display**

A graphic overview network display of the distribution system with substations, feeders. Distribution network colour coded by voltage shall be provided. This display shall present the distribution system in a graphic format provided by employer. Telemetered and calculated data like Real and reactive power flows shall be displayed as a value with a direction arrow/positive- negative signs. Lines that have exceeded their loading limits shall be highlighted. Substations and power stations shall be depicted by symbols that reflect the presence of alarms at that substation or power station. Cursor selection of a substation/ power station symbol shall result in the associated Single line diagram display for that substation/ power station.

### 3.13.3 Interchange Display

The interchange display shall be provided as a schematic diagram showing power transfers among various utilities. This diagram shall show each power system as a block with actual and scheduled net interchange values outside the block. Symbolic arrows shall indicate power flow directions. The diagram shall also show schedule deviations. This display shall show the frequency values collected from all substations having tie-lines.

### 3.13.4 Substation SLD displays Menu

A display shall be provided that lists all substations that can be viewed via a SLD display. The name of the SLD displays shall be listed in alphabetical order, according to substation name, with suitable separation in the list to enhance readability. Each entry in the list shall have a cursor target for graphic display selection.

### 3.13.5 Substation SLD Displays

SLD displays shall be provided for each substation, including those for which telemetry may not be available but are required for running the DMS applications. Each display shall present telemetered, manually entered, and calculated power system data on a Single line diagram that shows substation layout in terms of its buses, switches, lines, and transformers. The feeder names in the SLD shall have linkage with remote substation end SLD, distribution network associated with that feeder. It shall be possible to move to remote-end substations SLD by selecting this feeder. The user shall be able to perform any user interaction defined by the Specification on these displays.

### 3.13.6 Control panel displays

As utilities are presently using conventional panels at S/S for supervision & monitoring, The control panel displays giving look -alike feeling shall be provided for operator supervise & operate .

### **3.13.7 Substation Tabular Displays**

Tabular displays shall be provided for each substation. These displays shall list the real-time values of telemetered, manually entered, and calculated data associated with the substation as well as related information such as alarm limits. The user shall be able to perform any user interaction defined by the Specification on these displays.

### **3.13.8 Alarm Summary Displays**

Displays that list or summarize all unacknowledged and acknowledged alarms shall be provided. The summary shall separate acknowledged and unacknowledged alarms. Capacity shall be provided for at least 200 alarm messages for each alarm summary type. If an alarm summary display becomes full, the oldest messages shall be automatically deleted and the newest messages shall be added. It shall be possible to perform any alarm interaction from this display. The user shall be able to select between viewing events in chronological or reverse chronological order.

### **3.13.9 Event Summary Displays**

Event summary displays shall list the most recent events and shall be organized by category for those categories assigned to a given console, as one summary display for all categories assigned to a console, or by all conditions system-wide without reference to the categories assigned to a console, as selected by the user. The user shall be able to select between viewing events in chronological or reverse chronological order.

### **3.13.10 Operating Information Summaries**

The operating information summaries defined below shall be provided. Summary items shall be listed in reverse chronological order with the most recent item shown on the first page. All summary displays, except for Tag Summary shall be information-only displays; no user interaction, other than display call up, shall be associated with them. The Tag Summary shall be interactive, i.e., the user shall be able to place or remove tags on this summary.

### **3.13.11 Manual Override Summary**

The manual override summary shall list all telemetered and calculated device status and data values for which a user has substituted a value

### **3.13.12 Off-Normal Summary**

The off-normal summary display shall list devices and values that are found to be abnormal, i.e., are not in their normal state. Telemetered, calculated, and manually entered status and data values shall be included.

### **3.13.13 Out-of-Scan Summary**

The out-of-scan summary display shall list device status and data values that are not currently being processed by the system. If an entire telemetry source such as an RTU /FRTU /FPI is out-of-scan, the out-of-scan summary shall display the source without any of the individual device status or data values associated with the source

#### **3.13.14 Alarm Inhibit Summary**

This display shall list devices and data values for which the user has suspended alarm processing.

#### **3.13.15 Tag Summary**

This display shall list and describe all active device tags.

#### **3.13.16 Graphical Trending Summary Displays**

The summary display shall list all items being trended. The list shall include the item name, trace number or colour, trend orientation, and trend range.

#### **3.13.17 Tabular Trending Summary Displays**

The summary display shall list all items being recorded for tabular trends. The list shall include the item name and the file name.

#### **3.13.18 Notes Display**

This display shall include a minimum of 5 pages on which a user at any console may enter and edit messages. The contents of these pages shall be accessible by any console. The user shall have the ability to clear any page of this display and to type over previous messages.

#### **3.13.19 Computer system Configuration and Monitoring Displays**

Graphic and tabular displays shall be provided that allow the user to:

- (a) Monitor and revise the configuration of the computer system
- (b) Monitor the system's resource utilization statistics

#### **3.13.20 RTU/ FRTU/FPI Communication Channel Monitoring and Control Display**

This display shall show information on the status of the system's communication interface devices (including communication channels), the accessibility of each RTU/FRTU/FPI in a graphical form. The user shall be able to Enable/Disable any communication channel from this display.

### **3.13.21 SCADA/DMS Application Program Displays**

Application program displays shall be provided to satisfy the user interface requirements of the system functions stated throughout this Specification. Application program displays shall be based on a standard user interface design across all applications to provide a common look and feel. The application's information shall be presented in such a way as to facilitate user operations.

The required displays for all DMS Applications, shall also be made available to the user.

### **3.13.22 GIS integration**

The SCADA/DMS dynamic distribution network with GIS land base at the background shall be available for navigation. Operator shall be able to perform all functions & have features as envisaged in the specification. Suitable GIS adaptor shall be provided to import the distribution network model & GIS information from GIS system.

### **3.13.23 Help Displays**

Help displays shall be provided to aid the user in interpreting displayed information and to guide the user through a data entry or control procedure. Help displays shall be provided for each display that is provided with the system. Each display shall have a prominent cursor target that the user can select to request the associated help display. For standard displays, software aids (such as context sensitivity) shall be used to present pertinent help information in an expeditious manner. A programmer shall be allowed to modify and create help displays.



## **Section -2 SYSTEM SOFTWARE REQUIREMENTS**

### **4.0 General**

This section describes the characteristics of system software such as Operating system, RDBMS and support software (programming language compilers, database development and maintenance, display development, network services, report generation, diagnostics and backup utilities) to be provided by Contractor and the original software manufacturer as necessary to support the SCADA/DMS applications. This section also describes the standards to be followed for all supplied software. The contractor shall make use of common applications such as security, networking etc created under R-APDRP- IT infrastructure. However, it is necessary that functional, availability & performance aspects are met. Bidder shall assess the adequacy of software specified & if any additional software is required to meet all the requirements of the technical specifications, the same shall also be included in the offer.

### **4.1 Software Standards**

All SCADA/DMS software provided by the Contractor, including the Operating system, RDBMS and support software, shall comply with the industry-accepted software standards produced by national and international organizations, such as ANSI, ISO, IEC, IEEE, ECMA in order to facilitate maintenance and enhancement of the SCADA/DMS systems being supplied. In areas where these organizations have not yet set standards, the software shall comply with those widely accepted de- facto standards put forth by industry consortiums, such as OSF and X/Open. The Contractor shall commit to meet the "open systems" objective promoted by industry standards groups by using software products that are based on open standards

#### **4.1.1 Design and Coding Standards for SCADA/DMS applications**

All SCADA/DMS applications shall be maintainable by employer using the supplied software utilities and documentation. The SCADA/DMS software design and coding standards shall also address the following:

- (a) Expansion/ scalability: software shall be dimensioned to accommodate the ultimate size of SCADA/DMS system envisaged.
- (b) Modularity: software shall be modular to minimize the time and complexity involved in making a change to a program.
- (c) User-Directed Termination: Functions taking long execution times shall recognize and process user requests to abort the processing.

- (d) Programming languages: The software shall be written using ISO or ANSI or ECMA standard programming languages like FORTRAN, C, C++, and SQL and for Unix based systems the APIs shall be POSIX-conforming.
- (e) SOA architecture: Software shall conform to SOA.
- (f) Enterprise service bus (ESB) : ESB based architecture is essential to enable interaction of applications from different product manufacturer , platforms etc.
- (g) Portability & Interoperability: The software shall be designed for hardware independence and operation in a network environment that includes dissimilar hardware platforms to the extent possible. The use of system services software shall be built on Open standards

## 4.2 Operating System

The contractor shall use Unix /Linux / Microsoft Windows™ operating system servers. The servers based on of Unix O/s, shall generally comply with the evolving set of POSIX standards defined by IEEE.

## 4.3 Time and Calendar Maintenance

The SCADA/DMS system shall maintain Time and date for use by various software applications. The GPS based time receiver shall be used for synchronising the SCADA/DMS system time. All Servers and Operator workstation clocks shall be synchronised within the accuracy of +/-100 milliseconds. The SCADA/DMS system shall not be dependent on a particular server for time /calendar maintenance. . The SCADA/DMS shall include two redundant time and frequency standards. Failure of the online unit shall result in automatic switching to the redundant unit. The SCADA/DMS shall periodically check if the backup unit is operational and failure of either unit shall be alarmed.

The frequency reading shall be accessible by SCADA/DMS applications with three post-decimal digits resolution The system shall support communication protocols such as NTP and SNTP. The time and frequency standard unit shall support a common time code output format such as IRIG-B.

A surge protection system shall be included to prevent the time and frequency standard equipment from lightning.

## 4.4 Network Software

The network software for SCADA/DMS system shall include software for network communication, security and services.

#### **4.4.1 Network Communication**

Users and various applications shall be able to communicate within the SCADA/DMS local area network and operate as described in this Specification. The network communications software shall use a standard network protocol such as TCP/IP. The software shall link dissimilar hardware nodes, including local and remote workstations, application servers, communication servers, and various peripherals (such as printers) into a common data communication network allowing communications among these devices.

#### **4.4.2 Network Security**

A user authentication scheme consisting at least of a user identification and password shall be required for the user to request a connection to any network node.

#### **4.4.3 Network services**

The following network services shall be provided for the users of SCADA/DMS system:

- (a) Network file management and transfer, for files containing text, data, and/or graphics information
- (b) Network printing management
- (c) Network time synchronization
- (d) Network backup over LAN
- (e) Task-to-task communications to external computers
- (f) LAN global naming facilities.
- (g) Remote procedure call
- (h) Remote terminal session

#### **4.4.4 Security Services**

The security solution shall comprise of comprehensive solution for secured zone Firewalls i.e LAN Firewall & Gateway Firewall, intrusion Prevention system IPS (Network based & Host based) & Strong Authentication (multi layered), LDAP , Encryption mechanism. The contractor shall provide a tightly integrated intrusion detection system to detect and prevent intrusion

Followings are the functional requirement from the security system:

- System shall have Multilayer (at least network, application layer ) firewall which shall protect the complete system network from unwanted users. Further the separate firewall of different OEMs shall be provided to take care the security of all the servers & shall have High Availability architecture with No Single Point of Failure (NSPOF).
- Gateway Firewall should be capable of load balancing multiple links from different service providers.

- LAN Firewall shall provide isolation/security services between the subsystems installed under SCADA system of R-APDRP
- Firewalls deployed should not become a bottleneck. It shall be Robust, Secure, Scalable and future-proof with Centralized Management.
- Two type of IPS Host based & Network based shall be deployed with minimum hardware & they should not go blind in peak traffics.
- IPS should have hybrid technology to detect attacks. It should detect through a combination of Protocol Anomaly and Signature matching.
- Shall have Gateway antivirus which will protect from inflow of virus from the Internet and other WAN locations at the gateway itself with content filtering without any lag in data transmission.
- Shall have strong authentication containing user name and passwords which shall be very difficult to compromise.
- SSL over VPN to provide secured link over public network such as with RTU/FRTU/FPI

#### 4.4.4.1 Features

Followings are the features specific to each component of security system

##### 4.4.4.1.1 Firewall

The Firewall shall be hardware box Firewall system with following features.

- Firewall speed >250 Mbps
- Data encryption supported DES (56 bits) 3 DES (168 bits) and hashing algorithm like MD5 and SHA-1
- Encryption to offload the main CPU
- It shall have minimum 8 Ethernet 10/100 /1000 ports (4ports for connectivity to two web servers & 4 Ports for connectivity to LAN
- Support NAT and PAT
- Capability of working in Load sharing and hot standby mode
- Denial of service prevention.
- DNS guard features
- JAVA and ActiveX blocking
- Radius integration
- Web based management interface
- Stateful inspection for web, mail, SQL application etc.
- Detailed system logging and accounting feature
- No. of concurrent TCP Sessions supported shall be more than 5000.

#### **4.4.4.1.2 Intrusion Prevention System (IPS)**

The contractor shall provide a tightly integrated intrusion detection & prevention system Capable for detecting the intrusion attempt that may take place and intrusion in progress and any that has taken place.

Both Network based and Host based IPS should have centralized Management Console system which will be either the application server with NMS or any of the workstation. The Centralized management console shall have integrated event database & reporting system & it must be able to create and deploy new policies, collect and archive audit log for post event analysis. The system shall have Integrated Event Database & Reporting System.

Automated Update of the signature for two years shall be provided and there should be provision for creating customized signature

##### **(A) Intrusion Prevention System (Network Based)**

- After detecting any intrusion attempt there should be provision to configure to perform the following functions:
  - Capability for Detecting the intrusion attempt that may take place, intrusion in progress and the intrusion that has taken place
  - Reconfigure the firewall provided in this package.
  - Beep or play a .WAV file
  - Send an SNMP Trap datagram to the management console. The NMS server envisaged under the specification shall be used as management console also.
  - Send an event to the event log.
  - Send E-mail to an administrator to notify of the attack.
  - Save the attack information (Timestamp, intruder IP address, victim IP address/port, protocol information).
  - Save a trace file of the raw packets for later analysis
  - Launch a separate program to handle the event
  - Forge a TCP FIN packet to force a connection to terminate.
  - Detect multiple forms of illicit network activity: -Attempted
  - Vulnerability Exploits -Worms -Trojans -Network Scans -Malformed Traffic -Login Activity
  - The System shall support monitoring of multiple networks. The system shall also support the monitoring of additions or changes to addresses of devices on the network.

The system shall have detection rules for monitoring faults, dangerous and malicious activity related to IP based protocols. The Contractor shall also apply its power control and security experience to enhance these detection rules for specific issues within the system.

## **(B) Intrusion Prevention System (Host Based)**

Host based IPS shall run on the servers. After detecting any intrusion attempt there shall be provision to configure the IPS to perform following actions

- Send an SNMP Trap datagram to the management console. The NMS server envisaged under the specification shall be used as management console also.
- Send an event to the event log. Send e-mail to an administrator to notify of the attack.
- It should be capable of creating audit trail for user and file access activity, including file accesses, changes to file permissions, attempts to install new executables and/or attempts to access privileged services,
- In an event where user accounts are added, deleted, or modified changes to key system files and executables is done in by unauthorized account or there is unauthorized attempt to overwrite vital system files, to install Trojan horses or backdoors, suitable action shall be taken such as :
  - Terminate user Login (intruder)
  - Disable user Account (intruder)
  - Administrator can define the action to be taken
  - Forge a TCP FIN Packet to force a intruder connection to terminate.
- Should provided events check for suspicious file transfers, denied login attempts, physical messages (like an Ethernet interface set to promiscuous mode) and system reboots.

### **4.4.4.1.3 Gateway Antivirus**

This shall be used for Gateway scanning of viruses. Gateway antivirus shall have Centralized-user Administration which will Communicate directly with centralized user directories such as LDAP. It shall have the all the essential/standard features of Latest version of Gateway antivirus, some of the features are as following:

- It shall have Policy-based URL filtering and Dynamic Document Review.
- It shall protect web traffic with high-performance, integrated virus scanning and web content filtering at the gateway
- It shall ensure protection by combining list-based prevention with heuristic content analysis for both virus protection and web content filtering
- It shall eliminate unwanted content and malicious code & Scan all incoming and outgoing HTTP and FTP traffic etc.

The Security System shall use the best practices to prevent the System itself being a source of security compromise. The System shall be hardened, patched, tested, and designed with security as a primary

objective. Communication with (GUI and notifications) and within (agent reporting and updates) the System shall use encryption and authentication.

#### **4.4.4.2 Other aspects of security**

##### **4.4.4.2.1 Application Security Monitoring**

The standard operating system shall support the monitoring of security on host installed applications. The system shall support or allow the creation of monitoring for:

- Application Software Error Conditions
- Application Software Performance Issues
- Application Configuration Changes
- Application Logins, etc.

##### **4.4.4.2.2 Security Alarms**

The system shall be capable of annunciation, to include audible and visual alarms and remote paging whenever a security event takes place and shall support the following:

- Instant notification through email or pager
- Logical grouping of security events by time, location, and device, etc
- Interactive dashboard window for viewing and acknowledgement

##### **4.4.4.2.3 Analysis and Reports**

- The system with the stored information, shall be able to produce analyses and reports to meet security compliance requirements. The system shall be equipped with best practices ad-hoc reports widely used in the industry.
- The employer's personnel shall be trained to be capable of creating new custom analysis and reports, and revising existing, without requiring external consultation.

##### **4.4.4.2.4 Log Archiving**

The security system shall archive, record, and store all security related events in raw form for at least one year. As a minimum, the event logger shall record all security related events from the perimeter security devices and the host IPS. Graphical trend displays of each event shall be available along with specific information on the type of intrusion, the area affected and the source via IP address.

#### **4.4.4.2.5 Data Access through intranet**

The Web server at Control Center is to function as source of information on the distribution network. It will be accessed by utility intranet user. Any additional client software, if required, at external clients/users ends, the same shall be made dynamically available from Web server for its downloading by these external clients. There shall not be any restriction to the number of clients downloading this software (i.e. Unlimited number of client downloads shall be provided).

The external users shall be licensed users of the employer.

The following features are required:

- a) The Web servers shall be sized to support atleast 50 concurrent external intranet clients/users for providing access to real-time data.
- b) External intranet clients/users shall be connected to the web servers through secure authentication such as VPN access. These users shall be denied direct access to the SCADA/DMS protected LAN.
- c) Internal SCADA/DMS users shall not have any dependency on the availability of the Web servers.
- d) For the purpose of transfer of data/displays/ from the SCADA/DMS system to the Web server system, the SCADA/DMS system shall initiate a session with the Web server and any attempt to initiate a session by the Web server shall be terminated by the Firewall in SCADA/DMS system LAN. Interface between Web server and SCADA/DMS zone shall preclude the possibility of external clients defining new data/Report/Displays.

For any sessions initiating from the DMZ LAN into the protected LAN, the servers shall be located in a separate DMZ LAN that will be isolated from common applications connected directly to ISP such as email. The Access to these servers from the external web will be through authorization of Virtual Private Network.

- e) The web server shall provide access to allowable real time data and displays, at defined periodicity, for viewing by external clients/users. The access to each display shall be definable on per user type basis. It shall be possible to define up to 100 users. Further the SCADA/DMS system administrator shall exercise control over the real-time displays which can be accessed through the Web server.
- f) The Web server at Control Center shall also facilitate exchange of email messages from ISP (Internet Service Provider) and other mail servers supporting SMTP..
- g) Suitable load balancing shall be provided among the web servers where each shall serve proportionate number of clients. However in case of failure of one of the servers, all the clients shall automatically switch to the other web server(s).



Typical displays/pages for Intranet access shall be same as that on the SCADA/DMS. Real time SCADA data on web server shall be refreshed every minute

The access to Web server/site shall be controlled through User ID and password to be maintained /granted by a system administrator. Further, different pages/data access shall be limited by user type (i.e. CMD,, Mgmt user, incharge etc). The access mechanism shall identify and allow configuration of priority access to selected users.

Further, tools shall be provided for maintaining the website, web server configuration, E-mail configuration, FTP configuration, Mailing lists setup and customer support. Latest protections against viruses shall be provided.

#### **4.4.4.2.6 Signature Updating Requirements**

The system shall be able to accept timely updates. The updates shall keep the threat signatures current, providing the latest detection and protection. The updates shall also incorporate the latest security enhancements into the Security Management System. These enhancements shall increase security and functionality, without requiring redesign or reengineering efforts.

#### **4.4.4.2.7 Network Management system (NMS)**

A network monitoring and administration tool shall be provided. The interface of this tool shall show the DMS hardware configuration in form of a map. The network-monitoring tool shall automatically discover the equipment to construct the map. It shall support management of multi Vendor network hardware, printers, servers and workstations.

It shall support remote administration of network devices, management of thresholds for monitoring performance and generation of alarm and event notifications. It shall be possible to send these notifications to maintenance personnel through e-mail

The Network management system shall manage the interfaces to the SCADA/DMS servers, workstations, devices, communication interface equipment, and all SCADA/DMS gateways and routers ,switches etc

The network management software shall be based on the Simple Network Management Protocol (SNMP-Internet RFC 1157) over TCP/IP (CMOT), with additional proxy software extensions as needed to manage SCADA/DMS resources.

The NMS software shall provide the following network management capabilities:

- (a) Configuration management
- (b) Fault management
- (c) Performance monitoring.

The network management software shall:

- (a) Maintain performance, resource usage, and error statistics for all of the above interfaces (i.e. servers, workstation consoles, devices, telephone circuit interface equipment, and all SCADA/DMS gateways , routers etc) and present this information via displays, periodic reports, and on-demand reports.

The above information shall be collected and stored at user configurable periodicities i.e. upto 60 minutes. The Network Management System (NMS ) shall be capable of storing the above data for a period of one year at periodicity of 5 minutes.

- (b) Maintain a graphical display of network connectivity to the remote end routers
- (c) Maintain a graphical display for connectivity and status of servers and peripheral devices for local area network.
- (d) Issue alarms when error conditions or resource usage problems occur.
- (e) Provide facilities to add and delete addresses and links, control data blocks, and set data transmission and reception parameters.
- (f) Provide facilities for path and routing control and queue space control.

#### **4.5 Database structure**

The SCADA/DMS RTDB (Real Time Data Base) shall be an active process model. i.e. It shall initiate actions or events based on the input it receives. The RTDB shall describe the state of the power system at a given point in time and the events that move the system to a new state at the next point in time. This database is required to support the data access to real time information and to allow efficient integration and update.

A library of event routines may encapsulate or interface the RTDB with other components of the system. These event routines shall be the preferred means for application programs to interact with RTDB. This way, application programs (and programmers) only need to concern themselves with callable interface (API) of these routines. Each application shall interact with the RTDB through the event library. These event routines shall serve as generic APIs for database access thereby eliminating proprietary database function calls at the application level.

The SCADA/DMS shall include a single logical repository for all data needed to model the historical, current, and future state of the power system and SCADA/DMS – the Source Database (SDB). All information needed to describe

the models on which the SCADA/DMS operates, shall be defined once in the SDB and made available to all SCADA/DMS applications, real-time database, and user interface maintenance tools that need the information.

Any database update, whether due to local changes or imported network model changes, shall be able to be placed online in a controlled manner without causing undue interruption to network operations, including without losing any manually entered data. For example, a network model update to introduce a new substation shall not interrupt the ability to perform supervisory control actions or receive telemetry to view the network state. It shall be possible the changes, local or imported, to be placed online either automatically or under manual control with proper validation. It shall be possible to easily revert to an earlier database version, again without undue interruption to network operations.

The capability to import & export the CIM compliant network model data including the corresponding telemetry and ICCP data reference in XML format to send it to other parties shall be provided. The capability to import the CIM compliant network model data from other parties in XML format shall also be provided.

The SCADA/DMS shall provide a consistent interface to accept XML format data for updates from other database applications; and provide a consistent interface to import & export data in XML format.

#### **4.5.1 Software Maintenance and Development Tools**

##### **4.5.1.1 General requirements**

A set of software shall be provided to enable maintenance of application software and development of new software in software development mode.

All hardware and software facilities shall be provided to allow creation, modification and debugging of programs in all languages that are supplied.

The following shall thus be possible:

- Program and data editing
- Program compiling and assembling
- Linking
- Loading, executing and debugging program.
- Version management
- Concurrent development

The following features shall be provided:

- Library management
- Programs allowing to copy and print any data or program files

- Backup and restore
- File comparison
- Sort and merge
- Programs that allow to partially save and recover volumes
- Core and memory dump.

In addition tools shall have the following:

#### **4.5.1.2 Command language**

A complete command language shall be provided that allows interactive use of any console to interactively create, modify and debug programs in all languages provided. It should also be possible to create and save command procedure file and to execute it sequentially.

#### **4.5.1.3 Linkage Editor and Loader**

Compilers and assemblers, linkage editor and loader shall be provided to link object modules from an assembly or compilation to produce an executable module and load it in system. As far as possible, the loader shall accept object modules issued from various language compilers.

#### **4.5.1.4 Symbolic Debugger**

A language-independent, interactive symbolic debugger shall be provided to enable the user to test new software and inspect the characteristics of existing software. The execution of a program shall be under the control of the debugger according to parameters entered by the user. The following features shall be supported:

- (a) Program execution breakpoint control
- (b) Program execution sequence tracing
- (c) Display and modification of program variables
- (d) Attachment of specifically written debug code to the program under test.

The debugger shall allow halting execution of a program at predefined points, reading and modifying the registers and memory locations and executing step by step a program. Tender shall describe the features of debuggers for each type of equipment.

#### **4.5.1.5 System Integration**

System integration services shall be provided for adding new programs to the set of active software after the programs have been tested. These services shall include commands to substitute one program for another, to set up or modify operating system tables, and to schedule and activate a new program with a minimum of interference with the normal running of the SCADA/DMS functions. The capability to restore the system to its status prior to the new program integration shall be provided.

#### **4.5.1.6 System Generation**

System generation software and procedures shall be provided to generate an executable object code of all software, databases, displays, and reports. Employer personnel shall be able to perform a system generation on site, using only equipment, software, procedures, and documentation supplied with the SCADA/DMS. It shall not be necessary to return to the Contractor's facility or rely on the assistance of Contractor personnel.

The procedures necessary to perform a complete system generation shall be provided as interactive or batch commands maintained on auxiliary memory and on archive storage, source listings, and detailed manuals. System generation shall be accomplished without programming; only directives or control commands described in the procedures shall be required.

#### **4.5.1.7 Code Management**

A code management utility shall be provided for documenting and controlling revisions to all SCADA/DMS application programs. The utility shall maintain a library of source, object, and executable image code and provide a controlled means for changing library files containing this code.

The code management utility shall include inventory, version, and change control and reporting features. Program dependencies shall be included in the library for user reference. The code management facility shall retain a complete history of additions, deletions, and modifications of library files.

An integrated source code development subsystem supporting C, Fortran, Java, and C++, other programming languages used in the SCADA/DMS shall provide a software configuration management system to define the elements and the associated attributes of the applications provided in the SCADA/DMS. Source definitions for all elements of an application shall be maintained in disk files under a code management system. As a minimum, the code management system shall:

- 1) Manage source code and binary images
- 2) Allow tracking of code changes by date, author, and purpose
- 3) Manage documentation modules and associate them with source code, binary images, and other documentation
- 4) Support multiple teams of programmers working concurrently on the same modules
- 5) Provide an efficient link between modules

## 4.6 Database Development software

The databases organization shall be designed to meet the following major functional requirements:

- Data consistency,
- Compliance with the system performance requirements including both response times
- and expansion capabilities,

A Database development software shall be provided which shall contain database structure definitions and all initialisation data to support the generation of all relational , real time database (RTDB)-non-relational run-time databases required to implement the functions of SCADA/DMS system. All the facilities required for generating, integrating and testing of the database shall be provided with the SCADA/DMS system. The delivered SCADA/DMS database shall be sized for the ultimate system as described in this Specification. The database development facility shall be available on development system comprising of server & workstation. Once the database creation/ modification activity is over, the compiled runtime executables shall be downloaded to all respective machines. Executing the database generating functions shall not interfere with the on-line SCADA/DMS functions.

The database development function shall locate, order, retrieve, update, insert, and delete data; ensure database integrity; and provide for backup and recovery of database files. The database development function shall generate and modify all SCADA/DMS data by interfacing with all database structures. The location of database items shall be transparent to the user performing database maintenance.

Extensive reasonability, integrity, and referential integrity checks shall be made on user entries to detect errors at the time of entry. Invalid entries, such as entering an invalid data type or attempting to define contradictory characteristics for a database item, shall be detected and reported to the user in an error message. All error messages shall be in plain English. The user shall not be required to repeat steps that were correctly executed prior to the erroneous action. Help displays shall be available to provide additional, detailed information to the user on request.

All newly defined points shall be initially presented to the user with default values for all parameters and characteristics where defaults are meaningful. It shall also be possible to initialise a new database point description to an existing database point description. The user shall be guided to enter new data, confirm existing data, and change default values as desired.

All required entries for any database item selected for changes shall be presented to the user. When parameters are entered that require other

parameters to be specified, the additional queries, prompts, and display areas required to define the additional parameters shall be presented automatically.

- (a) Add, modify, and delete telemetered, non-telemetered, or calculated database items and data sources such as RTUs/ FRTUs / FPI, data links, and local I/O.
- (b) Add, modify, and delete application program data
- (c) Create a new database attribute or new database type
- (d) Resize the entire database or a subset of the database
- (e) Redefine the structure of any portion of the database.

The database tool for creation, editing, generation, export, import of ICCP database including complete definition, association, bilateral tables, objects etc shall be provided.

#### **4.6.1 Run-Time Database Generation and Maintenance**

The database development software shall generate incremental database changes as well as run-time (loadable) databases from the global source database (user entered database) Incremental structure changes in the source database such as addition of a bay or a substation shall not require regeneration of the entire run-time database. Based on the nature of the change, the database development software shall determine which portion of the database must be regenerated and which displays, reports, and software functions must be re-linked.

All errors that were not detected during data entry time but are encountered during run-time database generation shall be flagged. The database generation routines shall continue processing the database in an effort to detect all errors present in the database before terminating the generation task.

##### **4.6.1.1 Data Retention**

The database generation process shall retain and utilize data from the current SCADA/DMS database in the newly generated database, even when a newly generated database contains structure changes. Data to be retained across database generation cycles shall include, but not be limited to, quality codes, manual entries, tags, historical data, and tuning parameters.

##### **4.6.1.2 Making Database Online**

After an error-free database generation, the user shall be able to test the database in an off-line server prior to its use in an on-line server. The previous run-time database of the server shall be archived such that it is available to replace the new database upon demand. The archived database shall be deleted only when directed by the user.

Newly generated run-time databases shall only be placed on-line by user command. Following the assignment of a new database to a server and on user demand, the database management software shall access each SCADA/DMS server to ensure that all databases are consistent. Inconsistencies shall be annunciated to the user.

#### **4.6.1.3 On-Line Database Editing**

Selected database management functions and changes to a run-time database shall be possible without requiring a database generation. These shall be limited to viewing functions and changes to the contents, but not the structure of the database. On-line changes shall be implemented in all applicable SCADA/DMS run-time databases without system downtime. Changes shall also be implemented in the global database to ensure that the changes are not lost if a database regeneration is performed. On-line database editing shall not affect the SCADA/DMS system's reaction to hardware and software failures nor shall it require suspension of exchange of data among servers for backup purposes.

#### **4.6.1.4 Tracking Database Changes**

The database manager utility shall maintain Audit trail files for all changes made by all users. The audit trails shall identify each change including date and time stamp for each change, and identify the user making the change. An audit trail of at least last 2 months shall be maintained and another audit trail maintaining records of who/when performed the edit operation shall be maintained for a period at least 2 months.

#### **4.6.1.5 Initial Database Generation**

The initial database shall contain all data required by the SCADA/DMS systems. Default values shall be used in consultation with the employer for data that is not provided by employer. Population and maintenance of the distribution network model should be possible by using the database maintenance tools to build the database from scratch. In addition if required data already exists within the Employer's corporate Geographic Information System (GIS) as a part of R-APDRP scheme or otherwise, the SCADA/DMS database functions should leverage this effort by providing an interface/adaptor to extract GIS data using the CIM international standard IEC 61970/61968 and automatically generate the complete Network Operations Model. The data extracted should include network device information, connectivity, topology, nominal status and non-electrical data such as cable ducts, landbase data etc. Further Land base data can be sourced from GIS in Shape files or DXF.



## 4.7 Display Generation and Management

SCADA/DMS displays shall be generated and edited using interactive display generation software delivered with the system. The display generator shall be available on development system & once the display/ displays creation/ modification activity is complete, the compiled runtime executables shall be downloaded on all workstations/servers.

The display editor shall support the important construction options like:

- Copy/move/delete/modify,
- Building at different zoom level,
- Linking of any defined graphics symbol to any database point,
- Pop-up menus,
- Protection of any data field on any display against user entry based on log-on
- identifiers
- Activation of new or modified displays for any application or across all applications of the system by a simple command that causes no noticeable interruption of on-line DMS system activity.

All displays, symbols, segments, and user interaction fields shall be maintained in libraries. The size of any library and the number of libraries shall not be constrained by software. The display generator shall support the creation, editing, and deletion of libraries, including copying of elements within a library and copying of similar elements across libraries. A standard set of libraries and libraries of all display elements used in the delivered SCADA/DMS system shall be provided.

Displays shall be generated in an interactive mode. The user shall be able to interactively:

- (a) Develop display elements
- (b) Link display elements to the database via symbolic point names
- (c) Establish display element dynamics via database linkages
- (d) Define linkages to other displays and programs
- (e) Combine elements and linkages into display layers
- (f) Combine display layers into displays.

The display generation, compilation & loading shall not interfere with the on line SCADA/DMS functions.

All user interface features defined in this Specification shall be supported by the display generator.

#### **4.7.1 Display Elements**

The elements available to create a display shall consist of graphic primitives symbols, segments, User Interaction Field and layers. These elements shall be available to be linked to the SCADA/DMS functions and dynamically transformed on the display as governed by linkages to the database.

##### **4.7.1.1 Segments**

The display generator shall support the construction of display segments consisting of symbols, primitives, and dynamic linkages to the database and user interface. Typical uses of display segments are pull-down menus, bar charts, and common circuit breaker representations. The display generator shall be able to save display segments in segment libraries for later use. The SCADA/DMS system shall include a base library of segments commonly used by display builders.

The display generator shall support the addition, deletion, and modification of segments, including the merging of one segment with another to create a new segment. Segment size shall not be limited. Segments shall be defined at an arbitrary scale factor selected by the user.

##### **4.7.1.2 Dynamic Transformation Linkages**

Dynamic transformations shall be performed on symbols and display segments based upon dynamic linkages to database variables. All linkages to the database shall be defined via symbolic point names. Each symbol or segment stored in a library shall include its dynamic transformation linkages, although the specific point names shall be excluded. Dynamic transformation linkages shall support the dynamic data presentation.

#### **4.7.2 Display Generation and Integration**

The displays shall be constructed from the display elements described above. The display definition shall allow displays to be sized to meet the requirements of the SCADA/DMS application for which they are used; displays shall not be limited by the size of the viewable area of the screen. The display generation software shall allow unbroken viewing of the display image being built as the user extends the size of the display beyond the screen size limits. Each display shall include the display coordinates definition that will permit a user to navigate successfully to the portion of the display that is of interest.

It shall be possible for a user to build a new display starting with a blank screen or an existing display. The definition of each layer shall include a range of scale factors over which the layer shall be visible. The display generator shall also support manual control of layer visibility, where the user of the display shall determine the layers on view. Each display may incorporate manually and automatically (by scale factor) displayed layers. The user shall also define the

periodic update rate of the dynamic information on the display and any programs called before or after presentation of the display.

The display generator shall support the integration of new and edited displays into the active display library. During an edit session, the display generation software shall allow the user to store and recall any display. To protect against loss of display work when computer fails, the current work shall be automatically saved every 5 minutes (user adjustable) to an auxiliary memory file.

The display generator shall verify that the display is complete and error-free before integrating the display into the active display library. A copy of previous display library shall be saved & protected and it shall be brought back on line or can be deleted upon user request.. It shall not be necessary to regenerate any display following a complete or partial system or database generation unless the database points linked to the display have been modified or deleted.

#### **4.7.2.1 Imported CADD Drawings**

The display generator shall support the import of drawings, including power system one-line diagrams, developed by owner on Computer Aided Drafting and Design (CADD) systems. The drawings may be used in the SCADA/DMS system as the static background for displays. The display generator shall provide the capability to add, delete, and modify the dynamic information supplied to the drawings using the specified features of the display generation and management software. As necessary, employer will replace the static background by importing a new drawing from the CADD system and re-linking associated database elements. The display generator shall allow a user to update the dynamic information to reflect any changes required by the updated drawing.

### **4.8 Report Generation Software**

The SCADA/DMS system shall include report generation software to generate new report formats for SCADA/DMS and edit existing report formats. The user shall be guided in defining the basic parameters of the report, such as the report database linkages as symbolic point names, the report format, the report activation criteria, the report destination (workstation, printer, or text file), and the retention period for the report data.

The user shall be able to construct periodic reports and ad-hoc queries via interactive procedures. The capability to format reports for workstations and printers shall be provided. The user shall be able to specify the presentation format for periodic reports and ad-hoc query reports as alphanumeric display format, graphical display format, or alphanumeric printer format. The user shall be able to specify that processing functions, such as summations and other arithmetic functions, be applied to portions of the report data when the report is processed for display, printing, or file storage. The software shall provide for generation of reports that are the full character width of the printers and that use all of the printer's capabilities, such as font sizes and styles and print orientation.

For report data editing, the user shall be able to obtain the data from a retained report, modify the data, repeat the inherent data calculations, reprint the report, and save it in a report retention file on auxiliary memory without destroying the original report.

The user shall also be able to access a retained report, modify its point linkages to the database, modify its format, and save it in a report retention file on auxiliary memory as a new report without destroying the original report.

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

#### **4.9 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 executables and the executables 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 restore the system from the backup tapes/CDs etc. The DR system shall always have updated set of system build . It shall be synchronised with the SCADA/DMS control centre .

#### **4.10 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 are 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.

##### **4.10.1 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.

#### **4.10.2 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.

#### **4.10.3 Failure Analysis Utility**

Failure analysis Utility shall be provided to produce operating system and application program status data for analysing 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.

#### **4.10.4 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.

#### **4.10.5 System utilisation Monitoring Utility**

Software utility shall be provided in each server and workstation to monitor hardware and software resource utilisation 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.

#### **4.10.6 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.

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## Section -2

### HARDWARE REQUIREMENTS FOR SCADA/DMS

#### 5.0 Introduction

This section articulates the hardware requirements for the SCADA/DMS system . The conceptual hardware configuration diagram of SCADA/DMS control centre . The bidders are encouraged to optimise 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

detailed bill of quantities for SCADA/DMS . 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. The Bidder shall offer the minimum hardware configuration as specified here for various equipment, however if required, higher end hardware configurations shall be offered to meet all the requirements of the technical specification. The redundant hardware such as servers (Except DTS, development server) , CFE, etc shall work in hot standby manner. If the SCADA/DMS control centre is collocated with R-APDRP DC/DR centre, then IT infrastructure under R-APDRP such as LAN/WAN security & networking hardware shall be used. However, it is necessary to ensure that the functional requirements , availability & performance aspects are met as per SCADA/DMS system specification of R-APDRP

#### 5.1 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

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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 alongwith 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 alongwith 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.

## **5.2 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 used for 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 includes Operator Workstations, WAN router, LAN, Printer, , Time and Frequency system, External Auto loader, External Cartridge Magnetic tape drive, VPS, RTU/FRT U etc.

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### 5.2.1 Servers

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

**A) Application server**

- SCADA/DMS
- ISR
- NMS
- Web server

**B) Communication server**

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

**C) De –militarized server (DMZ)**

- web server with load balancing

**D) Training & development system server**

- DTS #
- Developmental server #

**E) Data recovery**

- DR/ Communication server ^

The minimum hardware configuration of the servers shall be:

- 2.4 GHZ each processor (in case the offered server is RISC & EPIC based processor speed shall be at least 1.2GHz)
- Minimum 2 Processors
- 8GB Main memory (RAM) For servers\* 4GB Main memory (RAM)
- 216 GB Auxiliary memory (Hard disk drive)/For servers \* 144 GB Auxiliary memory (Hard disk drive)
- 160/320GB Cartridge magnetic tape drive (DAT) or MO disk
- CD R/W drive
- 19" TFT colour monitor
- Keyboard & Mouse
- Dual 10/100/1000Mbps Ethernet ports (Single for DTS & Developmental server #)
- One hot pluggable port for external Cartridge magnetic tape drive
- TPC/ Spec mark performance compliance
- redundant power supply
- redundant fan

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

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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 TFT monitor, keyboard, and mouse through KVM switch with retraceable tray.

### **5.2.1.1 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 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 section 8.

- 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: Fibre 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

### **5.2.1.2 Communication Servers:**

#### **5.2.1.2.1 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

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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 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

#### **5.2.1.2.2 ICCP Server /inter control centre communication server**

Depending upon the protocol i.e ICCP or other intercontrol centre protocol used as permissible as per this specification for, the server shall be called as ICCP or inter control centre communication server. The redundant ICCP/*inter control centre communication server* servers shall be installed at each SCADA/DMS control centres of eligible towns of the state and DR centre & shall be used to retrieve, transmit and process data to and from remote sources i.e. remote control centres. Data retrieved and processed from remote sources may be 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 State Load Dispatch Centres (SLDC) of the state where scheme will be implemented for exchange of scheduling data.

#### **5.2.1.2.3 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.

#### **5.2.1.2.4 Web servers with Active directory :**

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

#### **5.2.1.3 Demilitarized/ Security servers**

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#### **5.2.1.3.1 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.

#### **5.2.1.3.2 Firewall:**

Two firewalls shall be provided, one between Web servers & SCADA/DMS dual LAN and another between Web servers & Web 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.

#### **5.2.1.4 Training & development system server**

##### **5.2.1.4.1 DTS server ;**

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

##### **5.2.1.4.2 Development server**

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

#### **5.2.1.5 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

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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 section 8.

- 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: Fibre 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

### **5.2.2 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/update 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:

- 2.4 GHz processor (in case RISC & EPIC it shall be at least 1.2GHz)
- 2 GB Main memory (RAM)
- 144 GB Auxiliary memory (Hard disk drive)
- 48x24x48 CD-R/W drive
- 21" TFT colour monitors
- Graphic adaptor cards
- Two speakers for audible alarms with configurable tones
- Keyboard & Mouse
- Dual 10/100/1000Mbps Ethernet ports
- One hot pluggable for external Cartridge magnetic tape drive
- Parallel, serial and USB (2.0) ports to accommodate printers, mouse and other peripherals

The specification of Remote VDU is same as of workstation for SCADA/DMS system mentioned above, except, it shall have suitable software & hardware to facilitate remote VDU user 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.

### 5.2.3 TFT colour monitor

The TFT monitor shall have flat panel colour screen. The following is the minimum characteristics of TFT colour 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	Dot Pitch	0.294 mm	0.28 mm
4	Resolution	1280x1024 minimum	1280x1024 minimum
5	Colour support	16 million	16 million
6	Refresh rate	Minimum 75Hz	Minimum 75Hz
7	On screen control	Yes	yes
8	Anti glare & anti static	Yes	yes
9	Tilt , Swivel	yes	yes

### 5.2.4 WAN router

Wan router shall be required for data exchange of SCADA /DMS control centres with DR centre , their respective IT system of R-APDRP system ( IT Data centre, ITDR centre)

, remote VDUs and LDMS & SLDC optional. The data exchange between the two centres 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

WAN Routers shall be required for data exchange of SCADA/DMS control centres with RTUs at various locations in the respective town, SCADA/DMS DR centre, LDMS & SLDC ,Utility's respective IT system of R-APDRP system ( Data centre, DR centre, customer care centre, Utility's Head Quarter and various other offices), remote VDUs etc. The data exchange between the two centres shall be primarily over MPLS based secured network using TCP/IP on various mediums as per the requirement and

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availability in the respective project area viz FO, radio, V-SAT etc . The router shall support the OSI and TCP/IP protocols.

The Routers shall be compatible with Owners existing MPLS based Wide Area Network created/ to be created under RAPDRP IT infrastructure. The Wide Area Links are planned for 2Mbps or higher Bandwidth capacity from ISPs (BSNL, MTNL or any other ISP)

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 8MB and upgradable upto 72MB

SDRAM: Minimum 64MB and upgradable upto 320MB

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 10/100M 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 atleast 100% additional number of free ports for future scalability

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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 & Annex.D & 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

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.

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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 (InterGroup 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: 200 Kpps or higher as per utility requirement at site

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

### 5.2.5 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, 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 centre 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



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- 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.,)

### **5.2.6 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 except Logger 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) Colour inkjet printer**

Colour 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 colour & 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 coloured 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**

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

- shall be colour laser printer
- have speed of at least 10 pages per minute for A3 & 17 pages for A4 in color
- 600 X 600 dpi
- Landscape and portrait output orientation
- Duplex printing
- Memory buffer of at least 128 Mbyte

### **5.2.7 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 centre. 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  $\pm 1.5$  microsec. 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 DD: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 conforming to ITU-T G.703) synchronization interface to meet the time synchronization requirement of the communication system. This interface shall conform 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.

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### **5.2.8 External Cartridge Magnetic tape drive**

One external 4mm DAT, 160/320 GB Cartridge magnetic tape drive shall be supplied for taking Backups and performing restores of the Hard disks of any computer. The external tape drive shall have hot-pluggable port for connection to any computer. Bidder may also provide equivalent Magneto Optical (MO) –disk in place for DAT drive (Cartridge magnetic tape drive)

### **5.2.9 Digital Light Processing (DLP) based Video Projection System**

The contractor shall provide a video projection system based on modular DLP (Digital Light Processing) technology. All the screen modules of the VPS system, shall be suitable to 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 2x3 matrix with each module minimum 67" diagonal
- 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 1024X768 pixels per module. The rear projection screens shall be capable of displaying full resolution of the 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. The half gain angle shall be at least 40 degrees with a tolerance of  $\pm 5$  degrees for both horizontal & vertical directions.

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- h) 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.
  - i) The projection bulb (lamp) shall have an average operating life of 9,000 hours (typical).
  - J) Centre to corner brightness shall be generally uniform.
  - K) The configuration of the VPS (no. of screens and size of each screen) is defined in the BOQ.
  - L) The VPS controller shall have audio-video signal input module to interface with video conferencing equipment, CCTV, VCD/DVD players. The VPS controller shall support three types of video signal inputs (PAL, SECAM, NTSC).

### **5.2.10 Furniture**

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

### **5.3 Auxiliary Power Supply for Computer systems**

The computer system should be suitable for operation with single-phase, 230  $\pm 10\%$  Vac, 50  $\pm 5.0\%$  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 its 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.

### **5.4 Environmental Conditions**

Equipment to be located in the SCADA/DMS control centre 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..

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## **5.5 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.

## **5.6 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 cabling.

## **5.7 Assembly and Component Identification**

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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.

### **5.8 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.

### **5.9 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) Magnetic cartridges (DAT)/ MOdisks
- (b) Printer paper
- (c) Printer toner, ink. Ribbons and cartridges
- (d) Special cleaning materials
- (e) CDs/DVDs

### **5.10 Certain criteria for Hardware /Configuration**

- 1. Each state can have maximum 1 DTS.
- 2. Each state can have maximum 1 common DR centre
- 3. One operator workstation shall be considered per 10 S/S at SCADA/DMS control centres. However, for locations less than 20 S/S shall have 2 operator workstation as minimum.
- 4. Remote VDUs shall be required at one each at HQ , Division, IT office & LDMS at S/S

## Section 2 CONFIGURATION & SYSTEM AVAILABILITY

### 6.0 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.

### 6.1 System Redundancy

The SCADA/DMS system envisages some functions as critical functions and others as non-critical functions as defined above. 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, ICCP, Communication servers, ISR application, servers for DMZ/ security system systems, DR and shall be configured as 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: 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 centre.
- (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.
- (h) DAT Magnetic tape autoloader shall be non redundant drive
- (i) 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.

### 6.2 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.

### 6.3 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

### 6.4 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.



## **6.5 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.

## **6.6 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 savecases.
- (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.

## **6.7 Error Detection and Failure Determination**

All servers, peripheral devices, on-line software functions, and maintenance functions in SCADA/DMS 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.

## **6.8 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.

## **6.9 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 system.

## **6.10 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 primary server 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.

## **6.11 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.

## **6.12 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.

## **6.13 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.

## **Section 2, TESTING & DOCUMENTATION**

### **7.0 General**

This section describes the specific requirements for testing and documentation of the SCADA/DMS system. The general requirements of testing and documentation are covered in **Section 7**.

#### **7.1 Type testing –**

Equipments wherever mentioned in the specification for type testing shall conform to the type tests listed in the relevant chapters. Type test reports of tests conducted in NABL accredited Labs or internationally accredited labs within last 5 years 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.

#### **7.2 Factory Acceptance Tests (FAT)**

The SCADA/DMS system including DR centre (DR is part of the project area) shall be tested at the Contractor's facility. All hardware and software associated with the SCADA/DMS system and at least two RTUs along with LDMS & 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), IT system under R-APDRP, SLDC 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.

##### **7.2.1 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 hardware documentation. All the SCADA/DMS system hardware shall be integrated and staged for testing. Applicable hardware diagnostics shall be used to verify the hardware configuration of each equipment. The complete hardware & software bill of quantity including software licenses & deliverables on electronic media shall also be verified.

##### **7.2.2 System Build test**

After completion of hardware integration test, the SCADA/DMS system shall be built from the backup software on electronic media (CDs/Magnetic Tapes) to check the completeness of backup media for restoration of system in case of it's crashing/failure. The software deliverables shall include one copy of backup software on electronic media.

### 7.2.3 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 softwares 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 CIM compliance
- (i) Verification of Security & Encryption using SSL for all FRTU/FPI connectivity
- (j) Verification of Data Integration from SCADA/DMS system other systems viz IT Systems etc over Open Standards over CIM/XML, IEC 61968 Series Standards, OPC, ICCP etc.,
- (k) Verification of Integration between GIS / SCADA/DMS System over OAG, CIM/XML or tight Native Integration, that enables updates within GIS to percolate over ESB / SOA to IT Systems
- (l) Verification of data exchange with other systems

- (m) Verification of interoperability profile of all profiles of all protocols being used.
- (g) Verification of RTU /FRTU/FPI communication interfaces
- (h) Verification of LAN and WAN interfaces with other computer systems
- (i) Testing of all user interface functions, including random tests to verify correct database linkages
- (j) Simulation of hardware failures and input power failures to verify the reaction of the system to processor and device failure
- (k) 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.
- (l) Demonstration of the software utilities, libraries, and development tools.
- (n) (m) Verification that the SCADA/DMS computer system meets or exceeds employer's performance requirements (as per table for peak & normal loading in section 8 Verification of Design parameters as mentioned in section 8 & wherever defined in the specification.
- (o) Verification that ultimate expansion requirements are met.
- (p) Verification of DTS (if it is in the project area)
- (q) Verification of Development system
- (r) Verification of data transfer of main to back up SCADA/DMS system.
- (s) Functions of DR system , if it is in the project area.
- (s) 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)

#### **7.2.4 Continuous operation Test (48 hours)**

This test shall verify the stability of the SCADA/DMS 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 viz. R-APDRP IT system 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 are observed , the Contractor shall rectify the problem and repeat the test.

### **7.3 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.

#### **7.3.1 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 through 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 equipments
- (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

#### **7.3.2 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 system
- (b) the RTU /FRTU/FPI communication channel monitoring in the SCADA/DMS 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.

#### **7.3.3 Field Performance Test**

The field performance test shall concentrate on areas of SCADA/DMS 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

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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 i.e R-APDRP IT , SLDC, DR system with SCADA/DMS system
- (b) Mapping of SCADA/ISR database with other system database viz R-APDRP IT , SLDC, DR 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 system
- (f) Verify the execution rates of all SCADA/DMS 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 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

#### **7.4 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 system (hardware and software) integrated with its RTUs/FRTU/FPIs and R-APDRP IT SYSTEM . However, the non-availability of RTUs/Data Concentrators/ FRTU/FPI , R-APDRP

–IT system etc & Communication System shall not be considered for calculating system availability. However , RTU/FRTU, communication equipments , 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 99.5% 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 99.5%, 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 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 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 system shall be considered as available if

- a) one of the redundant hardware is available so that all the SCADA/DMS applications are functional to ensure the design & performance requirement as envisaged in the specification
- b) atleast one of the operator console is available
- c) atleast 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 applications are available
- f) All SCADA/DMS 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

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.

#### **7.4.1 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.

#### **7.4.2 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 of an equipment, Power failure to the equipment, Communication link failure.

#### **7.5 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 customised 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 customisation
- 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 CIM/XML Adapters & Messaging Interfaces.
- y) Cyber Security Plan & Mitigation document 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 system on electronic media and two copies of these backup software shall be submitted to the owner.

## **SECTION 3**

### **TECHNICAL REQUIREMENTS OF RTU**

#### **1.0 General**

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

#### **1.1 Design Standards**

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

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

#### **1.2 RTU Functions**

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

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

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

- (d) IEC 60870-5-104 protocol to communicate with the Master station(s) , IEC 60870-5-101 for slave devices. & MODBUS protocol over RS485 interface , to communicate with the MFTs.
- (e) RTU shall have the capability of automatic start-up and initialisation following restoration of power after an outage without need of manual intervention. All restarts shall be reported to the connected master stations.
- (f) Remote database downloading of RTU from master station/SCADA/DMS control centre
- (g) Act as data concentrator on IEC60870-5-101/104/MODBUS protocols
- (h) Internal battery backup to hold data in SOE buffer memory & also maintaining the time & date.
- (i) As the SCADA/DMS system will use public domain such GPRS/CDMA etc, therefore it mandatory to guard the data/ equipment from intrusion/damage/breach of security & shall have SSL/VPN based security.
- (j) Shall have SNMP

**Support Feature:**

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

- a)** Support for Analog output in form of standard current loops viz 4-20Ma etc
- b) Support for IEC 60870-5-103, IEC 61850 protocols & ability to act as a gateway for Numerical relays may have to be interfaced in future with numerical relays with future vision of Smart grid.
- c) Have required number of communication ports for simultaneous communication with Master station(s), /MFTs and RTU configuration & maintenance tool.
- (d) PLC support
- (e) Communication with at least two master stations simultaneously on IEC 60870-5-104
- (f) Receiving and processing analog commands from master station(s) and Capability of driving analog output card.
- (g) RTU shall be capable of acquiring analog values through transducers having output as 4-20 mA, 0-10 mA, 0-+10 mA or +/- 5 volts etc using analog input modules.
- (h) Capability of time synchronisation with GPS receiver which may be required future at the time of SMART GRID.

### 1.3 Communication ports

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

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

It shall be possible to increase the number of communication ports in the RTU by addition of cards, if required in future. The RTU shall support the use of a different communication data exchange rate (bits per second) and scanning cycle on each port & different database for each master station. FRTUs & FPIs shall be communicating to SCADA/DMS Master control using IEC60870-5-104 /101 protocol over GPRS/CDMA/Radio .

#### 1.3.1 Master Station Communication Protocol

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

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



### 1.3.2 Communication Protocol between RTU & MFTs

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

### 1.4 Analog Inputs

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

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

The RTU analog-to-digital (A/D) converters shall have a digital resolution of at least twelve (12) bits plus sign. The overall accuracy of the analog input system shall be at least  $\pm 0.2\%$  (i.e. 99.8%) at 25 °C of full scale . Mean accuracy shall not drift more than 0.002% per degree C within the temperature range of –5 to +55 degree Linearity shall be better than  $\pm 0.05\%$ . The RTU shall be designed to reject common mode voltages up to 150 Vac (50 Hz). For dc inputs, normal mode noise voltages up to 5 Vac shall be rejected while maintaining the specified accuracy. Each input shall have suitable protection and filtering to provide protection against voltage spikes and residual current at 50 Hz, 0.1 ma (peak-to-peak) and overload. Loading upto 150% of the input value shall not sustain any failures to the RTU input.

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

Unipolar Voltage: 0-0.5V, 0-1V, 0-5V, 0-10V,

Unipolar Current: 0-1mA, 0-10mA, 0-20mA, 4-20Ma,

Bipolar Voltage: 0.5V, 2.5V, 5V, -20-0-20mA (- to +)

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

## 1.5 Status input

RTU shall be capable of accepting isolated dry (potential free) contact status inputs. The RTU shall provide necessary sensing voltage, current, optical isolation and de-bounce filtering independently for each status input. The sensing voltage shall not exceed 48Vdc.

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

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

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

The Double point status input will be from two complementary contacts (one NO and one NC) which is represented by 2-bits in the protocol message. A switching device status is valid only when one contact is closed and the other contact is open. Invalid states shall be reported when both contacts are open or both contacts are closed.

All status inputs shall be scanned by the RTU from the field at 1 millisecond periodicity.

## 1.6 Sequence of Events (SOE) feature

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

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

## **1.7 IED pass through**

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

## **1.8 PLC capability**

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

## **1.9 Control Outputs**

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

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

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

### **1.9.1 Heavy duty control output relays**

The control output contact from the RTU shall be used for initiating heavy duty relays for trip/close of switching devices and energising relays of OLTC raise lower. The contractor shall provide heavy duty relays. Each control output relays shall consist of atleast 2 NO contacts. The output contacts shall be rated for at least 5 Amps Continuous at 220Vdc and shall provide arc suppression to permit interruptions of an inductive load. Relay coils shall be shunted with diodes to suppress inductive transients associated with energizing and de-energizing of the relay coils. The relays shall conform to the IEC255-1-00 and IEC 255-5 requirements.

### **1.9.2 Control Security and Safety Requirements**

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

- (a) Select- check-before-operate operate (SCBO) sequence for control output.
- (b) No more than one control point shall be select ed/executed at any given time.
- (c) The control selection shall be automatically cancelled if after receiving the "control selection" message, the "control execute" command is not received within the set time period.
- (d) No control command shall be generated during power up or power down of RTU.

### **1.9.3 Local/Remote selector switch**

A manual Local/Remote selector switch shall be provided for each RTU to disable all control outputs by breaking the power supply connection to the control output s. When in the "Local" position, the Local/Remote switch shall allow testing of all the control outputs of RTU without activating the control outputs to field devices. A status input indication shall be provided for the Local/Remote switch to allow the SCADA system to monitor the position of the switch.

### **1.9.4 Dummy breaker latching relay**

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

### **1.10 Contact Multiplying Relays (CMRs)**

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

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

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

The relay shall conform to following requirement.

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

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

#### **1.11 Time facility**

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

#### **1.12 Diagnostic Software**

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

#### **1.13 SCADA language based on IEC61131-3**

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

#### **1.14 Input DC Power Supply**

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

- (a) Nominal voltage of 48 Vdc with variation between 40.8 and 57.6 Vdc.(i.e. 48(+20%/-15%)
- (b) Maximum AC component of frequency equal to or greater than 100 Hz and 0.012 times the rated voltage peak-to-peak.

The RTU shall have adequate protection against reversed polarity, over current and under voltage conditions, to prevent the RTU internal logic from being damaged and becoming unstable causing mal-operation. The specification for DCPS is given in respective section of MTS.

### **1.15 Environmental Requirements**

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

### **1.16 RTU Size and Expandability**

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

### **1.17 RTU Panels**

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

- (a) shall be free-standing, floor mounted and height shall not exceed 2200 mm. All doors and removable panels shall be fitted with long life rubber beading. All non load bearing panels/doors shall be fabricated from minimum 1.6 mm thickness steel sheet and all load bearing panels, frames, top & bottom panels shall be fabricated from minimum 2.0 mm thickness steel sheet
- (b) shall have maintenance access to the hardware and wiring through lockable full height doors.
- (c) shall have the provisions for bottom cable entry
- (d) The safety ground shall be isolated from the signal ground and shall be connected to the ground network. Safety ground shall be a copper bus bar. The contractor shall connect the panel's safety ground of to the owner's grounding network. Signal ground shall be connected to the communication equipment signal ground.

- (e) All panels shall be supplied with 230 Vac, 50 Hz, single-phase switch and 15/5A duplex socket arrangement for maintenance.
- (f) All panels shall be provided with an internal maintenance lamp, space heaters and gaskets.
- (g) All panels shall be indoor, dust-proof with rodent protection, and meet IP41 class of protection.
- (h) There shall be no sharp corners or edges. All edges shall be rounded to prevent injury.
- (i) Document Holder shall be provided inside the cabinet to keep test report, drawing, maintenance register etc.
- (j) All materials used in the enclosures including cable insulation or sheathing, wire troughs, terminal blocks, and enclosure trim shall be made of flame retardant material and shall not produce toxic gasses under fire conditions.

#### **1.18 Wiring/Cabling requirements**

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

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

- a) All cables shall have stranded copper conductor.
- b) Minimum core cross-section of 2.5 mm<sup>2</sup> for PT cables, 4 mm<sup>2</sup> for CT cables, if applicable and 2.5 mm<sup>2</sup> for Control outputs and 1.5mm<sup>2</sup> for Status inputs
- c) Rated voltage U<sub>o</sub>/U of 0.6/1.1KV
- d) External sheathing of cable shall have oxygen index not less than 29 & temperature index not less than 250. Cable sheath shall meet fire resistance test as per IS 1554 Part- I.
- e) Shielding, longitudinally laid with overlap.
- f) Dielectric withstand 2.5 kV at 50 Hz for 5 minutes

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

Armoured. Cables shall be used in the area where cable will pass through open area which may experience loading.

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

### **1.19 Terminal Blocks (TBs)**

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

All terminal blocks shall be suitably arranged for easy identification of its usages such as CT circuits, PT circuits, analog inputs, status inputs, control outputs, auxiliary power supply circuits, communication signals etc. TBs for CT circuits shall have feature for CT shorting (on CT side) & disconnection (from load side) to facilitate testing by current injection. Similarly, TBs for PT circuit shall have feature for disconnection to facilitate voltage injection for testing.

### **1.20 RTU Architecture**

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

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

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

### **1.21 LOCAL DATA MONITORING SYSTEM (LDMS)**

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



## SECTION 3

### TECHNICAL REQUIREMENTS OF FRTU

#### 2.0 General

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

#### 2.1 Design Standards

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

#### 2.2 FRTU Functions

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

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

- (a) Acquiring analog values from Multifunction Transducers or alternatively through transducer-less modules and the status inputs of devices from the substation, processing and transmitting to Master stations. Capability to acquire analog inputs from analog input cards receiving standard signals viz current loops 4-20Ma, RTD etc.
- (b) Receiving and processing digital commands from the master station(s)
- (c) Data transmission rates - 300 to 19200 bps for Serial ports for MODBUS. and 10/100 mbps for TCP/IP Ethernet ports
- (e) Use of IEC 60870-5-104/101 protocol to communicate with the Master station(s)
- (i) Use of MODBUS over RS485 interface, Protocol to communicate with the MFTs.
- (j) Have required number of communication ports for simultaneous communication with Master station(s), MFTs and FRTU configuration & maintenance tool.

- (k) FRTU shall have the capability of automatic start-up and initialisation following restoration of power after an outage without need of manual intervention. All restarts shall be reported to the connected master stations.
- (l) Remote database downloading of FRTU from master station from SCADA/DMS control centre
- (m) internal battery backup to hold data in SOE buffer memory & also maintaining the time & date.
- (n) As the SCADA/DMS system will use public domain such GPRS/CDMA etc, therefore it mandatory to guard the data/ equipment from intrusion/damage/breach of security & shall have SSL/VPN based security.
- (o) Shall support SNMP

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

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

## 2.3 Communication ports

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

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

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

### 2.3.1 Master Station Communication Protocol

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

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

### 2.3.2 Communication Protocol between FRTU & MFTs

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

## 2.4 Analog Inputs

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

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

The FRTU analog-to-digital (A/D) converters shall have a digital resolution of at least twelve (12) bits plus sign. The overall accuracy of the analog input system shall be at least  $\pm 0.2\%$  (i.e. 99.8%) at 25 °C of full scale. Mean accuracy shall not drift more than 0.002% per degree C within the temperature range of -5 to +55 degree. Linearity shall be better than  $\pm 0.05\%$ . The FRTU shall be designed to reject common mode voltages up to 150 Vac (50 Hz). For dc inputs, normal mode noise voltages up to 5 Vac shall be rejected while maintaining the specified accuracy. Each input shall have suitable protection and filtering to provide protection against voltage spikes and residual current at 50 Hz, 0.1 ma (peak-to-peak) and overload. Loading upto 150% of the input value shall not sustain any failures to the FRTU input.

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

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

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

## 2.5 Status input

RTU shall be capable of accepting isolated dry (potential free) contact status inputs. The RTU shall provide necessary sensing voltage, current, optical isolation and de-bounce filtering independently for each status input. The sensing voltage shall not exceed 48 Vdc/220VAC.

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

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

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

The Double point status input will be from two complementary contacts (one NO and one NC) which is represented by 2-bits in the protocol message. A switching device status is valid only when one contact is closed and the other contact is open. Invalid states shall be reported when both contacts are open or both contacts are closed.

All status inputs shall be scanned by the FRTU from the field at 1 millisecond periodicity.

## 2.6 Sequence of Events (SOE) feature

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

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

the change and store in SOE buffer within the RTU. A minimum of 300 events can be stored in the SOE buffer. SOE shall be transferred to Master Station as per IEC 60870-5-104 protocol. SOE buffer shall be maintained by FRTU on power supply interruption.

## **2.7 Control Outputs**

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

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

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

### **2.7.1 Heavy duty control output relays**

The control output contact from the FRTU shall be used for initiating heavy duty relays for trip/close of switching devices. The contractor shall provide heavy duty relays. Each control output relays shall consist of atleast 2 NO contacts. The output contacts shall be rated for at least 5 Amps Continuous at 220Vdc and shall provide arc suppression to permit interruptions of an inductive load. Relay coils shall be shunted with diodes to suppress inductive transients associated with energizing and de-energizing of the relay coils. The relays shall conform to the IEC255-1-00 and IEC 255-5 requirements.

### **2.7.2 Control Security and Safety Requirements**

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

- (a) Select- check-before-operate operate (SCBO) sequence for control output.
- (b) No more than one control point shall be selected/executed at any given time.
- (e) The control selection shall be automatically cancelled if after receiving the "control selection" message, the "control execute" command is not received within the set time period.
- (f) No control command shall be generated during power up or power down of FRTU.

### **2.7.3 Local/Remote selector switch**

A manual Local/Remote selector switch shall be provided for each FRTU to disable all control outputs by breaking the power supply connection to the control outputs. When in the "Local" position, the Local/Remote switch shall allow testing of all the control outputs of FRTU without activating the control outputs to field devices. A status input indication shall be provided for the Local/Remote switch to allow the SCADA system to monitor the position of the switch.

### **2.7.4 Dummy breaker latching relay**

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

## **2.8 Contact Multiplying Relays (CMRs)**

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

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

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

The relay shall conform to following requirement.

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

The relays coils shall be shunted with diodes to suppress inductive transients associated with energizing and de-energizing of the relay coils. The relays shall conform to the IEC 255-1-00 and IEC 255-5 requirements. The relays must be protected against the effects of humidity, corrosion & provide with a dust tight cover. The connecting terminals shall be screw type & legibly marked. The relays may optionally have a visual operation indicator. The relays are to be mounted in junction /termination box and therefore shall be equipped with suitable mounting arrangements. In case suitable space is not available in junction /termination box the same shall be mounted in FRTU panel.

## **2.9 Time facility**

The internal FRTU time base shall have a stability of 100 ppm. The RTU shall be

synchronised through synchronisation message from master station at every 5 minutes (configurable from 5 minutes to 60 minutes) over IEC 60870-5-104/101/NTP/SNTP

## **2.10 Diagnostic Software**

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

## **2.11 Input DC Power Supply**

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

- (a) Nominal voltage of 48 Vdc with variation between 40.8 and 57.6 Vdc.(i.e. 48(+20%/-15%)
- (b) Maximum AC component of frequency equal to or greater than 100 Hz and 0.012 times the rated voltage peak-to-peak.

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

## **2.12 Environmental Requirements**

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

## **2.13 FRTU Size and Expandability**

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

## **2.14 FRTU Panels**

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

- (a) shall be pole/ wall mounted compact size cabinet. The size shall be preferably in the order of 400 mm. All doors and removable panels shall be fitted with long life rubber beading. All non load bearing panels/doors shall be fabricated from minimum 1.6 mm thickness steel sheet and all load bearing panels, frames, top & bottom panels shall be fabricated from minimum 2.0 mm thickness steel sheet
- (b) shall have maintenance access to the hardware and wiring through lockable doors.
- (c) shall have the provisions for bottom cable entry
- (d) The safety ground shall be isolated from the signal ground and shall be connected to the ground network. Safety ground shall be a copper bus bar. The contractor shall connect the panel's safety ground of to the owner's grounding network. Signal ground shall be connected to the communication equipment signal ground.
- (e) All panels shall be supplied with 230 Vac, 50 Hz, single-phase switch and 15/5A duplex socket arrangement for maintenance.
- (f) All panels shall be provided with an internal maintenance lamp, space heaters and gaskets.
- (g) All panels shall be outdoor, dust-proof with rodent protection, and meet class of protection. IP41 if housed in RMU panel & IP54 in case of in open outdoor.
- (h) There shall be no sharp corners or edges. All edges shall be rounded to prevent injury.
- (j) All materials used in the enclosures including cable insulation or sheathing, wire troughs, terminal blocks, and enclosure trim shall be made of flame retardant material and shall not produce toxic gasses under fire conditions.

## **2.15 Wiring/Cabling requirements**

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

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

- h) All cables shall have stranded copper conductor.



- i) Minimum core cross-section of 2.5 mm<sup>2</sup> for PT cables, 4 mm<sup>2</sup> for CT cables, if applicable and 2.5 mm<sup>2</sup> for Control outputs and 1.5mm<sup>2</sup> for Status inputs
- j) Rated voltage U<sub>0</sub>/U of 0.6/1.1KV
- k) External sheathing of cable shall have oxygen index not less than 29 & temperature index not less than 250. Cable sheath shall meet fire resistance test as per IS 1554 Part- I.
- l) Shielding, longitudinally laid with overlap.
- m) Dielectric withstand 2.5 kV at 50 Hz for 5 minutes
- n) External marking with manufacture's name, type, core quantity, cross-section, and year of manufacture.

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

## **2.16 Terminal Blocks (TBs)**

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

All terminal blocks shall be suitably arranged for easy identification of its usages such as CT circuits, PT circuits, analog inputs, status inputs, control outputs, auxiliary power supply circuits, communication signals etc. TBs for CT circuits shall have feature for CT shorting (on CT side) & disconnection (from load side) to facilitate testing by current injection. Similarly, TBs for PT circuit shall have feature for disconnection to facilitate voltage injection for testing.

## SECTION 3

### 3.0 Transducer & Weather Sensor Requirements:

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

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

Voltage:

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

(c) Impulse Withstand:

IEC 60688 or 60687 compliance is required.

(d) Electromagnetic Compatibility:

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

(e) Permanent Overload Protection:

IEC 60688 or 60687 compliance is required.

(f) Temporary Overload Protection:

IEC 60688 or 60687 compliance is required.

(g) High Frequency Disturbance:

IEC 60688 or 60687 compliance is required.

The transducers shall comply with the following general characteristics:

(a) Shock Resistance:

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

(b) Vibration Strength:

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

(c) Input Circuit Consumption:

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

(d) Reference Conditions For Accuracy Class:

IEC 60688 or 60687 compliance is required.

(e) Temperature Rise:

IEC 60688 or 60687 compliance is required.

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

### 3.1 Multi Function Transducers (MFTs)

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

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

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

Multi function transducers shall accept nominal 48 V DC as auxiliary power supply. Optionally, MFT can be self powered also. Multi function transducer shall be provided with RS485 interface to communicate with RTU over Modbus protocol in multi-drop mode. Optionally, the MFT with IEC60870-5-101/104 can be used.

The MFTs shall be suitable for mounting on DIN rails. The MFT terminals shall

accept upto two 2.5 mm<sup>2</sup> / 4 mm<sup>2</sup> for PT/CT circuit terminations as applicable.

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

### **3.2 DC Transducer**

The DC transducer (DCT) are of two types.

- (i) Voltage
- (ii) Current

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

### **3.3 Transformer Tap Position Transducer**

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

- (i) Variable resistance type
- (ii) Lamp type

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

- (a) The input measuring ranges shall be from 2 to 1000 ohms per step, which is tuneable at site with at least 25 steps.
- (b) Dual output signal of 4 to 20 mA DC, 0.5% accuracy class as per IEC 688 shall be provided. One output will be used for driving a local digital indicator (to be provided by the contractor) and the other will be used for interfacing with the RTU. Alternatively for RTU, MODBUS link may be used.  
In case of lamp type, additional resistance/potentiometer unit shall be provided to convert the dry type contacts to a variable resistance as defined in (a) above, suitable for the remote indication.

## 3.4 Weather Sensors

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

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

### 3.4.1 Wind Speed Sensor

Sensor		Anemometer 3 cup assembly, very robust to withstand strong wind gust.
Output	:	4 to 20 mA at 0-500 ohm impedance or RS 485 with MODBUS protocol
Starting Threshold	:	0.5 m/s or better
Range	:	0.9 - 60 m/s
Resolution	:	0.1 m/s
Accuracy	:	2 % or better
Mechanical	:	3 Cup assembly and housing (complete), should be very robust and capable to withstand strong wind gust and made up of suitable non-rusting material
Mounting Accessories	:	Made of suitable good quality material like steel or high strength fibre.
Operating Temperature	:	0 ° C to + 60 ° C ( -5 ° C to + 55 ° C for project area with snowfall history)

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

#### **3.4.2 Wind Direction Sensor**

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

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

#### **3.4.3 Air Temperature Sensor**

Sensor	:	Air Temperature Sensor
Output	:	4 to 20 mA at 0-500 ohm impedance or RS 485 with MODBUS protocol
Temperature Range	:	0 ° C to + 60 ° C( -5 ° C to + 55 ° C for project area with snowfall history)
Resolution	:	0.1° C
Accuracy	:	≤ 0.5 ° C or better
Radiation Shield	:	Radiation Shield made of weather resistant material and suitable to sensor used.

#### **3.4.4 Relative Humidity Sensor**

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

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

#### **3.4.5 Rainfall Sensor**

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

#### **3.4.6 Atmospheric Pressure Sensor**

Sensor	:	Atmospheric Pressure sensor
Output	:	4 to 20 mA at 0-500 ohm impedance or RS 485 with MODBUS protocol

Range	:	600 mb to 1100 mb
Resolution	:	1 mb or better
Accuracy	:	2 % of range
Operating Temperature Range	:	0 ° C to + 60 ° C( -5 ° C to + 55 ° C for project area with snowfall history)

#### **3.4.7 Weather Sensor Installation Requirement**

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

The Employer will prefer to install the sensors on roof top of control centre/substation or other building. The mounting arrangement for all the sensors shall be designed suitably for installation on the roof top. The mounting arrangement of the Wind Velocity & Wind Direction sensors shall be of suitable height to avoid obstruction from the nearby structures.



## SECTION 3

### TEST EQUIPMENTS FOR RTU/FRTU

#### 4.0 RTU/FRTU Configuration and Maintenance Tool

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

##### 4.1 RTU/FRTU Data base configuration & Maintenance software tool

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

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

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

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

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

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

#### **4.3 Laptop PC for above software tools along with interfacing hardware**

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

## SECTION 3

### TESTING, TRAINING & DOCUMENTATION

#### 5.0 RTU/FRTU Testing

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

(a) Type Testing:

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

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

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

(c) Site Acceptance Test (SAT)

(i) Field Tests

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

(ii) Availability Tests

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

## **5.1 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

## **5.2 DOCUMENTATION**

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

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

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

**Table-1: List of Tests on RTU/FRTU**

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

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

2) \* For RTU only & \*\* For FRTU only

- 3) Contractor can provide test certificates for the type tests mentioned in B,C,D & supporting protocols from Govt of India/NABL/International accredited Labs. If not provided, the same needs to be 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 (Test 33)	ON	Level 3	30 A/m at 1MHz of magnetic field strength			A
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 <sup>0</sup> C for 16 hrs			0
Damp heat test (Test 39)	ON	-	at 95% RH and 40 <sup>0</sup> C			0

**SECTION- 4**  
**AUXILIARY POWER SUPPLY SYSTEM**

## **SECTION- 4**

### **AUXILIARY POWER SUPPLY SYSTEM**

#### **4.0 General**

This section describes the technical requirements for Auxiliary Power Supply System. The BOQ for Auxiliary Power Supply system equipments required for SCADA/DMS control centre, 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 (which ever 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.

#### **4.1 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

##### **4.1.1 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
- b) Inverter unit
- c) Battery Low Voltage Disconnect device
- d) Static bypass switches
- e) Manual maintenance bypass switches
- f) Isolation transformer
- g) Load transformer and filters
- h) Control panels including source selection equipment & ACDBs, automatic controls and protection
- i) Hardware and software as required for parallel operation of two no of UPS 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.

#### **4.1.2 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.

#### **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 to IEC 62040 or equivalent. EN/BS standards for design, performance and EMC requirements.
- The input mains AC supply to the UPS shall be 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, 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:

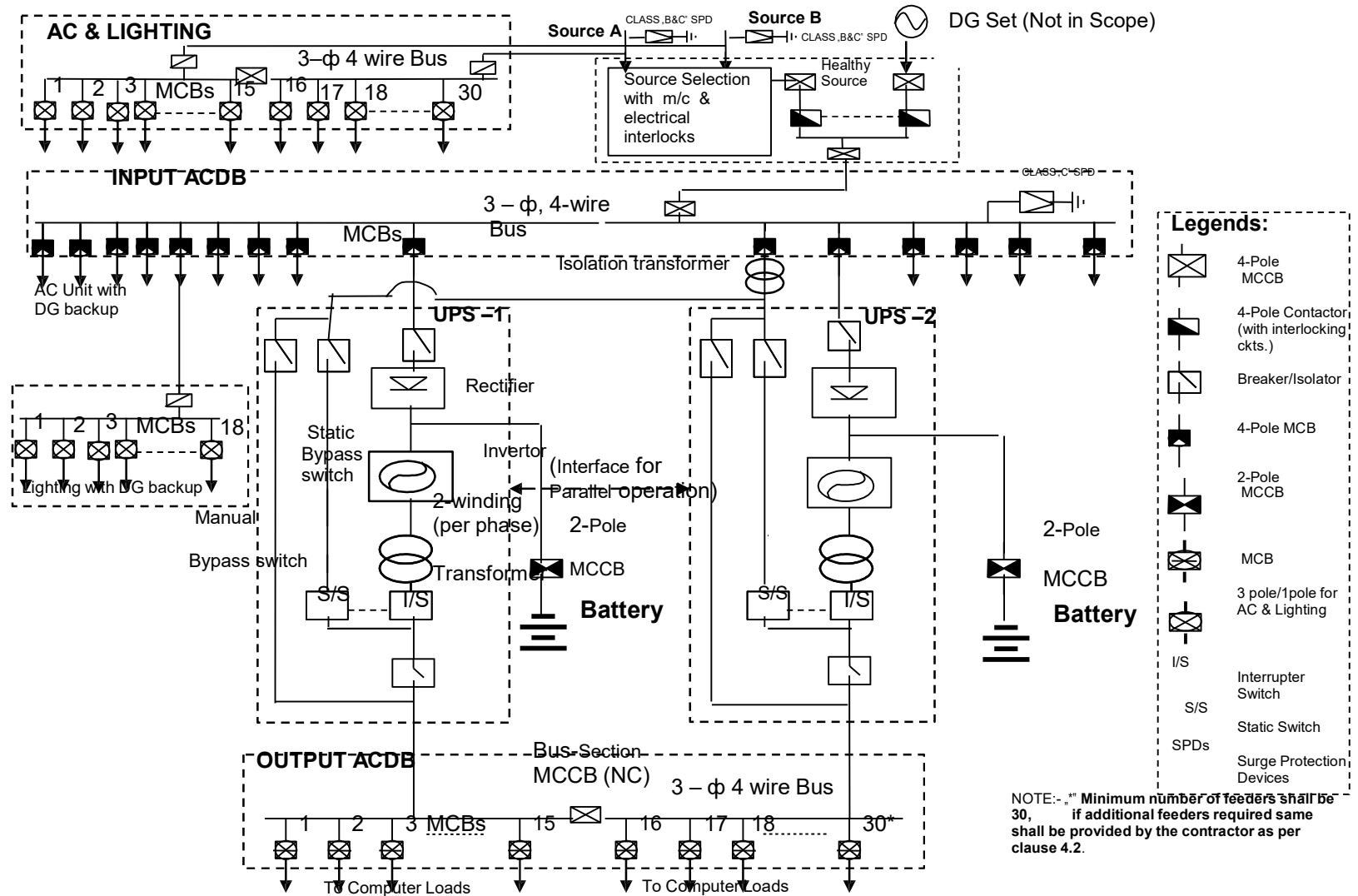
#### **4.1.4 Rectifier/Charger Units**

Each rectifier/charger unit output voltage shall be regulated to match the characteristics of the batteries and inverter. The rectifiers/chargers shall provide voltage regulated DC power to the invertors while also charging and maintaining the batteries at full capacity.

The rectifier/charger units shall have the following characteristics:

- a) Input Voltage and frequency characteristics as per clause 4.1.3 above.
- b) Input current limit of 125 percent of the nominal full load input current
- c) Maximum input current total harmonic distortion of 5 percent at nominal input voltage and under full load.
- d) The output shall be current limited to protect the rectifier/charger unit circuitry and to prevent the batteries from over-charging.
- e) Capacity to recharge the batteries to 90% of its capacity (from fully discharged state i.e. ECV of 1.75) within 8 hours while carrying full load.
- f) Automatic equalizing after partial discharge of the batteries.
- g) Temperature dependent battery charging with temperature sensing probes mounted on the battery banks.
- h) Automatic float cum boost charging feature.

**FIG. 4-1 : CONCEPTUAL AUXILIARY POWER SUPPLY SYSTEM CONFIGURATION**



#### 4.1.5 Invertors

The invertors shall normally operate in synchronism with the mains AC power source. Upon loss of the mains AC power source or its frequency deviating beyond a preset range, the invertors shall revert to their own internal frequency standard. When the mains AC source returns to normal, the invertors shall return to synchronized operation with the mains AC source. Such reversal of operation of inverters from synchronous to free running mode and vice-versa shall not introduce any distortion or interruption to the connected loads. A suitable dead band for frequency may be provided to avoid unnecessary frequent reversal of inverter operation between free running mode and synchronised mode under fluctuating frequency conditions.

The invertors shall have the following characteristics:

- (a) Inverter unit shall be based on Pulse Width modulation (PWM) technique.
- (b) The nominal output voltage shall be 415 Volt  $\pm 1\%$ , 3-phase, 4-wire AC up to rated load.
- (c) The transient voltage response shall not exceed  $\pm 4\%$  for the first half-cycle recovering to  $\pm 1\%$  within ten cycles for a 100 percent step load application or removal.
- (d) The free running frequency shall not deviate by more than  $\pm 0.1\%$  for the rated frequency of 50 Hz.
- (e) The invertors shall be synchronized to the main AC source unless that source deviates from 50 Hz by more than 1% (adjustable to  $\pm 1/2/3/4/5\%$ ).
- (f) The output voltage harmonic distortion shall not exceed 5% RMS and no single harmonic component shall exceed 3%.
- (g) The invertors shall be capable of resistive load operation & deliver at least 80% of the nominal capacity at the rated power factor and be capable of operation with loads ranging from the rated through unity power factor. Inverter shall also accept 100% load at crest factor of at least 3:1 for Switching Mode Power Supply (SMPS) load of computer system equipments without de-rating.
- (h) The invertors shall provide protection logic to automatically shut down and isolate itself from the load when the battery voltage drops below a preset voltage.
- (i) The invertors shall provide interrupter switch to isolate the unit from the load on failure of the unit. The interrupter switch shall be rated to carry full continuous load and to interrupt the inverter under full fault load.
- (j) The invertors shall be capable of supporting a start-up surge or overload of 150 percent of rated output for up to 60 seconds.

In case the inverter subsystem does not include an internal load transformer, an external load transformer of delta-wye configuration, 3-phase, 50Hz, 415 V AC, suitable for the inverter shall be provided.

#### **4.1.6 Static Bypass Switches**

Each UPS system shall include static bypass switch to facilitate automatic transfer of loads from the inverter sub-system output to bypass AC source through isolation transformer. Isolation transformer shall be rated for at least two times the rating of single UPS sub system. However, in case of parallel-redundant UPS systems, the transfer to Static bypass must occur only when the inverters of both the UPS systems have failed.

The transfer to Static Bypass from the inverter shall take place under the following fault conditions:

- (a) The inverter load capacity is exceeded
- (b) An over- or under-voltage condition exist on the inverter output
- (c) Inverter failure.

The static bypass switches shall be high-speed devices rated to transfer and carry full rated load. The static bypass switches shall provide protection to prevent out of phase transfers. The switching speed of the static bypass switches shall be less than 1 millisecond. During the changeover, the output voltage should not fall below 205V A.C., 50Hz  $\pm 5\%$ , in order to avoid any disruption to computer load supply. An automatic transfer back to the inverter subsystem shall occur if the transfer from the inverter subsystem was caused by a temporary overload and the load has returned to normal or by a temporary over/under voltage condition on inverter output and the voltage has returned to normal.

The transfer back to the inverter subsystem, both automatic and manual, shall be inhibited under the following conditions:

- (a) The frequency of bypass AC source is outside the frequency band of  $\pm 1\%$  of 50Hz (adjustable to 1/2/3/4/5 percent).
- (b) The inverter output voltage and frequency are beyond the preset range.
- (c) An overload exists.

#### **4.1.7 Manual Maintenance Bypass Switches**

Manual bypass switches are provided to facilitate maintenance of the UPS system and shall provide transfer of the connected load from one UPS output to the other UPS system. These switches shall be rated to transfer and carry continuous full rated load.

#### **4.1.8 Batteries**

UPS system shall have a set of storage batteries designed for continuous UPS application. The battery set shall have sufficient capacity to maintain output at full rated load for the specified backup duration after 8 hour charging. The backup duration of the

battery shall be as specified in the BOQ. The battery set shall be maintenance free VRLA type Batteries. The detailed requirement of batteries is given under clause 4.4

#### **4.1.9 Battery Breaker for UPS system**

A 2-pole MCCB of suitable rating shall be provided near the battery bank (at suitable location on the frame of the battery bank) to allow disconnection of the batteries from the rectifier/charger unit and inverter. This shall also provide over-current protection to the battery circuits.

#### **4.1.10 UPS Control/Monitoring**

The Contractor shall supply control panel to permit automatic & manual operation of UPS, display of associated alarms and indications pertaining to the UPS. In each UPS system, a local display of the following analog and status/alarm signals/indications as a minimum shall be included:

Analog signals for the following measurements:

- i. AC input voltage (to display each phase)
- ii. AC output voltage (to display each phase)
- iii. AC output current (to display each phase)
- iv. AC input mains Frequency
- v. AC UPS Output Frequency
- vi. DC voltage (battery subsystem)
- vii. DC current (battery subsystem)

Status/Alarms signals for the following indications :

- a) Parallel operation of inverters
- b) Inverters running in synchronised / free running mode.
- c) Battery Low voltage alarm (battery subsystem)
- d) Load on battery alarm
- e) Battery Circuit Breaker Open alarm
- f) Overload trip alarm
- g) High-temperature alarm
- h) Equipment failure alarm

For remote monitoring a wall mounted type panel consisting of audio visible alarm or PC based monitoring system shall be provided in the control room. For PC based monitoring system required computer hardware and software shall be provided by the contractor. The monitor of PC shall be 15" TFT type.

#### **4.1.11 Internal Wiring**

All internal wires shall be of stranded copper conductor, sized according to the current requirements with minimum insulation rating of 1100 VAC. Extra-flexible wire shall be used for all circuits mounted on door or swing panels within the UPS

#### **4.1.12 Enclosures/Panels design**

The UPS electronic equipment and associated circuitry & all devices shall be housed in a freestanding enclosures/panels. Modules and sub-assemblies shall be easily replaceable and maintainable. Cable entry shall be from the bottom/top of the enclosures (to be finalized during detailed engineering). The applicable degree of protection of enclosures shall be IP20 however, suitable protection shall be provided against vertical dripping of water drops. UPS shall be installed with the necessary base frame including anti-vibration pad. The thickness of the structural frames and load bearing members shall be minimum 2.0 mm and for front & rear, sides, bottom and top covers shall be minimum 1.6 mm. For other requirement of enclosure/panel, clause 4.2.3.4 may be referred.

#### **4.1.13 Equipment / Panel Earthing**

Each enclosure shall include suitable signal & safety earth networks within the enclosure. The signal-earthing network shall be separate & terminated at a separate stud connection, isolated from safety earth network. Each earth network shall be a copper bus bar, braid or cable. The contractor shall connect safety and signal earths of each enclosure to the earth grid/earth riser through suitable 50X6 sq. mm. GI strips. For other requirement of enclosure/panel earthing, clause 4.2.3.5 may be referred.

#### **4.1.14 External Power Connections**

All breakers/switches shall be suitably rated to match the requirement of external power connections.

#### **4.1.15 Testing of UPS**

##### **4.1.15.1 Type Test of UPS**

The Contractor shall supply type tested UPS equipments. The Contractor shall submit the UPS type test reports of earlier conducted tests (including performance & EMC requirements) on the same make, model, type & rating as offered, as per IEC 62040 or equivalent EN/BS standards. For type testing requirements in addition to provisions of section 7 is also to be complied.

##### **4.1.15.2 Factory Acceptance Test of UPS**

A factory acceptance test shall be conducted on all the equipments and shall include, but not be limited to the following, appropriate to the equipment being tested:

- (a) Verification of all functional characteristics and requirements specified
- (b) Voltage drop and transients generated during switching operations
- (c) System efficiency tests
- (d) Verification of all features and characteristics included in all the delivered equipments and also as per specification requirements.
- (e) Inspection and verification of all construction, wiring, labelling,

documentation, and completeness of the hardware

Before the start of factory testing, the Contractor shall verify that all change orders applicable to the equipment have been installed. As a part of the factory tests, unstructured testing shall be performed to allow Employer representatives to verify proper operation of the equipment under conditions not specifically tested in the above structured performance test. A minimum of 8 hours of the factory test period shall be reserved for unstructured testing. The Contractor's test representative shall be present and the Contractor's technical staff members shall be available for consultation with Employer personnel during unstructured test periods. All special test facilities used during the structured performance test shall be made available for Employer's use during unstructured testing.

The respective factory acceptance tests for UPS are listed in Table 4.1

#### 4.1.16 Environmental Conditions

UPS & all other hardware and components shall be capable of continuous operation at rated load without failures in the following environmental conditions:

**Temperature/humidity** - Ambient temperature of 0° to 50°C and upto 95 percent humidity, non-condensing. However, air conditioned environment shall be provided for VRLA batteries.

**Table 4.1 LIST OF FACTORY & SITE TESTS FOR UPS**

Sl. No.	Test	Factory Acceptance Tests	Site Tests
1.	Interconnection Cable Check	√	√
2.	Light Load Test	√	
3.	UPS Auxiliary Devices Test	√	√
4.	A.C. input failure Test	√	√
5.	A.C. input return Test	√	√
6.	Simulation of parallel redundant UPS fault	√	
7.	Transfer Test	√	√
8.	Full Load Test	√	√
9.	UPS Efficiency test	√	
10.	Unbalanced Load test	√	
11.	Balanced Load test	√	
12.	Current division in parallel or parallel redundant UPS test	√	
13.	Rated stored energy time test (Battery test)		√
14.	Rated restored energy time test (Battery test)		√
15.	Battery ripple current test		√
16.	Overload capability test	√	
17.	Short circuit test	√	
18.	Short-circuit protection device test	√	
19.	Restart test	√	√



<b>Sl. No.</b>	<b>Test</b>	<b>Factory Acceptance Tests</b>	<b>Site Tests</b>
20.	Output Over voltage test	√	
21.	Periodic output voltage variation test	√	
22.	Frequency variation test	√	
23.	Harmonic Components test	√	
24.	Earth Fault test	√	
25.	On site ventilation test		√
26.	Audible noise test	√	
27.	Parameter/Configuration settings	√	√
28.	Phase Sequence Test	√	√
29.	Coordination and discrimination of Tripping of associated breakers (MCCB/MCBs) in upstream & down stream		√

## 4.2 AC DISTRIBUTION BOARDS

AC distribution boards shall be provided for UPS input and output power distribution. The distribution boards shall distribute power and provide protection against failures on feeder circuits, to the equipment. The Contractor shall be responsible for design, engineering, manufacturing, supply, storage, installation, cabling, testing & commissioning of AC distribution boards required for distribution of power. The nominal input frequency is 50 Hz, which may vary from 47.5-52.5Hz. The phase to neutral input voltage shall be (Nominal 240V) varying from 190V to 265 V.

The Input ACDB will cater for the load requirements of DC power supply system, air-conditioning alarm system, fire protection alarm system, lighting loads and one spare of 20A minimum, in addition to UPS system load. The Output ACDB shall cater for only critical loads in the control centre. The number of feeders and their ratings in the output ACDB shall be decided during detail engineering. At least five spare feeders in the output panel shall be provided.

All MCCBs shall conform to IEC-60947-2 & IS 13947-2/IEC 947-2, IEC-60898 and IS 8828 and shall be of Four (4) Pole type of requisite rating. MCBs used for load feeders in output ACDB shall be of minimum curve B characteristics. The load feeders shall be coordinated with requirement of loads of computers and other loads.

### 4.2.1 Enclosures/Panels

The equipments of ACDBs shall be physically mounted in freestanding enclosures/panels. MCCBs and sub-assemblies shall be easily replaceable and maintainable. Cable entry shall be from the bottom/top of the enclosures (to be finalized during detailed engineering). The Contractor shall state the type, size and weight of all enclosures and indicate the proposed manner of installation. The applicable degree of protection of enclosures shall be at least IP21. The thickness of the structural frames and load bearing members shall be minimum 2.0 mm and for front & rear, sides and top covers shall be minimum 1.6 mm. For wall mounted type of output ACDB the above requirements shall not be applicable.

### 4.2.2 Equipment/Panel Earthing & Surge Protection

Each enclosure shall include suitable safety earth networks as per clause 4.2.3.5. . Surge protection devices shall be installed in the input ACDB to provide adequate protection against current and voltage transients introduced on input AC due to load switching surges. These protection devices shall be in compliance with IEC- 61312, IEC- 61024 and VDE 0100-534 for following surges:

a) Low Voltage Surges (Class C)

Between	Requirement
R, Y, B & N	$I_n \geq 10 \text{ kA}, 8/20 \mu\text{S}$ for each phase
N & PE	$I_n \geq 20 \text{ kA}, 8/20 \mu\text{S}$
$I_n$ = Value of Nominal Discharge Current.	

### **4.2.3 CABLING REQUIREMENTS**

The contractor shall supply, install and commission all power cables, control cables, network interface cables and associated hardware (lugs, glands, cable termination boxes etc.) as required for all equipment. The contractor shall be responsible for cable laying and termination at both ends of the cable. The Contractor shall also be responsible for termination of owner supplied cables if any at contractor's equipment end including supply of suitable lugs, glands, terminal blocks & if necessary cable termination boxes etc. All cabling, wiring and interconnections shall be installed in accordance with the following requirements.

#### **4.2.3.1 Power Cables**

All external power cables shall be stranded aluminium/Copper conductor, armoured XLPE/PVC insulated and sheathed; 1100V grade as per IS 1554 Part-I. The conductor for the Neutral connection from UPS to Output ACDB shall be sized 1.8 times the size of the Phase conductors to take care of the non-linear loads. However, the cable between UPS & Battery bank shall be of copper conductor (armoured type).

#### **4.2.3.2 Cable Identification**

Each cable shall be identified at both ends, which indicates the cable number, and the near-end and far-end destination. All power cables shall have appropriate colour for identification of each phase/neutral/ground. Cable marking and labelling shall comply with the requirements of the applicable standards.

#### **4.2.3.3 Cable and Hardware Installation**

The Contractor shall be responsible for supplying, installing, and terminating all cables and associated hardware (lugs, glands, etc.), required to mechanically and electrically complete the installation of facilities for the project.

#### **4.2.3.4 Enclosures/Panels design**

Enclosures/panel shall be of freestanding type of design. Cable entry shall be from the bottom/top of the enclosures (to be finalized during detailed engineering). The enclosures shall not have doors that are wider than 80 cm and doors shall be hinged with locking as per standard design of the manufacturer. Keyed locking is required with identical keys for all enclosures. The enclosures shall not exceed 220 cm in height. The thickness of the structural frames and load bearing members shall be minimum 2.0 mm and for others shall be minimum 1.5 mm. The panels/boards shall be equipped with necessary cable gland plates. The Contractor shall state the type, size and weight of all enclosures and indicate the proposed manner of installation.

Wiring within panel shall be neatly arranged and securely fastened to the enclosure by non-conductive fasteners. Wiring between all stationary and moveable components, such as wiring across hinges or to components mounted on extension slides, shall allow for full movement of the component without binding or chafing of the wire. Conductors in

multi-conductor cables shall be individually colour coded, and numbered at both ends within enclosures.

The enclosures shall be painted inside and outside. The finish colour of all enclosures shall be aesthetically pleasing and shall be approved by the owner. Further, finish colour of external surfaces shall be preferably of same colour for all enclosures/panels.

Maintenance access to the hardware and wiring shall be through full height lockable doors.

Each panel shall be supplied with 240 VAC, 50Hz single-phase sockets with switch.

Each ACDB and equipment within ACDB enclosures shall be clearly labelled to identify the enclosure/equipment. All labelling shall be consistent with Contractor-supplied drawings.

#### **4.2.3.5 Enclosure/Panel Earthing**

Each enclosure shall include suitable earth networks within the enclosure. Earth network shall be a copper bus bar, braid or cable inside enclosures.

The safety earth network shall terminate at two/more studs for connecting with the earthing grid. Safety earthing cables between equipment and enclosure grounding bus bars shall be of minimum size of 6 mm<sup>2</sup>, stranded copper conductors, rated at 300 volts. All hinged doors shall be earthed through flexible earthing braid.

For all enclosures requiring AC input power, the green earthing wire from the AC input shall be wired to the safety-earthing stud. The Contractor shall provide all required cabling between enclosures for earthing. The contractor shall connect safety and signal earths (as applicable) of each enclosure to the nearest earth grid/earth riser through suitable 50X6 sq. mm. GI/25x3 Cu strips. The contractor may use the existing grid wherever available. In case the suitable earthing grid is not available the same shall be made by the contractor.

The signal earthing network shall terminate at a separate stud connection, isolated from safety ground. The stud connection shall be sized for an external earthing cable equipped with a suitable lug.

All earthing connections to equipment shall be made directly to each equipment chassis via earthing lug and star washer. Use of the enclosure frame, skins, or chassis mounting hardware for the earthing network is not acceptable.

### 4.3 DC POWER SUPPLY SYSTEM

The DC Power Supply system shall be capable of meeting the load requirements for various Telecom equipments, RTUs and other associated equipment located at indoor, i.e. at the substations, the control centers and customer care system. The AC input to the ACDB shall be provided from the ACDB described under clause 4.2 at control center. At other locations the AC input to the DCPS system shall be single phase AC which will be provided from the existing system. At these locations the class B & C level of surge protection (between phase-neutral and neutral – protective earth) as specified under and conforming to IEC 61312, IEC 61024 and VDE 0100-534 shall be installed in the DCPS system.

Surge protection devices shall be installed in the DCPS panel to provide adequate protection against current and voltage transients introduced on input AC due to load switching and low energy lightning surges. These protection devices shall be in compliance with IEC- 61312, IEC- 61024 and VDE 0100-534 for following surges:

a) Lightning Electromagnetic impulse and other High Surges (Class B):

Between	Requirement
Ph & N	$I_{imp} \geq 50 \text{ kA}, 10/350 \mu\text{S}$ for each phase
N & PE	$I_{imp} \geq 100 \text{ kA}, 10/350 \mu\text{S}$
$I_{imp}$ = Value of Lightning Impulse Current	

b) Low Voltage Surges (Class C)

Between	Requirement
Ph & N	$I_n \geq 10 \text{ kA}, 8/20 \mu\text{S}$ for each phase
N & PE	$I_n \geq 20 \text{ kA}, 8/20 \mu\text{S}$
$I_n$ = Value of Nominal Discharge Current.	

#### 4.3.1 General Technical Requirements for SMPS based DC power supply units

SMPS based DC power supply system is to be used in Auto Float-cum-Boost Charge mode as a regulated DC Power source. DCPS system is to be installed indoors and shall be provided with IP21 panels. The System shall consist of the following:

- (a) SMPS modules
- (b) Controller module to control and monitor all DCPS modules.

The number and rating of SMPS modules shall be provided as per the Employer's requirements stipulated in the BOQ. The Panel, Distribution/Switching arrangement shall be provided for the ultimate system capacity. Ultimate System capacity is defined as 150% of the present capacity specified. The ultimate capacity is over and above the requirement of redundancy wherever specified. All factory wiring for the panel shall be for the ultimate capacity so that only plugging-in of SMPS module shall enhance the DC power output. The size of fuses, MCBs, switch, bus etc shall be suitable for the ultimate capacity.

The system shall be sufficiently flexible to serve any load depending on manufacturer's design, rating and number of SMPS modules used in panel and system configuration. To cater for higher load requirements, same type of SMPS modules mounted in the same rack or different racks shall be capable of working in parallel load sharing arrangement. The DCPS system shall be suitable for operation from single phase A.C. mains.

#### **4.3.2 Operational/Component Requirements**

The basic modules shall operate at specified ratings and conform to requirements stipulated in this specification. The DCPS system shall meet requirement of the latest TEC specification / IEC/BS for other parameters not specified in this specification. The component parts of the equipment shall be of professional grade of reputed manufacturer to ensure prompt and continuous service and delivery of spare parts. The component shall conform to relevant IEC/IS standards. The contractor shall obtain Employer's approval of major component before procurement of the same. Conceptual diagram for DCPS is shown in figure 4-2.

The DCPS shall be suitable for operation at ambient temperature of 0-50 deg and relative humidities up to 95 %.

#### **4.3.3 Wiring**

All insulated conductors except those within the confines of a printed circuit board assembly shall be of the rating enough to withstand the maximum current and voltage during fault and overload. All insulated conductors/cables used shall conform to IS 1554 or equivalent international standard.

All wiring shall be neatly secured in position and adequately supported. Where wires pass through any part of metal panel or cover, the hole through which they pass shall be suitably secured.

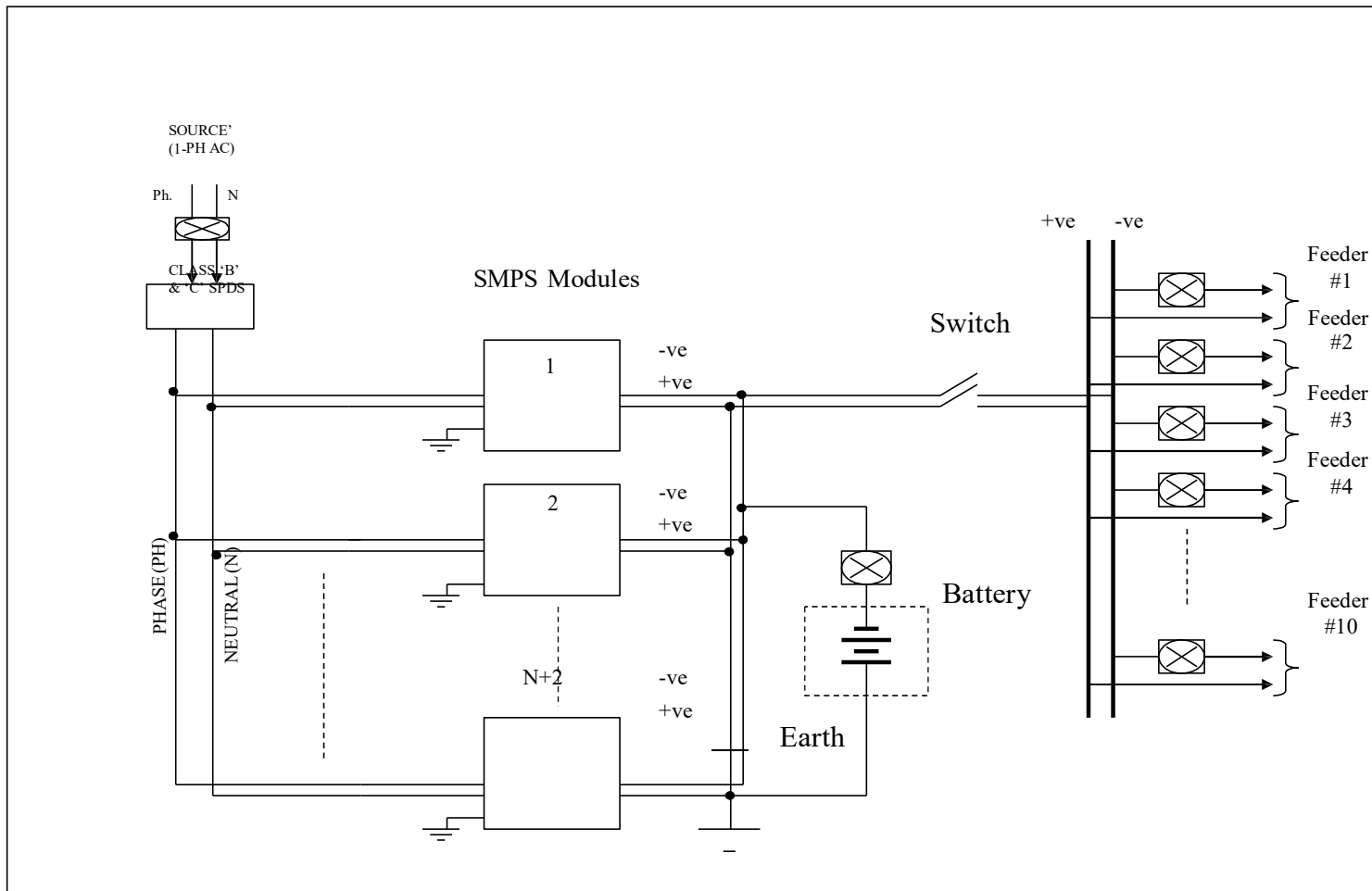
#### **4.3.4 Bus Bars**

High conductivity Cu bus bar shall be provided and shall be sized to take care of the current of ultimate DCPS system capacity for which it is designed. However, it shall not be less than 25mm X 5mm.

#### **4.3.5 Earthing**

Two earth terminals shall be provided in the frame of the system. The Contractor shall connect these earth terminals to the earth bus. All modules and devices shall be connected to these earth terminals. The hinged door shall be connected to the panel with braided Cu at two point at least.

**FIG. 4-2 : CONCEPTUAL CONFIGURATION OF DC POWER SUPPLY (DCPS) SYSTEM**



#### **4.3.6 Finish and Painting**

The finish of Steel/Aluminum alloy structure and panels shall conform to relevant IS specification (or equivalent international specifications). The colour scheme for panel, Door and Modules shall be decided during detailed engineering.

#### **4.3.7 Marking and Labelling of Cables**

The Contractor shall propose a scheme for marking and labeling the inter panel cables and get it approved from the Employer. A cabling diagram, screen printed or any other better arrangement ensuring better life expectancy shall be placed in the inside of the front door or any other convenient place for ready reference of the maintenance staff.

#### **4.3.8 Name Plate**

A name plate etched, engraved, anodized or any other better arrangement ensuring better life expectancy shall be suitably fixed on each panel /module and contain at least the following information :

- (a) Type of the Unit / Model No
- (b) Manufacturer"s Name and identification
- (c) Unit serial No
- (d) Year of manufacture
- (e) Input voltage and phase
- (f) Output Voltage and Current

#### **4.3.9 System and Panel Configuration**

The mechanical and electrical requirements of the Panel are described as below:

#### **4.3.10 System Configuration**

The SMPS modules shall be accommodated in panels. The system shall employ a modular configuration to provide flexibility, keeping in view the future load requirements of DC Power. The system shall be configured for ultimate capacity as brought out in Section 4.3.1 General Technical Requirements. The control, Monitoring, Alarm arrangement and DC & AC distribution shall be provided suitably in the panel.

The number of SMPS modules to be provided in the DCPS system shall be provided in  $N+2$  configuration, where N is the number of SMPS modules to meet the battery charging current (10% of  $C_{10}$  AH Capacity) of the offered battery plus the load requirement stipulated in the BOQ. The current rating of each module shall be considered as output current of the SMPS module at nominal voltage (48V).

It shall be possible to easily mount/remove the modules from the front side of the panel. The SMPS modules/SMPS module sub-racks shall be designed to slide into the panels and fixed securely by a suitable mechanical arrangement.



#### **4.3.11 Constructional Features of Panel**

Panel (Enclosure) shall be freestanding type of design. Cable entry shall be from the bottom/top of the enclosures (to be finalized during detailed engineering). The enclosures shall not have doors that are wider than 80 cm and doors shall be hinged with locking as per standard design of the manufacturer. Keyed locking is required with identical keys for all enclosures. The enclosures shall not exceed 220 cm in height. The thickness of the structural frames and load bearing members shall be minimum 2.0 mm and for others shall be minimum 1.5 mm. The panels/boards shall be equipped with necessary cable gland plates. The Contractor shall state the type, size, and weight of all enclosures and indicate the proposed manner of installation.

Wiring within panel shall be neatly arranged and securely fastened to the enclosure by non-conductive fasteners. Wiring between all stationary and moveable components, such as wiring across hinges or to components mounted on extension slides, shall allow for full movement of the component without binding or chafing of the wire. Conductors in multi conductor cables shall be individually colour coded, and numbered at both ends within enclosures.

The enclosures shall be painted inside and outside. The finish colour of all enclosures shall be an aesthetically pleasing and shall be approved by the owner. Further, finish colour of external surfaces shall be preferably of same colour for all enclosures/panels.

Maintenance access to the hardware and wiring shall be through lockable, full height, from doors.

Each panel shall be supplied with 240 VAC, 50Hz single-phase sockets with switch and lighting lamp for panel illumination.

The manufacturer so as to ensure the uninterrupted use of the equipment shall do proper thermal engineering of hardware design. The Panel shall be designed to allow cooling preferably by natural convection. The Bidders shall submit detail design of proposed Panel/enclosure and heat dissipation calculations during detailed engineering. Forced cooling is permitted (DC Fans are permitted in the Panel or SMPS module) for equipment mounted indoors (buildings/rooms/shelters). If cooling is provided at Panel level it shall be provided with additional fan with facility for manual switch over. Proper filtering shall be provided to control dust ingress. There shall be an arrangement for automatic Switching-OFF of fans during AC input failure. The required individual modules may be separated by air baffle to provide effective convection. The manufacturer shall also ensure that the failure of fan does not cause any fire hazards. The failure of any of the fans shall draw immediate attention of the maintenance staff.

#### **4.3.12 Electrical Requirements :**

**AC input supply:** The nominal input frequency is 50 Hz, which may vary from 47.5-52.5Hz. The input voltage shall be single phase (Nominal 240V) varying from 190V to 265V.

There shall be an automatic arrangement for shutting off of the SMPS module whenever the input voltage is beyond the specified operating limits with suitable alarm indication. The SMPS module shall resume normal working automatically when the input is restored within the working limits. Hysteresis within specified working limits shall not cause shutting down of the SMPS. A tolerance of  $\pm 5V$  may be acceptable for protection & alarm operation.

#### **4.3.13 DC output Characteristics of Modules**

The module shall be capable of operating in “Auto Float-cum-Boost Charge” mode depending on the condition of the battery sets being sensed by the Control unit.

- (a) The float voltage shall be continuously adjustable & pre-settable at any value in the range of  $-48$  to  $-56V$  either at the module or may be set from the common controller configuration. Further, the prescribed float voltage setting shall be based on recommendations of the VRLA battery supplier.
- (b) In Boost charge mode SMPS shall supply battery & equipment current till terminal voltage reaches set value, which is normally  $2.3V/cell$  ( $55.2V$ ) or as recommended by the VRLA battery supplier & shall change over to constant voltage mode
- (c) The DC output voltage variation shall not be more than 2% for load variation from 25% load to full load.

#### **4.3.14 Current Limiting (Voltage Droop)**

The current limiting (Voltage Droop) shall be provided in DCPS modules in float and boost charge modes of operation. The float/boost charge current limiting shall be continuously adjustable between 50 to 100% of rated output current for output voltage range of  $-44.4$  volts to  $-56$  Volts.

The float and boost charge current limit adjustment shall be provided in the DCPS system. The SMPS modules shall be fully protected against short circuit. It shall be ensured that short circuit does not lead to any fire hazard.

#### **4.3.15 Soft/Slow Start Feature:**

Soft/Slow start circuitry shall be employed such that SMPS module input current and output voltage shall reach their nominal value within 10 seconds.

The maximum instantaneous current during start up shall not exceed the peak value of the rectifier input current at full load at the lowest input voltage specified.

#### **4.3.16 Voltage overshoot/Undershoot :**

The requirements of (a) to (c) given below shall be achieved without a battery connected to the output of SMPS module.

- (a) The SMPS modules shall be designed to minimise DC output voltage

Overshoot/Undershoot such that when they are switched on the DC output voltage shall be limited to  $\pm 5\%$  of the set voltage & return to their steady state within 20 ms for load variation of 25% to 100%.

- (b) The DC output voltage overshoot for a step change in AC mains as specified in clause 4.3.12 Electrical Requirements shall not cause shut down of SMPS module and the voltage overshoot shall be limited to  $\pm 5\%$  of its set voltage and return to steady state within 20ms.
- (c) The modules shall be designed such that a step load change of 25 to 100% and vice versa shall not result in DC output voltage Overshoot/Undershoot of not more than 5% and return to steady state value within 10 ms without resulting the unit to trip.

#### **4.3.17 Electrical Noise :**

The Rectifier (SMPS) Modules shall be provided with suitable filter at output with discharge arrangements on shut down of the modules. The Psophometric Noise and ripple shall be as per relevant standards.

#### **4.3.18 Parallel Operation**

SMPS modules shall be suitable for operating in parallel with one or more modules of similar type, make and rating, other output conditions remaining within specified limits.

The current sharing shall be within  $\pm 10\%$  of the average current per rectifier module individual capacity of each rectifier module in the system (mounted in the same or different Panels) when loaded between 50 to 100% of its rated capacity for all other working conditions.

#### **4.3.19 Protection**

The SMPS module, which has failed (for any reason) shall be automatically isolated from the rest of the modules and an alarm shall be initiated for the failure.

##### **4.3.19.1 DC Over voltage protection**

DCPS shall be fitted with an internal over voltage protection circuit.

In case output DC voltage exceeds  $-57V$  or as per the recommendations of the manufacturer of batteries, the over voltage protection circuit shall operate & shut off the faulty module. A tolerance of  $\pm 0.25V$  is permitted in this case.

Shutting off of faulty SMPS module shall not affect the operation of other SMPS modules operating in the Panel. Operation of over voltage shut down shall be suitably indicated and extended monitoring/control unit. The circuit design shall ensure protection against the discharge of the Battery through the SMPS module in any case. The over voltage protection circuit failure shall not cause any safety hazard.

#### **4.3.20 Fuse/Circuit Breakers**

Fuses or miniature circuit breakers (MCB) shall be provided for each SMPS module as follows:

1. Live AC input line
2. Control Circuit

All fuses/circuit breaker used shall be suitably fault rated.

#### **4.3.21 AC Under/Over Voltage Protection**

AC input Under/Over voltage protection shall be provided as per clause 4.3.12 for Electrical Requirements.

#### **4.3.22 Over Load/Short Circuit Protection**

The SMPS shall be protected for Over load/Short circuit as per clause 4.3.14 Current Limiting (Voltage Droop).

#### **4.3.23 Alarms and indicating lamps**

Visual indications/display such as LEDs, LCDs or a combination of both shall be provided on each SMPS module for detection of SMPS module failure.

#### **4.3.24 Termination**

Suitable termination arrangements shall be provided in the panel for termination of inter cubicle cables from other equipment such as owners ACDB, Telecom and other associated equipments and alarm cables. All the termination points shall be easily accessible from front and top. AC and DC terminals shall be separated by physical barriers to ensure safety. All the terminals except AC earth shall be electrically isolated.

#### **4.3.25 DC Terminations**

All terminations including through MCBs shall be through lock and screw type terminations. Load and batteries shall be connected to DCPS through appropriate MCBs. The isolation of any of the battery from the load shall create an alarm. DC distribution shall be provided with adequate no of feeders (with three no of spare) with appropriate MCBs (6 Amp thru 32 Amp) for termination of the loads. Actual rating of the MCBs and no of feeders shall be finalized during the detail engineering.

DC distribution may be done either on wall mounted panel or on the DCPS panel. The proper rated MCB shall be provided at the combined output of the SMPS modules (if not provided at each SMPS module). All the AC, DC and Control/alarm cabling shall be supplied with the Panel. All DC +ve and -ve leads shall be clearly marked. All conductors shall be properly rated to prevent excessive heating.

#### **4.3.26 Power Cables**

All power cables shall be stranded copper conductor XLPE/PVC insulated and PVC

sheathed, single core/two core/three core/four core, 1100V grade as per IS 1554 Part-I.

#### **4.3.27 Earthing Cables**

Earthing cables between equipment and grounding bus bars shall be minimum size 70 mm<sup>2</sup> stranded conductors copper/copper strip, rated at 300 volts. All hinged doors shall be earthed through flexible earthing braid. Signal and Safety earthing shall be provided separately.

#### **4.3.28 Alarms**

Following Visual indications/display such as LEDs, LCDs or a combination of both shall be provided to indicate :

Functional Indications for local monitoring:

- a) Mains available (not mandatory if provided at module level)
- b) DCPS/SMPSSs in Float
- c) DCPS/SMPSSs in Charge Mode

Alarm Indication for local monitoring:

- a) Load Voltage High /Low
- b) DCPS module/SMPS fail
- c) Mains out of range
- d) System Over Load
- e) Mains "ON"/Battery Discharge
- f) Temp. Compensation fail
- g) Battery fail/isolated

All the protections/alarms shall be within tolerance of 0.25V in case of DC voltage, 1% in case of DC current and  $\pm 5V$  for AC voltage

Alarm Indication for remote monitoring:

- a) Input AC mains supply fail alarm
- b) Battery low voltage (Pre cut off) alarm
- c) DCPS module fail

Potential free Contacts in two numbers for each of the above remote monitoring alarms (one for remote alarm interfaced through RTU and one redundant for local monitoring at suitable location) shall be provided. All these potential free contacts are to be wired and terminated at the suitable location for termination to RTU.

#### **4.3.29 Temperature Compensation for Battery**

There shall be provision for monitoring the temperature of battery and consequent arrangement for Automatic temperature compensation of the SMPS output voltage to match the battery temperature dependant charge characteristics. The output voltage of

the rectifier in Float/Charge operation shall decrease or increase at the rate of 72 mV (24 cell battery) per degree increase or decrease in temperature over the set voltage or as may be recommended by the VRLA Battery supplier. The output voltage shall decrease till the open circuit voltage of the battery is reached. The open circuit voltage range shall be settable between 2.1V/cell to 2.2V/cell. The increase in output voltage due to decrease in temperature has been taken care of by the tripping of the unit due to output voltage high (57V) protection. Failure of temperature compensation circuit including sensors shall create an alarm and shall not lead to abnormal change in output voltage.

#### **4.3.30 Digital Meters/Display Unit**

There shall be provision to monitor the following parameters through digital meters or digital display units:

- (a) Input AC voltage.
- (b) Out put DC voltage
- (c) Output DC current of charger
- (d) Battery current
- (e) Load current.

The Digital display of meters or display unit shall be with minimum 3<sup>1</sup>/<sub>2</sub> digital display of height 12mm and shall have an accuracy 1.5% or better.

#### **4.3.31 Type Testing of DCPS**

The contractor shall supply DCPS System, which was already type tested. The test reports for immunity, Emission and surge must be in accordance with relevant IEC/CISPR standards shall be submitted . The Contractor shall submit the DCPS type test reports of earlier conducted tests on the same make, model, type & rating which shall include the following tests. For type testing requirements in addition to provisions of this section 7 is also to be complied.

##### **Type Tests on DCPS**

- 1 Surge immunity (Level 4- as per IEC 61000-4-5)
- 2 Electrical Fast Transients/Burst (Level 4 – as per IEC 61000-4-4)
- 3 Electrostatic Discharge (Level 4 – as per IEC 61000-4-2)
- 4 Radiated Electromagnetic Field (Level 3 – as per IEC 61000-4-3)
- 5 Conducted disturbances induced by radio-frequency field (Level 3 – as per IEC 61000-4-6)
- 6 Damped oscillatory magnetic field (Level 3 – as per IEC 61000-4-10)
- 7 Voltage dips, short interruptions and voltage variations (Level 2 – as per IEC 61000-4-11)
- 8 Conducted Emission (Level - Class A, Group 1 as per IEC CISPR 11)
- 9 Radiated Emission (Level - Class A, Group 1 as per IEC CISPR 11)
- 10 Verification of Protection class (IP 21) for enclosure
- 11 Safety Tests (as per IEC 60950)
- 12 Burn in test for 72 hours at maximum operating temperature

#### 4.3.32 Factory/Site Testing of DCPS

The factory/site tests to be carried out on DCPS system/module in the factory and site are listed respectively in Table below. The manufacturer shall conduct routine tests on all the systems/modules and submit the report before offering for FAT. The routine tests shall include atleast the tests mentioned under FAT.

Sl.No.	Test	FAT	SAT
<b>Tests on DCPS System</b>			
1.	Mechanical & Visual Check Tests	√	√
2.	Insulation Test.	√	
3.	High Voltage Withstand Test	√	
4.	Switch On Test	√	√
5.	DCPS Low voltage & High voltage limits check Test	√*	√
6.	Pre-alarm test for Battery Voltage Low	√*	√
7.	Battery Low Voltage Disconnect Level Test	√*	√
8.	AC Input Low and High voltage limits check Test	√*	
9.	Rectifier Fail Alarm Test	√*	√
10.	Voltage Regulation Test	√*	√
11.	Current Sharing Test	√*	
12.	Total Output Power Test	√*	√
13.	Hot Plug In Test	√*	√
14.	Calibration & Parameter settings	√*	√
15.	Automatic Float cum Boost Charge Mode Change Over Test	√*	√
16.	Battery Path Current Limiting Test	√*	√
17.	Battery Charging and full load Current Test	√*	√
18.	Battery Temperature Compensation Test	√*	
19.	Total Harmonic distortion Test	√*	
20.	Burn in Test for 8 hours at max operating temperature	√*	
<b>Tests on SMPS module</b>			
21	Mechanical & Visual Check Test	√*	
22	Module-On Test	√*	
23	Input low/high voltage cut-off test	√*	
24	Voltage Droop Test	√*	
25	Voltage Regulation Test	√*	
26	Power Output & Current Limit Test	√*	
27	DC High Voltage Test	√*	
28	O/P Voltage Ripple Test	√*	
29	Psophometric Noise Test	√*	
30	Efficiency Test	√*	
31	Power Factor	√*	
32.	Input Current Limit	√*	

Sl.No.	Test	FAT	SAT
33.	Input AC Frequency Range Test	√*	
34.	Rectifier Dynamic Response	√*	
35.	Output Short Circuit Test	√*	
36.	Hold up Time Test	√*	

Note\* : These tests (Sl. No. 5-36) shall be conducted on 10% samples of the offered batch and other tests (Sl. No 1-4) shall be conducted on each equipment during the FAT.



#### **4.4 BATTERY REQUIREMENTS**

The contractor shall supply Valve Regulated Lead Acid (VRLA) maintenance free Battery for UPS & DCPS system. Each battery set shall have sufficient capacity to maintain output at full rated load for duration as defined in **BOQ**. The Bidder shall furnish detailed battery sizing calculations along with all arrangements and supporting structures, for UPS and DCPS system being proposed, along with the bid. In all cases the battery is normally not allowed to discharge beyond 80% of rated capacity (80% DOD) at 10 hours rate of discharge.

The contractor supplying the cells/batteries as per this document shall be responsible to replace/repair free of charge, the battery/cell becoming faulty, owing to defective workmanship or material as per the provisions of the bid document.

Battery sizing calculation for UPS shall be done considering the actual charging achieved in eight hours i.e. in case 100% charging is not achieved in eight hours the Ah of the battery shall be enhanced by the ratio of charging actually achieved in eight hours.

##### **4.4.1 Constructional Requirements**

The design of battery shall be as per field proven practices. Partial plating of cells is not permitted. Paralleling of cells externally for enhancement of capacity is not permitted. Protective transparent front covers with each module shall be provided to prevent accidental contact with live module/electrical connections. It shall be possible to easily replace any cell of the battery at site in normal working condition.

##### **4.4.2 Containers**

The container material shall have chemical and electro-chemical compatibility and shall be acid resistant. The material shall meet all the requirements of VRLA batteries and be consistent with the life of battery. The container shall be fire retardant and shall have an Oxygen Index of at least 28%. The porosity of the container shall be such that so as not to allow any gases to escape except from the regulation valve. The tensile strength of the material of the container shall be such that so as to handle the internal cell pressure of the cells in the worst working condition. Cell shall not show any deformity or bulge on the sides under all working conditions. The container shall be capable of withstanding the rigours of transport, storage and handling. The containers shall be enclosed in a steel tray.

##### **4.4.3 Cell Covers**

The cell covers shall be made of suitable material compatible with the container material and permanently fixed with the container. It shall be capable to withstand internal pressure without bulging or cracking. It shall also be fire retardant. Fixing of Pressure Regulation Valve & terminal posts in the cover shall be such that the seepage of electrolyte, gas escapes and entry of electro-static spark are prevented.

#### **4.4.4 Separators**

The separators used in manufacturing of battery cells, shall be of glass mat or synthetic material having high acid absorption capability, resistant to sulphuric acid and good insulating properties. The design of separators shall ensure that there is no misalignment during normal operation and handling.

#### **4.4.5 Pressure Regulation Valve**

Each cell shall be provided with a pressure regulation valve. The valve shall be self re-seal able and flame retardant. The valve unit shall be such that it cannot be opened without a proper tool. The valve shall be capable to withstand the internal cell pressure specified by the manufacturer.

#### **4.4.6 Terminal Posts**

Both the +ve and –ve terminals of the cells shall be capable of proper termination and shall ensure its consistency with the life of the battery. The surface of the terminal post extending above the cell cover including bolt hole shall be coated with an acid resistant and corrosion retarding material. Terminal posts or any other metal part which is in contact with the electrolyte shall be made of the same alloy as that of the plates or of a proven material that does not have any harmful effect on cell performance. Both +ve and –ve posts shall be clearly and unambiguously identifiable.

#### **4.4.7 Connectors, Nuts & Bolts, Heat Shrinkable Sleeves**

Where it is not possible to bolt the cell terminals directly to assemble a battery, separate non-corroding lead or copper connectors of suitable size shall be provided to enable connection of the cells. Copper connections shall be suitably lead coated to withstand corrosion due to sulphuric acid at a very high rate of charge or discharge.

Nuts and bolts for connecting the cells shall be made of copper, brass or stainless steel. Copper or brass nuts and bolts shall be effectively lead coated to prevent corrosion. Stainless steel bolts and nuts can be used without lead coating.

All inter cell connectors shall be protected with heat shrinkable silicon sleeves for reducing the environmental impact including a corrosive environment.

#### **4.4.8 Flame Arrestors**

Each cell shall be equipped with a Flame Arrestor to defuse the Hydrogen gas escaped during charge and discharge. Material of the flame arrestor shall not affect the performance of the cell.

#### **4.4.9 Battery Bank Stand**

All batteries shall be mounted in a suitable metallic stand/frame. The frame shall be properly painted with the acid resistant paint. The suitable insulation shall be provided between stand/frame and floor to avoid the grounding of the frame/stand.

#### **4.4.10 Capacity Requirements**

When the battery is discharged at 10-hour rate, it shall deliver 80% of C (rated capacity, corrected at 27°Celsius) before any of the cells in the battery bank reaches 1.85V/cell.

All the cells in a battery shall be designed for continuous float operation at the specified float voltage throughout the life. Float voltage of each cell in the string shall be within the average float voltage/cell  $\pm 0.05V$  band.

The capacity (corrected at 27°Celsius) shall also not be less than C and not more than 120% of C before any cell in the battery bank reaches 1.75V/cell. The battery voltage shall not be less than the following values, when a fully charged battery is put to discharge at C/10 rate:

- (a) After Six minutes of discharge : 1.98V/cell
- (b) After Six hours of discharge : 1.92V/cell
- (c) After 8 hours of discharge : 1.85V/cell
- (d) After 10 hours of discharge : 1.75V/cell

Loss in capacity during storage at an average ambient temperature of 35° Celsius for a period of 6 months shall not be more than 60% and the cell/battery shall achieve 85% of its rated capacity within 3 charge/discharge cycles and full rated capacity within 5 cycles, after the storage period of 6 months. Voltage of each cell in the battery set shall be within 0.05V of the average voltage throughout the storage period. Ampere-hour efficiency shall be better than 90% and watt-hour efficiency shall be better than 80%.

#### **4.4.11 Expected Battery Life**

The battery shall be capable of giving more than 1200 charge/discharge cycles at 80% Depth of discharge (DOD) at an average temperature of 27° Celsius. DOD (Depth of Discharge) is defined as the ratio of the quantity of electricity (in Ampere-hour) removed from a cell or battery on discharge to its rated capacity. The battery sets shall have a minimum expected operational life of 5 years at normal operating conditions or 1200 charge / discharge cycles (whichever is early).

#### **4.4.12 Routine Maintenance of Battery system**

For routine maintenance of battery system, the contractor shall supply 1 set of following tools:

- a. Torque wrench.
- b. Tool for opening /closing of pressure regulation valve of battery.
- c. Hand held digital Multimeter for measurement of resistance, AC/DC voltages.

#### **4.4.13 Testing of Battery**

The contractor shall supply type tested battery as required for DCPS and UPS system. The Contractor shall submit the Battery type test reports of earlier conducted tests on the same make, model, type & rating as offered as per the IEC 60896 or equivalent IS/EN/BS standards. These Type test reports shall be submitted for the highest rating battery to be supplied under the contract. For type testing requirements in addition to provisions of this section 7 is also to be complied. The tests mentioned in the Table 4.2 shall be conducted on the battery at site and factory.

**TABLE 4.2 LIST OF FACTORY & SITE TESTS FOR BATTERY**

S. No.	Test	Factory Tests	Site Tests
1.	Physical Verification	√	√
2.	C/10 Capacity test on the cell	√	
3.	8 Hrs. Charge and 30 minutes (duration as specified) discharge test at full rated load for UPS.		√

#### **4.5 Testing Requirements**

The requirements for type tests, factory acceptance tests and field acceptance testing have been specified under the respective clauses. After completion of field acceptance testing the auxiliary power supply system shall be put under availability test for fifteen (15) days. Availability test shall be carried out by the employer/owner. During the availability test the APS shall be used as required to be used for rest of the life. In case of any failure or mal-operation during this period the contractor shall take all necessary action to rectify the problems. The APS shall be accepted only after rectification of the problems by the contractor in a manner acceptable to the employer.

#### **4.6 2KVA UPS**

Two KVA UPS shall be supplied for bill collection centres as per the quantity specified in the BOQ. The technical particulars of these UPS shall be as mentioned below:

##### **Technical Specification for 2 KVA (1.6 KW) UPS**

	Parameter	Requirements
INPUT	Voltage	230±15%V AC, 50Hz, Single phase
	Frequency	50 ± 5% Hz
OUTPUT	Power	2 kVA / 1.6 kW (at 0.8 pf)
	Voltage	230V AC Single phase (±1 %)

	Parameter	Requirements
	Frequency	50 Hz & $\pm 0.2\%$ (Free Running)
	Regulation	$\pm 1\%$
	Transient Response	$\pm 5\%$ for 100% load change and recovers to normal within 10 milliseconds
	Waveform	Pure Sine wave, THD $< 2\%$ (linear load)
	Short term overload	110% for 15 minutes and 150% for 10 seconds
	Efficiency (Peak)	$> 90\%$
	Supported load pf	0.6-unity
	Change Over	Transfer time (in Sync Mode) less than 5 msec
BATTERY	Type	SMF/lead Acid tubular
	Backup time	4 hours
	Recharge Time	Maximum 12 hours*
	Life	Minimum 3 years (SMF)/ 8 years (LATB)
GENERAL	LED Indicators	Mains ON, Converter / Inverter faults, O/P high/low, Bypass mode, Inverter ON/OFF
	Audible Alarm	Main Failure, Low Battery, Overload
	Isolation	UPS output isolated from Mains Input
	Protection class	IP-21
	Temperature	0-45° C (Battery shall be sized at an average temp. of 27 deg C.)
	Humidity	Upto 95% RH (Non condensing)

\* **Note** : Battery shall be sized to deliver rated load for specified duration after charging for 12 hours from fully discharged state of battery (1.75V for VRLA).

#### 4.7 Documentation

The following specific document for items covered under this section shall be submitted which shall be in addition to the applicable general document required under section 7.

- Data Requirement Sheets (DRS)
- Battery sizing calculations
- Cable sizing calculations
- Inventory of the hardware
- Panel General arrangement drawing
- Panel Internal General Arrangement drawing indicating modules, major devices/components location etc.
- Installation drawings
- Schematic drawings
- Type Test reports
- FAT plan & procedure
- SAT plan & procedure
- External cable laying & termination schedule details
- Availability test plan & procedure

#### 4.8 Mandatory Spares

List of mandatory spares for UPS, DCPS are mentioned in the BOQ

## **COMMUNICATION SYSTEM**

### **SECTION – 5**

#### **TECHNICAL REQUIREMENTS OF TERMINAL EQUIPMENT & NMS**

## **SECTION 5**

### **TECHNICAL REQUIREMENTS OF TERMINAL EQUIPMENT& NMS**

This section describes the Fiber Optic communication network configuration and the equipment characteristics for communication system to be installed in the project area under R-APDRP. The subsystems addressed within this section are:

- (1) Fibre Optic Transmission System (FOTS)
- (2) Network Management System (NMS)
- (3) DDF (Digital Distribution Frame) Patching Facilities

The requirements described herein are applicable to the communication network depicted in section 7 and the Network Management System (NMS) for monitoring and control of this communication network. NMS and TMN (Telecom Network Management System) have been interchangeably used in this specification.

The bidders are encouraged to propose any hardware configurations better suited to the characteristics of the bidder's standard products as long as the equipment characteristic requirements of this specification are met. The SDH equipment of the proposed manufacturer must be in successful operation in the field for at least one year.

#### **1.1. Basic Communication Requirements**

The basic communication needs as detailed below shall be provided using the proposed FO communication network:

- (i) If in a city /project area, MPLS/MLLN based on FO connectivity is available , then 2MBPs /64kbps links will be used for communication between SCADA/DMS control centre & RTUs/FRTU,
- (ii) Otherwise, utility may create FO network envisaged between SCADA/DMS control centre and RTUs on TCP-IP using IEC 610870-5-104 protocol.
- (iii) Secured VPN/SSL 64Kbps links on GPRS/CDMA on public network for communication of FRTU & FPI
- (iv) Remote VDU location will be connected using the owner provided 64 Kbps PSTN leased line MPLS/MLLN for which the modems shall be supplied by the contractor.

#### **1.2 General Network Characteristics**

##### **1.2.1 Description**

The proposed FO communication network is depicted in section 8. The communication system

would support the data requirements of SCADA/DMS in point to multi point and/or multipoint to multipoint configurations using Ethernet over SDH. The detailed BOQ is described in section 8, is based on fibre optic network considering the lowest bit rate of the Synchronous Digital Hierarchy (SDH) ie. STM-1. However, the bidder may offer higher bit rate SDH systems to meet the data requirements of the offered SCADA/DMS systems if required to meet the functional & performance requirements of the system.

## **1.2.2 General Systems Requirements**

Under this section terminal equipment refers to SDH equipment of Fibre Optic Transmission System (FOTS) and its interfaces along with other items (routers/switch, interface converters etc. if provided external to SDH equipment to meet the specification). Required characteristics of fibre optic terminal equipment, NMS system, and associated equipment of communication system are specified herein at the system level, subsystem level, and equipment level in the following sections.

### **1.2.2.1 System Timing and Synchronization**

The Contractor shall provide system wide timing synchronization fully distributed throughout the telecom network. The system wide timing synchronization shall be slaved to a single GPS based master clock provided under SCADA.DMS system. One 2 MHz (75ohm conforming to ITU-T G.703 & G811 quality) port of the master clock shall be provided for synchronization of the communication system. The system equipment requiring “clock” shall be connected to this 2 MHz port of Master Clock using external clocking. For this purpose, appropriate interface(s) in the terminal equipment, cables and all other associated hardware shall be provided by the Contractor. The functional requirement of GPS clock has been specified in Section-02, Chapter-05

### **1.2.2.2 System Maintainability**

Once a failure or degradation of performance is detected in the communications system, its cause shall be promptly isolated and corrected. To facilitate performance trending, efficient diagnosis and corrective resolution, the system shall permit in-service diagnostic testing to be executed both locally and from remote locations, manually and/or initiated under NMS control.

Preventive and problem oriented maintenance of the communications system shall be performed using diagnostics tools such as NMS and test equipment. They shall support complete maintenance of all system elements and shall permit the diagnosis of any fault without requiring additional test equipment. For all redundant systems, disconnection and repair of any failed device shall not interrupt the operation of the system.

### **1.2.2.3 System Upgradeability and Expandability**

Equipment supplied shall be sized (though not necessarily equipped) to support system/ subsystem expansion to full capacity as provided by specified aggregate transmission rates. Equipment units provisioned for unequipped subunit expansions, shall be terminated at appropriate patching facilities



or termination blocks. Power supplies and NMS shall be sized for maximum equipped system ultimate

#### **1.2.2.4 Equipment Availability**

The calculated availability requirements are as follows:

- a. The availability of each fiber optic link shall be at least 99.99%.
- b. The availability of subscribers (on Ethernet interfaces) shall be at least 99.9%.

The calculated availability is defined as the theoretical availability determined by a statistical calculation based on the mean-time-between-failure (MTBF) and the mean-time-to-repair (MTTR) of the components and subsystems comprising the FOTS.

The bidder shall confirm that the equipment & configuration proposed by the bidders shall be capable of demonstrating the specified availability figures. The contractor shall submit the availability analysis for the proposed equipment/ sub system. The analysis shall include the mean-time-between failure (MTBF) and mean-time-to-repair (MTTR) of all of the components on the link. For this analysis, an MTTR of at least 4 hours, shall be assumed.

#### **1.2.3 General Equipment Characteristics**

All Contractor supplied equipment shall be new and of the finest production quality. The Purchaser will not accept modules or printed-circuit boards that are modified by appending wires or components. Wired strapping options shall be incorporated in the board design to meet the above requirement.

All applicable requirements stated in this section shall equally apply to the NMS equipment

##### **1.2.3.1 Revision Levels and Modifications**

All hardware, firmware and software delivered as part of the communications network shall be field proven and at the most current revision level. All modifications and changes necessary to meet this requirement shall be completed prior to the start of the factory tests or under special circumstances, on written approval by owner, prior to the completion of SAT.

All field modifications required to update the hardware, firmware and software to the latest revision level occurring after the above specified testing, shall be fully disclosed, documented and presented to the EMPLOYER for their consideration. Satisfaction of this disclosure requirement does not obligate the Contractor to implement the changes provided the latest revision date occurs after the above requirements are met. The intent is to provide the EMPLOYER with the documentation and opportunity to consider their implementation.

All field modifications of the hardware, firmware and software that is required to meet installation,

performance specifications, shall be fully documented as part of the deliverables, both as a separate field modifications record and as corrected equipment/configuration documentation.

### 1.2.3.2 Equipment Capacities

Equipment supplied shall be sized and equipped with sufficient capacity to support the the basic communication needs specified in clause 1.1 and configuration requirements, including spare specified in clause 1.3 of this section.

### 1.2.3.3 Redundancy Requirements and Protection Schemes

The Contractor(s) shall ensure that single point of failure does not lead to communication equipment failure. The failure of one element shall not prevent the use of any other that has not failed. Equipment redundancy and Automatic Protection Schemes (APS) are specified in the Table 1-1.

The offered equipment shall support at least SNCP as per standard ITU-T G.841. In case the equipment offered by the Bidder does not support the above mentioned minimum protection methods, the bidder shall have to provide all additional equipment needed to provide same level of flexibility, redundancy and functionality at no additional cost to purchaser. The bidders shall provide details of protection schemes supported in the Bid document.

**Table 1-1  
Equipment Redundancy Requirements Summary**

<b>Fiber Optic transmission System:</b> <b>SDH equipment (ADM and TM)</b> <b>Power Supply &amp; Converters -----</b>  <b>Common Control* Cards -----</b>  <b>Tributary Cards E1(ADM and TM)-----</b>  <b>* = Common control cards which are essentially required for operation of the equipment.</b>	  1:1 APS or distributed power supply 1:1 APS  N:1 APS
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The offered equipment shall support automatic switchover function between the redundant modules and all required modules and hardware to support the automatic switch over shall be provided by the Contractor.

### 1.2.3.4 Lost Signal Recovery

At any digital signal level, reapplication of a lost signal shall result in automatic resynchronization and full restoration to normal operation without manual intervention. All alarms incident to the signal failure, shall be automatically cleared at the equipment, rack and monitoring levels and normal

operation indications restored and reported if applicable. Under NMS Control controlled sequencing of the alarm response and restoration may alter normal switch over/ switchback.

#### **1.2.4 Optical Fibre Characteristics**

The characteristics of optical fibre cable to be installed under this package are detailed in this Section

### **1.3 Fibre Optic Transmission System**

The Fibre Optic Transmission System (FOTS) is defined herein to include ETSI digital optical line termination equipment. The FOTS shall be based on SDH technology. Minimum aggregate bit rate shall be STM-1 and equipped with minimum 4 Ethernet interfaces (IEEE 802.3/IEEE 802.3u) supporting layer 2 switching as tributaries. The Ethernet interfaces shall support VLAN (IEEE 802.1P/Q), spanning tree (IEEE 802.1D) quality of service. The Contractor may offer external Layer-2 switch to meet the functionality if Layer -2 switching is not supported within the offered SDH equipments. The SDH equipment shall also support E1 interfaces (G.703). The requirement of tributaries & aggregates are indicated in the BOQ.

The Contractor shall provide (supply and install) connectorised jumpers (patch cords) from FODP-to-equipment and equipment-to-equipment connection. Two numbers of spare jumpers shall be provided in each connection. Fiber jumpers shall be of sufficient lengths as to provide at least 0.5m of service loop when connected for their intended purpose.

#### **1.3.1 SDH Equipment**

##### **1.3.1.1 Functional Requirement**

The offered equipment shall be configurable either SDH Terminal Multiplexer (TM) or SDH Add/Drop Multiplexer (ADM) or Digital Cross Connect (DXC). The BoQ is provided in the appendices. **SDH Equipment** is considered to be divided in three parts i.e. **Optical cards** (Line), **Tributary Cards** and **Base Equipment** (Consisting of Common Cards, Power supply cards, power cabling, sub-rack, other hardware and accessories required for installation of equipment i.e. everything besides optical cards and tributary cards). The Bidder shall list out all type of cards/items being provided, in the BoQ and identify price for each separately.

The offered equipment shall support at least four optical directions with STM 1 as aggregate interfaces, 8 Ethernet Interfaces & 8 E1 interfaces as tributaries. The SDH equipment shall be

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equipped with required aggregate and tributary interfaces based on the network topology as indicated in the BOQ. The offered equipment shall support the following network topologies:

- a) TM (with protected/unprotected aggregates)
- b) ADM (with protected/unprotected aggregates)
- c) DXC (with protected/unprotected aggregates)

The ADM Equipment shall be capable of VC-12 level Cross Connection of up to 4 STM-1 equivalent and support mapping of each Ethernet interface over any single or multiple VC-12s.. The equipment shall support VC-12 cross connection in all the 4 directions.

In the Proposed BOQ one SDH equipment has been considered upto two protected optical directions (four unprotected directions). In case the bidder offers SDH equipment supporting more than two optical directions (protected ) and/or more than four optical directions (unprotected), the bidder may propose the optimized BOQ of SDH equipment at all locations without compromising the functional requirement of specification. The bidder shall indicate & submit the justification for the proposed optimization along with the bid wherever applicable.

#### **1.3.1.2 Redundancy and Protection**

Redundancy and protection requirements have been specified in clause 1.2.3.3 the network connectivity is planned in rings with SNCP protection. However, it shall be possible to protect the point to point STM1 and E1 channels across the network using the proposed scheme of protection. On linear sections of the network, protected links using 4 fibres may be implemented. The actual protection scheme shall be finalized during detailed engineering. The Contractor shall provide all required optical cards, protection cards (if any) and size the equipment accordingly.

#### **1.3.1.3 Service Channel**

Service channels shall be provided as a function of the SDH equipment and shall be equipped with Service Channel Modems that shall provide at a minimum: One voice channel (order wire) with analog interface (0.3 to 3.4 kHz) and One data channel. Both omnibus and selective calling facilities shall be provided. There shall be a facility to extend the line system order-wire to any other system or exchange lines on 2W/4W basis. Also it shall be possible to extend the service telephone to another room away from the equipment; the Contractor shall be required to install the service telephone at the location indicated by the EMPLOYER during implementation.

#### **1.3.1.4 Supervision and Alarms**

ISM (In Service Monitoring) circuitry shall be provided as a function of the SDH equipment. Local visual alarm indicators shall be provided on the equipment, as a rack summary alarm panel. Alarms shall be as per ITU-T Standards G.774, G.783 and G.784. Additionally, one local craftsperson terminal interface and Q/SNMP/Web/Telnet interfaces for a local craftsperson terminal interface and remote equipment monitoring (NMS) is required. However the type of interface shall not limit the NMS system requirement specified in the clause 1.4 of this chapter.

The Equipment shall support collection of at least four (4) external alarms for monitoring and control of station associated devices by the NMS as per section **NMS Architecture**. The Owner/Purchaser identify the alarm contact points during survey / detailed engineering and the wiring supply, installation and termination from these external points to the installed equipment shall be carried out by the Contractor.

### 1.3.1.5 Synchronisation

The equipment shall provide synchronization as per table 2-2. One 2MHz synchronization output from each equipment shall be provided.

### 1.3.1.6 Electrical and Optical I/O Characteristics and General Parameters

Table 1-2 provides the electrical and optical characteristics as well as other general parameters for SDH equipment.

**Table 1-2**  
**Electrical and Optical I/O Characteristics and General Parameters**

<b>Optical Wavelength</b> <sup>NOTE (1)</sup>	1310/1550nm
<b>Optical Source</b> <sup>NOTE (2)</sup>	Laser
<b>Optical Source Lifespan</b>	Better than 5 X10 <sup>5</sup> hours
<b>Optical Fibre Type</b>	G.652
<b>Optical Connectors</b>	Type FC-PC
<b>Transmission Quality</b>	Per ITU-T G.821, G.823, G.826
<b>Source Primary Power</b>	-48 Vdc
<b>Equipment Specifications</b>	Per ITU-T G.783
<b>Tributary, Electrical Interface</b>	Per ITU-T G.703, 75 Ω/ 120 Ω
<b>Ethernet 10/100 Mbps interface</b>	Per IEEE 802.3/802.3u

**Table 1-2**  
**Electrical and Optical I/O Characteristics and General Parameters**

<b>SDH Bit Rates</b>	Per ITU-T G.703
<b>Optical Interfaces</b>	Per ITU-T G.957, G.958
<b>Frame and Multiplexing Structure for SDH</b>	Per ITU-T G.707
<b>Synchronisation</b>	Per ITU-T G.813
<b>Management Functions</b>	Per ITU-T G.774, G.784
<b>Protection Architectures</b>	Per ITU-T G.841
<b>Built In Testing and Alarms</b>	Per ITU-T G.774, G.783, G.784

**NOTE (1)** Optical wavelength shall be selected considering the characteristics of the optical fibre and the link budget.

**NOTE (2) Eye Safety for Laser Equipment:** To avoid eye damage, when a receiver detects a line interruption, it is required that the optical power of the laser shall be reduced to safe limits on the transmitter in the opposite direction as per ITU-T G.958.

**NOTE (3) Temperature Stabilisation:** Meet or exceed operational performance requirements through entire temperature range as specified

**NOTE (4)** In case other than FC-PC connector is provided in the equipment suitable patch cord with FC-PC connectors are to be provided to connect with FODP.

### **1.3.2 Optical Link Performance Requirements**

The optical fibre link performance requirements are specified as follows.

#### **1.3.2.1 Link Budget Calculations**

The fibre optic link budget calculations shall be calculated based upon the following criteria:

- (1) Fibre attenuation: The fibre attenuation shall be taken to be the guaranteed maximum fibre attenuation i.e. 0.23 dB/Km @1550nm and 0.35 dB/km @1310nm.
- (2) Splice loss: Minimum 0.05 dB per splice. One splice shall be considered for every 2 kms.
- (3) Connector losses: Losses due to connectors shall be considered to be minimum 1.0 dB per link.
- (4) Equipment Parameters: The equipment parameters to be considered for link budget calculations

shall be the guaranteed “End of Life (EOL)” parameters. In case, the End of Life parameters are not specified for the SDH equipment, an End of Life Margin of at least 2 dB per link shall be considered.

(5) Optical path Penalty: An optical path penalty of at least 1 dB shall be considered to account for total degradations due to reflections, inter symbol interference, mode partition noise and laser chirp.

(6) Maintenance Margin: A maintenance margin of at least 0.5 dB shall be kept towards cabling, repair splicing, cable ageing and temperature variations etc.

(7) Other losses: Other losses, if any required specifically for system to be supplied shall also be suitably considered.

(8) Dispersion: The fibre dispersion shall be taken to be the guaranteed maximum dispersion i.e 20 ps/nm.Km @1550 nm and 6 ps/nm Km @ 1310 for DWSM fibres.

(9) Bit Error Rate: The link budget calculations shall be done for a BER of  $10^{-10}$ .

The bidders shall confirm in their offer that the offered equipment and their interfaces shall meet the above link budget calculation criteria for the link lengths mentioned in the BOQ (which does not include sag, service loops, working lengths, wastage etc). Detailed link budget calculation shall be submitted during the detailed engineering.

### **1.3.2.2 Link Performance**

The Link performance for ES, SES and BER for the fibre optic links shall correspond to National Network as defined in ITU-T G.826. Further, the Packet loss shall not be more than one percent in any of the Ethernet circuits of the offered system.

### **1.3.2.3 FODP to SDH Equipment Connectivity**

The Contractor shall provide rack mounted/wall mounted Fiber Optic Distribution Panels (FODPs) and shall terminate the fiber optic cabling on to the FODPs. The Contractor shall be responsible for connectivity between the FODP and the optical equipment and shall also supply of patch cords for the same. The patch cord shall have FC-PC type connectors at FODP end..

The patch -cord return loss shall be equal to or better than 40 dB and insertion loss equal to or less than 0.5 dB.

The FODP rack shall be located preferably in the same room as of the Optical equipment rack, except where space constraint dictate otherwise. The patch-cord length between the FODP & equipment rack shall be suitably protected from abrasion, crush or mechanical damage otherwise by flexible conduits or equivalent EMPLOYER approved techniques.

## **1.4 NETWORK MANAGEMENT SYSTEM(NMS)**

The Contractor shall provide a Network Management System (NMS) also referred as TMN to provide operational support for the FOTS and associated equipment. This NMS shall provide the capability to monitor, reconfigure, and control elements of the telecommunications network from a centralized location (Control Centre) and at each node of the network where equipment is located. This NMS system shall assist Purchaser in the operations and maintenance of the wideband communication resources including detection of degraded equipment, system performance, the diagnosis of problems, the implementation of remedial actions and the allocation or reallocation of telecommunications resources and addition/deletion of network elements and remote monitoring of alarms/indications. **The bidder shall provide details of the offered NMS in the bid supporting all the features.**

### **1.4.1 Applicable Standards**

The NMS design concept, functional and informational architecture and physical architecture, shall be in compliance with ITU-T Recommendation M.3010. However, the NMS system based on TCP/IP stack shall also be acceptable provided such NMS implementation ensures security and reliability of the data transmission over the DCC, equivalent to that achieved in TMN implementation based on OSI stack (M.3010).

### **1.4.2 NMS Architecture**

The NMS shall provide

- a. Collection of Management data from all Network Elements (NEs) supplied under this package. The minimum monitoring and control requirements for the communication equipments shall be as per Clause 1.3 Fibre Optic Transmission system.
- b. Processing of above management data by using processor(s) located at control Centres.
- c. Monitoring and control of the NEs as defined below:



- I) TMN system at Control Centre (including local operator console) shall support management of all equipments supplied and monitoring of the entire network supplied under this package. At a minimum functions (viz configuration management, fault management, performance management and security management as defined in clause 1.4.3 of this section) of Network Management Layer (NML) and Element Management Layer (EML) as defined in CCIT M.3010 shall be provided.
- II) Monitoring and control of NEs using Craft Terminals as defined in clause 1.4.6
- d. Supervisory monitoring and control of the following station associated devices to the extent supported by equipment:
- e. Communication channel support as specified in section 1.4.4.

The supplied TMN system shall be capable of handling all management functions for at least 200 % of the supplied network elements. The TMN hardware shall be so designed that failure of a single processor/component shall not inhibit any of the functionality of the TMN at control centre.

The Contractor shall submit for EMPLOYER's approval the TMN architecture describing in detail the Database used in TMN, Hardware (Refer Clause 1.4.6 ), Software and operating system (Refer Clause 1.4.7 ), Craft Terminals (Refer Clause 1.4.5 ), Data communication between NEs, Local Consoles and TMN Processor(s), Routers/ Bridges, Expansion Capabilities etc. of the proposed system.

### **1.4.3 Management Functions**

The TMN shall support following Management functions:

#### **1.4.3.1 Configuration Management**

Configuration management is concerned with management, display, and control of the network configuration. Minimum specific requirements that shall be satisfied include the following:

- a. Provide tools to establish and maintain the backbone topology and configuration information and provide graphical maps depicting the configurations.
- b. Gather descriptive information about the current configuration of the equipment, provide operator displays, and prepare reports.

- c. Provide tools for planning, establishing, and changing the static equipment configuration. Provide for changes to the equipment configuration in response to equipment failures, planned upgrades, and operator requests to take equipment offline for testing.
- d. Provide verification testing to support new equipment installation.

#### **1.4.3.2 Fault Management**

Fault management is concerned with detecting, diagnosing, bypassing, directing service restoral, and reporting on all the backbone network equipment, system and links, Minimum specific requirements that shall be satisfied include the following:

- a. Display equipment status in a consistent fashion regardless of the source of the data on a graphical topological, map-type display. Status shall be displayed through the use of colours on links and nodes as well as through text.
- b. Obtain status and detect faults through periodic polling, processing of unsolicited alarms and error events, and periodic testing for connectivity.
- c. Maintain an alarm summary of unacknowledged alarm events on the management station display and maintain a log of all received alarms. The operator shall be able to acknowledge and clear alarms individually and as a group. The use of alarm correlation techniques is encouraged to minimize the proliferation of alarms caused by a single, common event. All alarms shall be configurable as critical alarms, major alarms and minor alarms with different colours like red, amber/orange, blue etc. The normal condition shall be green (preferably) in colour.
- d. Provide the capability to diagnose and isolate failures through analysis of error and event reports and through the use of both on-line and off-line diagnostic tests and display of monitored data.
- e. Support in reducing failures through the use of automatic failover to redundant equipment where possible and through operator-initiated actions where automatic failover is not possible. The status of fail over shall be reported to TMN.
- f. Track network equipment failure history.

### **1.4.3.3 Performance Management**

Performance management is concerned with evaluation of the use of network equipments and their capability to meet performance objectives. Minimum specific requirements that shall be satisfied include the following:

- a. Provide support for an operator to initiate, collect, and terminate performance metrics under both normal and degraded conditions. For example, BER of each link together with other data measured at each node, shall be available on operator request.
- b. Monitor point to point, end to end errors/signal quality and history. Provide operator controls to monitor performance of specified events, measures, and resources. Specifically provide displays to permit the operator to:
  - 1. Select/deselect network equipments, events, and threshold parameters to monitor
  - 2. Set monitoring start time and duration or end time
  - 3. Set monitoring sampling frequency
  - 4. Set/change threshold values on selected performance parameters
  - 5. Generate alarm events when thresholds are exceeded.
  - 6. Set multiple thresholds on certain performance parameters. Alarm categories include as a minimum a warning and a failure.
  - 7. Calculate selected statistical data to measure performance on selected equipment based on both current and historical performance data maintained in performance logs as per G,826. Performance data provided is limited to what is available from the equipment Contractors.
  - 8. Provide graphical displays of NE current performance parameter values. Provide tabular displays of current, peak, and average values for performance parameters.
  - 9. Generate reports based on system statistics such as daily, weekly, monthly yearly performance reports.

### **1.4.3.4 Security Management**

The TMN shall be provided with security features to limit access to monitoring and control capabilities to only authorized personnel. One access level of System Administrator and at least three levels of operator access shall be provided - read only, and write. The system administrator shall be able to create, define and modify operators with different access levels, network domains and perform all kind of maintenance and up gradation of the TMN system. With "read only" access level, network parameters should only be viewed. Access to database maintenance, command control and test functions shall be available with "write " access level. Means shall be provided to ensure only one authorized user has write capability for a selected domain of the network.

Human error and conflict detection are also required. Such errors and access violations shall be reported to the offending user as error messages and warnings.

#### **1.4.4 Communication Channel Requirements and Integration**

The TMN data transport shall utilize the transmission system service channel in the overhead. In case overhead channels are not available, the Contractor shall provide suitable interfaces with 1+1 protection in their supplied equipment for transport of TMN data.

#### **1.4.5 Craft Terminal**

Each SDH equipment on the telecom network shall include provision for connecting a portable personal computer (PC) to be known as craft terminal to support local commissioning and maintenance activities. It shall also be possible to remote login to other NE(s) through craft terminal. Through the use of this PC and local displays/controls, the operator shall be able to:

- a. Change the configuration of the station & the connected NEs.
- b. Perform tests
- c. Get detailed fault information

The portable computer shall be connected to a V.24/V.28 interface available at terminal stations. Portable (laptop) computers (Craft terminals), each complete with necessary system and application software to support the functions listed above, shall be supplied to the Purchaser as per BOQ given in appendices.

#### **1.4.6 Hardware Requirements**

NMS shall include at least one server/master processor, two operator consoles (work stations), one

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network printer and the craft terminals as indicated in the BOQ.

#### **1.4.6.1 Master Processor, Server/Workstation and Craft Terminal**

The master processor, server/workstation and craft terminal shall have Pentium/AMD or RISC based processor(s) which shall be sufficient to meet all the functional requirement and expansion capabilities stipulated in this specification. Only reputed make like Dell, IBM, HP, Compaq make shall be supplied. The master processor, server/workstation shall have minimum configuration of 2 GHz processor (1.0 GHz in case of RISC processor), 256 MB SD RAM, 32 MB VRAM, CD-R/W drive, 72 GB Internal Disk Drive, 101-Enhanced style keyboards, mouse, USB(2.0), parallel and serial ports. VDUs for Local Operator consoles shall be 19" TFT Colour with a minimum resolution of 1024 X 768. Appropriate network drive card shall also be provided wherever required. Internal/external data/fax modem shall be provided in work stations.

However, the internal disk drive for the master processor shall be redundant and all the data shall be mirrored. Further, the TMN software shall support data mirroring on redundant disk drives.

CPU enclosures shall be desktop type and shall include available expansion slots except for the Craft Terminal which shall be a laptop. The craft terminal shall have minimum configuration of 2 GHz processor, 256 MB RAM, CD-R/W/DVD drive, 30 GB Internal Disk Drive, keyboard, mouse/trackball etc., USB(2.0), parallel and serial ports to accommodate printers, and Internal/external Data/Fax modem and a battery back-up of at least 60 minutes. VDUs shall be 15" TFT active matrix colour LCD with a minimum resolution of 1024 X 768.

#### **1.4.6.2 Peripherals and hardware**

TMN system shall be provided with one network printer. The network printer shall be connected to the LAN of the TMN system and shall be of Laser Jet type capable in printing in colours having a minimum print speed 4 pages per minute, capable to print at least A4 & A3 and a minimum resolution of 300dpi.

The printer under this specification shall include print enhanced buffering to prevent loss of print data in the event of a print failure.

#### **1.4.6.3 Power Supplies**

The TMN system shall use 230 volt 50 Hz AC from the UPS system provided under this project at Control Centre locations.

#### **1.4.7 General Software/Firmware Requirements**

Due to various alternative design approaches, it is neither intended nor possible to specify all software and firmware characteristics. It is the intent herein to provide design boundaries and guidelines that help to ensure a demonstrated, integrated program package that is maintainable and meets both hardware systems requirements and the customer's operational requirements.

##### **1.4.7.1 Operating System Software**

Operating system software shall be provided to control the execution of system programs, application programs, and management devices, to allocate system resources, and manage communications among the system processors. The Contractor shall make no modifications to the OEM's operating system, except as provided as USER installation parameters.

##### **1.4.7.2 Applications Software**

All applications software shall be written in a high-level programming language unless developed using industry proven application programs and development tools provided with the system. The Contractor shall make no modifications to the applications program except as provided as User development tools.

##### **1.4.7.3 Software Utilities**

A utility shall be provided to convert all reports into standard PC application formats i.e. dbase, dxf, excel, ASCII etc. as applicable.

##### **1.4.7.4 Revisions, Upgrades, Maintainability**

Software revisions, upgrades and maintainability is specified as follows:

###### **1.4.7.4.1 Versions**

All firmware and software delivered under this specification shall be the latest field proven version available at the time of approval. Installed demonstration for acceptance shall be required.

###### **1.4.7.4.2 Program Rewrites**

All firmware provided shall support its fully equipped intended functional requirements without additional rewrite or programming.

#### **1.4.7.4.3 Expansion**

All software shall be easily USER expandable to accommodate the anticipated system growth, as defined in this specification. Reassembly recompilation or revision upgrades of the software or components of the software, shall not be necessary to accommodate full system expansion.

#### **1.4.7.4.4 Standards Compliance**

Software provided shall be compliant with national and international industry standards such as IEEE, ISO and OSF.

#### **1.4.7.4.5 User Maintainability**

All provided software shall be completely maintainable by the end USER utilizing the software services, tools and documentation that shall be delivered with the system.

#### **1.4.7.5 Database(s)**

The contractor shall develop all the databases for final communication network following the global acronyms for all stations. Database(s) to be provided shall contain all structure definitions and data for the integrated functional requirements of TMN system.

TMN operator Groups shall share the same virtual database. This means that they shall share the same database and database manager, whether or not physically separate databases are maintained.

#### **1.4.7.6 Help**

All applications shall be supported by USER accessible HELP commands that shall assist the USER in the performance of its tasks. HELP commands for an application shall be available to the USER from within the active application and shall not interfere with the activities of the application

### **1.5 DDF Patching Facilities**

The Contractor shall supply and install all cabling, wiring, connectors, cross connects and Digital Distribution Frames (DDF) associated with the installation and interconnection of equipments procured under this package as follows:

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- (I) DDF shall be provided for termination of 16 E1 as minimum
- (II) Cables (including connectors) for E1 level connections between DDF and telecom Equipment.
- (III) Cables (including connectors) required for E-1 level connections of all other equipment to DDF and telecom Equipment.
- (IV) All Ethernet ports shall be terminated with RJ-45 connector. Provision for 100% expansion with connector for terminating additional Ethernet ports shall be provided.
- (V) Any other cables, connections etc required for a fully functional, integrated system.

## 1.6 ENVIRONMENT, EMI, POWER SUPPLY, CABLING AND EARTHING

The purpose of this section is to describe the minimum general equipment characteristics and specifications for environmental conditions, source power conditioning and backup, equipment construction, and installation. The section also highlights the stringent Electro Magnetic Compatibility (EMC) guidelines for equipment that will be operated under the severest Electro Magnetic Interference (EMI) and Electro Static Discharge (ESD) conditions expected in an Extra High Voltage (EHV) power system environment.

### 1.6.1 Environmental Requirements

Equipment and their components provided under this specification shall operate reliably under the following environmental conditions.

#### 1.6.1.1 Temperature and Humidity

Most of the equipment will not be installed in environmentally controlled shelters. Therefore, equipment shall operate in accordance with the limits shown in Table 1-3.

**Table 1-3**  
**Environmental Operating Limits**

<b>Temperature Range:</b>	(Un Controlled Environment)
<b>To Specification</b>	0 to +45 °C
<b>Operation without damage</b>	-10 to +55 °C
<b>Shipping/storage</b>	-40 to +60 °C
<b>Relative Humidity, non-condensing</b>	Upto 90% (non condensing)



**Table 1-3  
Environmental Operating Limits**

<b>Elevation:</b> <b>Operating</b> <b>Non-operating</b>	to 3,500 m to 10,000 m

For each location, the Contractor is required to assess the environmental conditions for the equipment to be installed under this specification. The Contractor is responsible for all necessary enclosure, rack or equipment upgrades to ensure the proper operation of the installed equipment.

#### **1.6.1.2 EMI and Electrostatic Interference**

At each location, the Contractor shall assess the need for shielding against radiated emissions and shall provide recommended solutions for any EMI problem found at each location.

This section provides the type of immunity tests for which the equipment shall be required to pass without failure. For the individual tests to be carried out at the different interfaces, references are made to the relevant IEC and ITU-T recommendations.

#### **1.6.1.3 Tropicalization**

Communications equipment will often be stored and operated in uncontrolled environment areas and will be subject to mould, growth of fungus, corrosion and oxidation. The equipment and components shall be suitably tropicalized during manufacture through commissioning, as necessary.

#### **1.6.1.4 Contaminants**

Communications equipment may be located in areas of poor air quality with the main contaminant being dust. Cabinets shall be tight fitting utilizing filtered ventilation openings only.

### **1.6.2 Primary Source AC/DC Power Requirements**

Power requirements of telecommunications equipment is as specified below:

#### **1.6.2.1 Primary Source AC Power**

It will be the Purchaser's responsibility to provide required Primary AC Power support for communications equipment installed under this specification. The Primary AC Power supplied will be 220 VAC +10%/-15%, 50Hz with a frequency variance between 46 and 55 Hz..

All equipment and components provided under this specification requiring Primary AC Power, shall be designed for normal operation under the above stated tolerances for 220 VAC supply.

The Contractor shall provide in the survey report to the EMPLOYER the projected 220 VAC Primary Power load requirement per equipment and totals, by location, for equipment provided under this specification.

The communication equipment shall be powered from 48 V DC from DCPS except NMS/Craft Terminal which shall be powered from 230 V AC. Necessary power distribution, protection and cabling from DCPS/Inverter/UPS shall be the responsibility of the contractor.

### **1.6.3 Equipment Constructions, Assembly and Installation**

All equipment supplied under this specification shall be constructed, assembled and installed in accordance with the following requirements:

#### **1.6.3.1 Identification**

All cabling, racks/enclosures, equipment, modules and materials shall be uniquely identifiable. All the inter cubicle cables shall be provided with identification tags at both ends of termination for easy traceability.

#### **1.6.3.2 Equipment Sub-Racks and Cabinets (Enclosures)**

All equipment provided under this specification, shall be physically mounted in sub-racks, which will be mounted in cabinets (enclosures). The Contractor shall determine and propose for the EMPLOYER approval, the type, size, weight and manner of installation for each location.

##### **(A) Equipment Cabinet (Enclosure) Construction**

- (1) Equipment cabinets (enclosures) shall be steel/ steel & Aluminium extrusion fabricated and finished on all surfaces. All metal and welds shall be thoroughly cleaned and sanded to obtain a smooth finish. All surfaces shall be treated for rust and primed to form a bond between metal and the finish coats of paint.

- (2) Equipment cabinets (enclosures) shall be designed free-standing but shall be mounted to the floor. Cabinets (enclosures) shall have secured fitting, lockable, full-length front doors for access to hardware and wiring. Equipment covers for exposed components mounted inside cabinets are not required unless specifically recommended.
- (3) 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
- (4) Equipment cabinets (enclosures) shall be confirm to IP41 protection class as per IEC 529 specification, or better.
- (5) The racks shall be provided with lighting system and switches for easy maintenance.
- (6) 5/15A duplex plugs shall be provided on each cabinet and electricity supply shall be extended to this plug for testing and commissioning purpose.
- (7) Racks shall be provided with key based door locking arrangement.

#### **1.6.3.3 Signaling Distribution**

The Contractor shall be responsible for all signal wiring associated with furnished equipment in accordance with the following:

- (1) All signal wiring connections to the communications equipment shall be via Krone type terminal blocks.
- (2) The Contractor shall provide subscriber level wiring and patching wherever required.

#### **1.6.3.4 Lightning and Transient Voltage Protection**

The Contractor shall be required to provide protection from lightning and transient voltages to meet the requirements specified in EMI/EMC in clause 1.7.1 above and other protections deemed necessary for successful operation of the system.

#### **1.6.3.5 Station Safety Earthing and Signal Grounding**

For each facility, the Contractor is responsible for meeting the following station and equipment earthing requirements:

- (1) All safety earthing and signal grounding shall be in full compliance with EMI/EMC requirements as per relevant international standards
- (2) Each cabinet (enclosure) or cabinet (enclosure) group shall include suitable signal ground and safety earth networks. The signal ground network shall terminate at a separate signal ground stud connection isolated from safety earth.
- (3) Each earth/ground network shall utilize copper bus bars, copper braids and/or 16 sq mm or bigger earth cable. All equipment earth/ground connections shall be made directly to the equipment chassis utilizing grounding lugs and secured metal-to-metal with star washers. Use of the enclosure frame, skin or chassis mounting hardware as part of the earthing/grounding networks, is not acceptable.
- (4) The safety earth network shall be connected to "earth ground" at the safety earth stud. The earth stud connection shall be sized for an external earthing cable equipped with a 2/0 solid copper lug secured metal-to-metal with star washers. Primary AC feeds and distribution within enclosures requires earthing wire connection to the safety earth stud.
- (5) The safety earth and signal ground networks shall be inter-connected only at the safety earth stud and signal ground stud.

The Contractor shall provide all required earthing /grounding cable/strips to extending it to substation earthing system. The Contractor shall also be responsible for providing earthing systems including earth pits, earthing studs and earthing grid etc, as required, wherever the existing station earthing is found to be unsuitable for equipment being provided by the Contractor.

Cabinet (Enclosure) and equipment safety earthing and signal grounding shall be subject to the EMPLOYER's approval.

#### **1.6.3.6 Interconnections**

All power and signal cabling between component units of the communications systems shall be supplied and installed by the Contractor and shall be shown on contractor-supplied as-built drawings.

#### **1.6.3.7 Finish Colors**

Unless otherwise specified, finish colors for enclosures shall be gloss white enamel on the inside, and semi-gloss medium gray enamel on the outside. Only brushed aluminum trim shall be used. The actual colouring scheme shall be finalised during project execution

### **1.6.4 Location of Equipment, Cable Routes and Associated Civil Works**

During the Site Surveys, the Contractor shall determine and propose locations for all equipment to be supplied under this contract. Further, the Contractor shall locate and identify proposed routing for all cabling between all equipment locations including existing and planned equipment not provided under this contract, but required to be connected under the scope of this contract. This subsection defines the requirements and clarifies the responsibilities of the EMPLOYER and the Contractor regarding equipment siting, intra and inter facility interconnectivity and necessary associated civil works.

#### **1.6.4.1 Locations for Supplied Equipment**

All transmission equipment, the TMN and associated equipment shall generally be collocated in the same communications room located in the Control Room Building whenever possible. At all locations, the communication equipment shall be kept at the nearest available space in the RTU room/building/control room. The supply of all the interconnecting cables and interconnections is to be done by the contractor.

#### **1.6.4.2 Cable Routing**

In case TMN workstations are located remotely, the Contractor shall provide all cable, wiring, long haul landline interfacing and installation to facilitate communication channel requirements for the TMN .

#### **1.6.4.3 Associated Civil Works**

The Contractor shall provide all required minor civil works necessary for full connectivity as required in the Contractor's scope of work as follows:

- (1) All wall and floor penetrations, extension of cable trench necessary for the installation of all cabling to be performed in accordance with the requirements of this specification.

- (2) Installation of racks, cabinets, cable raceways, and cabling supplied as part of this contract.

## **1.8 Factory testing**

The factory test requirements (Type Testing and Factory Acceptance Test) are to be carried out as follows:

### **1.8.1 Type Testing**

"Type Tests" shall be defined as those tests which are to be carried out to prove the design, process of manufacture and general conformity of the materials to this Specification. The Contractor shall offer the type tested equipment as per relevant standards and shall submit the earlier carried out type test reports of the test requirement specified below for Employer's review and approval. In case any of the test reports are not submitted or not meeting the requirement, the same shall be carried out by the Contractor at no additional cost to the Employer.

#### **1.8.1.1 List of Type Tests**

The type testing requirement for communication equipment is defined in the section below:

The type testing shall be conducted on the SDH equipment with all cards.

#### **1.8.1.2 Temperature and Humidity Tests**

The tests listed below are defined in IEC Publication 68.

##### **(a) Low Temperature Test: Operation to Specifications**

Low temperature tests shall be conducted as defined in IEC Publication 68-2-1, test method and, with the following specifications:

- (1) Test Duration: The equipment is started up as soon as thermal equilibrium has been reached and operated for sixteen (16) hours. Its performance is checked during the test.
  - (2) Degree of Severity: Test shall be done at 0 °C.
  - (3) Acceptance Criteria: No degradation of performance during and after the test.
-

**(b) Low Temperature Test : Operation without Damage**

Low temperature tests shall be conducted as defined in IEC Publication 68-2-1, test method Ad, with the following specifications:

- (1) Test Duration: The equipment is started up as soon as thermal equilibrium has been reached and operated for 72 hours. Its performance is checked during the test and after the test as soon as the thermal equilibrium is reached at the room temperature (*Post-test*).
- (2) Degree of Severity: Test shall be done at -10 °C.
- (3) Acceptance Criteria: Degradation of performance is allowable during the test, however there shall be no degradation of performance in the *post-test*.

**(c) Dry Heat Test : Operation to Specifications**

Dry heat test shall be done as defined in IEC Publication 68-2-2, test method Bd, with the following specifications:

- (1) Test Duration: The equipment is started up as soon as thermal equilibrium has been reached and operated for 96 hours. Its performance is checked during the test.
- (2) Degree of Severity: 45 °C.
- (3) Acceptance Criteria: No degradation of performance during and after the test.

**(d) Dry Heat Test : Operation without Damage**

Dry heat tests shall be done as defined in IEC Publication 68-2-2, test method , with the following specifications:

- (1) Test Duration: The equipment is started up as soon as thermal equilibrium has been reached and operated for 96 hours. Its performance is checked during the test and after the test as soon as the thermal equilibrium is reached at the room temperature (*Post-test*).
  - (2) Degree of Severity: Test shall be done at 55°C.
  - (3) Acceptance Criteria: Degradation of performance is allowable during the test,
-

however there shall be no degradation of performance in the *post-test*.

**(e) Damp Heat Test**

Damp heat testing reveals aging with respect to the humidity level and applies basically to electronic equipment. This test shall be done as defined in IEC Publication 68-2-3 with the following specifications:

- (1) Test Duration: The equipment is started up as soon as thermal equilibrium has been reached and operated for 10 days. Its performance is checked during the test.
- (2) Degree of Severity: Test temperature shall be 40 deg C & RH shall be 93 (+3/-2) % non condensing as per referred standard..
- (2) Acceptance Criteria: The equipment shall meet the specified requirement and there shall not be any degradation in BER.

**(f) Temperature Variation Test**

Temperature variation testing shall be as per IEC Publication 68-2-14 (Gradual Variations, Method Nb). The equipment shall be powered on and various parameters shall be monitored continuously during the test period.

- (1) Number of cycles required is five (5)
- (2) The degree of severity: temperature: as per table 2-3 (Operation to specification range i.e. 0 deg C & 45 deg C)
- (3) Cycle duration for each temperature is three (3) hours.
- (4) Ramp : 1 °C/minute.
- (5) Acceptance Criteria: The equipment shall meet the specified requirement and there shall not be any degradation in BER.

**1.8.1.3 Power Supply and EMI/EMC tests**

The test procedure and acceptance criteria shall be as defined in IEC 870-2-1.

**(a) Immunity Tests**

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The list of Immunity tests are specified below in Table 1-4:

**Table 1-4**

Test Nos.	Test Name	EUT Status	Test Level	Power Supply Points		Control lines & alarms	Telecom Lines	Passing Criteria
				CM	DM	CM	CM	
1	Surge Immunity Test	ON	Level 3	2 kV	1 kV	2 kV	---	A
2	Electrical Fast Transient Burst Test	ON	Level 3	2 KV	-	1 kV	1 kV	A
3	Damped Oscillatory Wave Test	ON	Level 3	2.5 kV	1 kV	2.5 kV	2.5 kV	A
4	Electrostatic Discharge Test	ON	Level 3	+/- 6 kV in Contact discharge mode or +/- 8 kV in Air discharge mode				A
5	Radiated Electromagnetic Field Test	ON	Level 3	10 V/m electric field strength				O
6	Conducted Radio Frequency Common mode	ON	Level 3	10 V rms DC clamp injection method as per IEC 61000-4-6 on DC & Control Signals				A
7	Damped Oscillatory Magnetic Field Test	ON	Level 3	30 A/m at 1MHz of magnetic field strength				O
8	Power frequency magnetic field	ON	Level 3	30 A/m of magnetic field strength (Continuous duration sine wave)				O
9	Power frequency voltage withstand	OFF	-	1 KVrms for 1 minute				No break down or flashover shall occur
10	Insulation Resistance Test	OFF	-	Measure Insulation resistance using 500 V DC Megger before & after Power Freq & Impulse voltage withstand tests				As per manufacturer standard

**(b) Emission Tests**

The list of Emission tests are specified below :

Conducted and radiated emissions:- To comply with Class A (Class B for low capacity (below 34 Mbps data rate) of CISPR 22 (1993) “Limits and methods of measurement of radio disturbance characteristics of Information Technology Equipments”

### 1.8.2 Factory Acceptance Tests

The factory acceptance test shall demonstrate the technical characteristics of the equipment in relation to this specifications and approved drawings and documents. The list factory acceptance tests for FOTS is provided in table 2-6 below. This list of factory acceptance tests shall be supplemented by the Contractor's standard FAT testing program. For general requirements of testing section 7 is to be referred. FAT for other items shall include at least: Physical verification, demonstration of technical characteristics, various operational modes, functional interfaces, alarms and diagnostics etc in addition to the standard manufacturers test program. For Test equipment, FAT shall include supply of proper calibration certificates, demonstration of satisfactory operation, evidence of correct equipment configuration and manufacturer’s final inspection certificate

**Table 1-5:**  
**Fibre Optic Transmission System & NMS Factory Acceptance Testing**

Item	Description:
1.	Physical inspection for conformance to drawings and appearance of equipment and TMN hardware
2.	Optical output power
3.	Transmitter light wave spectral analysis
4.	Low receive level threshold
5.	Generation of bit error rate curve
6.	Electrical interface tests which include: output and input jitter, bit error rate, pulse shape, and line rate tolerance
7.	Measurement of analog and digital service channel parameters/functionality

<b>8.</b>	Performance of supervision, alarm, diagnostics, loopbacks etc. through Craftsperson interface,
<b>9.</b>	Network Management interface performance along with NMS/TMN
<b>10.</b>	Testing of TMN to demonstrate proper operation of all functions : Configuration Management, Performance Management, Fault Management and Security management. Standard features and required customization of the TMN shall be demonstrated for proper functioning.
<b>11.</b>	Simulation of failure conditions and failover of each redundant unit.
<b>12.</b>	Test of spare card slots/parts/modules for selected tests
<b>13.</b>	Checks of power supply/converter voltage margins
<b>14.</b>	Random inspections and any other additional tests to verify the accuracy of documentation
	End of table

### **1.8.3 Site Acceptance Tests (SAT)**

The Contractor shall be responsible for the site tests and inspection of all equipment supplied in this contract.. All equipment shall be tested on site under the conditions in which it will normally operate in the presence of Employer's representative.

The tests shall be exhaustive and shall demonstrate that the overall performance of the contract works satisfies every requirement specified. A minimum Site Acceptance Testing requirement for Telecom equipment is outlined in following section. This testing shall be supplemented by the Contractor's standard installation testing program, which shall be in accordance with his quality plan(s) for Telecom equipment installation.

During the course of installation, the EMPLOYER shall have full access for inspection and verification of the progress of the work and for checking workmanship and accuracy, as may be required. On completion of the work prior to commissioning, all equipment shall be tested to the satisfaction of the EMPLOYER to demonstrate that it is entirely suitable for commercial operation.

The SAT Shall be completed in following phases:

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### 1.8.3.1 Installation Testing

The field installation test shall be performed for all equipment at each location. If any equipment has been damaged or for any reason does not comply with this Specification, the Contractor shall provide and install replacement parts at its own cost and expense.

In the installation test report, the Contractor shall include a list of all hardware or components replaced or changed between the completion of factory tests and the start of field tests and show that documentation and spare parts have been updated.

The minimal installation testing requirements for the fiber optic transmission subsystem are provided in Table 1-6 S.no. 1, 2, 5, 6 and 9.

### 1.8.3.2 Commissioning Tests

The commissioning tests shall verify that communication can be performed over the fiber optic link under test. Test specified in table 1-6 S.no. 3, 4, 6, 7, 8 and 10 shall be carried out. In addition, Bit Error/Packet loss measurements shall be made on the fibre optic to verify compliance with designed link performance for a minimum duration of 48 Hours.

- (1) End to end testing
- (2) Data connectivity from SCADA/DMS/MBCCC with remote location (RTU/ billing center etc.) shall be verified.
- (2) Installation testing for TMN as per tables 1-7 (3) (4) Testing of TMN to demonstrate proper operation of all functions : Configuration Management, Performance Management, Fault Management and Security management. All the standard features and required customization of the TMN shall be demonstrated for proper functioning.
- (3) Demonstration of Protection switching and synchronisation of equipment as per synchronization plan.

**Table 1-6**  
**Fibre Optic Transmission system Installation and Commissioning Testing**

Item:	Description:
1.	Physical Inspection for conformance to drawings, rack elevations and appearance of

**Table 1-6****Fibre Optic Transmission system Installation and Commissioning Testing**

	equipment and cabling
2.	Station power supply input and equipment power supply (DC-DC converter) output voltage if access to o/p is available or external converters used measurements
3.	Terminal transceiver performance testing (Tx power, receive signal strength etc.)
4.	Service channel performance, EOW functionality in link test.
5.	Craftsperson interface, alarm and control functional performance
6.	Rack and local alarms: No unwanted alarms shall be present and all alarms shall be demonstrated to be functional
7.	Network management interface and supervision performance to be tested along with TMN equipment at Control Centre location.
8.	Correct configuration, level setting & adjustments and termination of Input/ output interfaces
9.	Proper establishment of Safety and signalling earthing system and resistance to ground to be checked.
10.	Simulation of failure conditions and failover of protected components.

**Table 1-7****TMN Installation Testing**

<b>Item:</b>	<b>Description:</b>
1.	Physical inspection for conformance to drawings, rack elevations and appearance of equipment and cabling
2.	Workstation hardware inventory, configuration and characteristics
3.	Demonstration of proper operation of all hardware, including workstations peripherals

## **Section-5**

### **SELF SUPPORTING METAL FREE AERIAL FIBRE OPTIC CABLE**

#### **2 Introduction**

Utility shall use Fiber optic leased line communication system provided telecom service provider in the project area. In case, the same is not available then utility may use Fiber optic option as envisaged in this section & may use the specification for self supporting metal free aerial fibre optic cable

This section describes the functional requirements, major technical parameters and all testing requirements for self supporting metal free aerial fibre optic cable and associated fittings for communication system and sub-systems to be provided under this package.

The fibre optic network (FO) network shall connect all the Substations & SCADA/DMS Control Centre The network connectivity is proposed to form loop covering most of the locations to provide the redundancy in the network wherever Possible.

#### **2.1 Fibre Optic Network**

The FO network comprises of the following major items:

- (i) Self supporting metal free aerial/ under ground fibre optic cable along with necessary hardware & fittings/ HDPE ducts & accessories, splice Enclosure, Fibre Optic Distribution Panel etc.
- (ii) Fibre Optic Transmission Equipment with user interface

The technical requirements for under ground FO cable & installation has been specified under this section. The technical requirement for Fibre Optic Transmission Equipment is specified in this section.

#### **2.2 Fibre Optic metal Free Aerial Cable**

Self Supporting Metal Free Aerial Optical Fibre Cable shall be installed on existing 33/11 kV lines. The estimated cable route length requirements are indicated in the appendices. However, the Contractor shall supply & install the Self Supporting Metal Free Aerial Optical Fibre Cable as required based on detailed site survey to be carried out by the Contractor during the project execution. The Contract price shall be adjusted accordingly.

##### **2.2.1 Basic Construction**

The Metal Free Aerial Optical Fibre Cable shall be low in weight, and shall have small diameter, small volume and high flexibility. The Optical Fibre cable shall also have good mechanical protection with stable temperature performance conditions, as it will be exposed

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to varying environmental conditions in the field like applicable wind and snow loading.

#### **2.2.1.1 Secondary Protection**

The secondary protection may be provided for the primary coated fibres may be protected by loose packaging within a tube or tubes and or in groove, which shall be filled with thixotropic jelly.

#### **2.2.1.2 Number of fibres**

Six (6) nos. of DWSM G.652 fibres shall be provided in the cable. The BOQ has been specified in the appendices.

#### **2.2.1.3 Strength Member**

The strength member (s) shall be provided for strength and flexibility of the cable. The strength member(s) shall be Solid FRP non-metallic and shall have anti buckling properties. These shall also keep the fibre strain within permissible values. The non-metallic strength member(s) may be in the cable core or embedded within the sheath.

#### **2.2.1.4 Cable Core Assembly**

Primary coated fibres in loose tube/tubes and/or in groove stranded together around a central strength member using helical or reverse lay techniques shall form the cable core. Alternatively multiple **units** of fibres may be placed loosely in a single tube with the strength members in the sheath.

#### **2.2.1.5 Core Wrapping**

The main cable core containing fibres shall be wrapped by layer/layers of Polyester foil/tape. The nylon/polyester binder tape or thread shall be used to hold the tape if required.

#### **2.2.1.6 Moisture barrier (Protection)**

The main cable core (containing fibres & core wrapping) shall be protected by flooding compound (jelly) have properties of non hygroscopic dielectric material and/or by water swellable tape. The core wrapping shall not adhere to the secondary fibre coating.

#### **2.2.1.7 Filling compound**

The filling compound used in the loose tube and in the cable core shall be compatible to fibre, secondary protection of fibre, core wrapping etc. The drip point shall not be lower than +70 degree C. The fibre movement shall not be constrained by stickiness & shall be easily removable for splicing. Reference material test method to measure drop point shall be as per ASTM D 556. The filling and the flooding jelly compound shall be as per the TEC specs GR no. G/ORM-01/02 MAR 99 and the subsequent amendment, if any.

#### **2.2.1.8 Inner Sheath**

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A non-metallic moisture barrier sheath may be applied over and above the cable core. The core shall be covered with tough weather resistant High Density Polyethylene (HDPE) sheath black in colour and the colour shall conform to Munsell Colour Standards. Thickness of the sheath shall be uniform & shall not be less than 1.8 mm including the strength members if used in the sheath. The sheath shall be circular, smooth, free from pin holes, joints, mended pieces and other defects. Reference test method to measure thickness shall be as per IEC 189 para 2.2.1 and para 2.2.2.

#### **2.2.1.9 Reinforcement**

The aerial optical fibre cable shall be reinforced with Aramid Yarn in the periphery over the inner sheath. The Aramid Yarn shall be uniformly and equally distributed on the entire periphery (circumference) of the cable. The quantity of the Aramid Yarn used per kilometre length of the cable with its D-Tex value shall be indicated by the Contractor.

#### **2.2.1.10 Outer jacket**

Outer jacket shall be circular and uniform tough weather resistant & UV stabilised polyethylene compound HDPE material. Sheath/jacket black in colour shall be provided over and above the reinforcement of aramid yarn. The thickness of the outer sheath/jacket shall not be less than 2.0 mm. The sheath shall be free from pin holes, joints, scratches, mended pieces and other defects etc. and it shall have smooth finish.

#### **2.2.1.11 Cable diameter and tolerance**

The manufacturer shall define the cable diameter. The finished cable diameter shall be within  $\pm 0.5$  mm from the defined cable diameter.

#### **2.2.1.12 RIP Cord**

The two suitable (minimum) water blocking rip cords shall be provided which shall be used to open the inner and outer (HDPE) sheath of the cable. It shall be capable of consistently slitting the sheath without breaking for a length of 1 meter at the installation temperature. The rip cord(s) shall be properly waxed to avoid wicking action and shall not work as water carrier. The rip cord used in the cable shall be readily distinguishable from any other components (e.g. Aramid Yarn etc.) utilized in the cable construction.

**Note : The Contractor may offer cable(s) of other design , however, the offered cable shall meet the specified technical and testing requirements. The Bidder shall submit details of cable design, test reports and customers certificates for successful operation of the offered cable, wherever alternate design has been proposed.**

#### **2.2.2 Raw Material**

The cable shall use the raw materials approved against the TEC specs No. G/ORM-01/02 MAR.99 and the subsequent amendment issued if any.



The change in the design of the optical cable shall call for fresh type testing.

The HDPE Black in colour used for sheath shall be UV stabilized and shall withstand UV test for 2000 hrs (minimum).

The material used in optical fibre cable must not evolve hydrogen that will affect the fibre loss.

**A test certificate from a recognised laboratory or institute may be acceptable.**

### **2.2.3 Cable Material Compatibility**

Optical fibre, buffers/core tubes, and other core components shall meet the requirements of the compatibility with buffer/core tube filling material(s) and/or water-blocking materials that are in direct contact with identified components within the cable structure as per clause no. 6.3.4 of GR-20-CORE issue 2, July 1998 and subsequent amendments, if any.

### **2.2.4 Safety Requirement**

The material used in the manufacturing of the optical fibre cables and for use in splicing and maintenance shall be non-toxic and dermatologically safe in its life time and shall not be hazardous to health.

### **2.2.5 Operating requirement**

The design and construction of aerial metal free optical fibre cable shall be inherently robust and rigid under all conditions of operation, adjustment, replacement, storage and transport.

The optical fibre cable shall be able to work in hilly area in snow loading conditions.

Life of cable shall be at least 25 years.

It shall be possible to operate and handle the aerial metal free optical fibre cable with tools as per TEC specs GR no. G/OFT-01/02 MAR 99 and subsequent amendment if any. If any special tool required for operating and handling the optical fibre cable, the one set of the same shall also be provided along with the supplied cable system.

It shall be possible to install the Aerial optical fibre cable with accessories and fixtures as per the TEC specs GR no. G/OAF-01/01 FEB 98 and subsequent amendments if any.

The Aerial optical fibre cable shall work satisfactorily in electrical field environment of 11 KV and shall not degrade with presence of electrical field. The cable shall be capable to be installed on 132 KV/66KV/33KV/11KV lines .

The Self Supporting Metal Free Aerial Optical Fibre Cable shall be designed and manufactured to meet the following minimum conditions of operation, installation & storage:

(a) Minimum Span length : 100 metres

- (b) Maximum ice loading : As applicable for specified site.
- (c) Operational wind pressure : min 45 Kg/m<sup>2</sup>

The supplied cable shall meet the span, wind loading and ice loading requirement of the specified location where the cable is to be installed.

#### 2.2.6 Sag of the span lengths

- (i) Maximum sag allowed without excess load (**i.e. with self weight and no wind & ice load condition**) : 1% of the span length.
- (ii) Maximum sag allowed with excess load (**i.e. with all applicable loads**) : 2% of the span length

#### Temperature range

- (i) Operation : -20° to +70°C
- (ii) Installation : -15° to + 50°C
- (iii) Storage : -50° to + 70°C

Tensile force design parameter : **As required to meet the specified requirement.**  
 Minimum bending Radius : **20 D** (D is diameter of the cable)

#### 2.2.7 FO Cable Link Lengths

2.2.7.1 The FO cable links lengths indicated in the BOQ are from gantry tower/pole to pole, pole to pole and from gantry towers/poles to FODPs. For purpose of payment cable route length shall be considered from gantry tower to pole, pole to pole (span lengths) and approach length from gantry towers/poles to FODPs. The actual cable length to be delivered shall take into account various factors such as sag, service loops, splicing, working lengths and wastages etc. and no additional payment shall be payable in this regard. The unit rate for FO cable quoted in the Bid price schedules shall take into account all such factors.

2.2.7.2 **Survey for Aerial cable** : The bidder is encouraged to make site visits (at their own expense), prior to bid submission. The successful bidder (Contractor) is required to visit all sites and the lines where the self supporting metal free aerial optical fibre cabling system is to be installed to perform the design and implementation functions. The Contractor shall submit the survey format for Employer's approval. The Contractor shall inform the survey schedule to the Employer well in advance and Employer may be associated with the Contractor during the survey activities. After survey, the Contractor shall submit the detailed survey report for Employer's approval for all the suggested links indicating the following as a minimum:

- a. List of all spans and total link length.
- b. Suitability of installation of the proposed cable on the proposed reoute.
- c. Tower/Pole wise identification of type(s)\_and numbers of fittings and accessories required.
- d. If vibration dampers are required to be installed, the number and placement of dampers for each span shall be submitted alongwith the calculations.
- e. Proposed splice locations and cable drum schedules.
- f. Proposed routing of cables from the poles/towers up to the termination points in the buildings.
- g. The installation arrangement of the joint boxes and the FODPs.
- h. Height of installation of optical fibre cable in different poles/rotes.
- i. Route for underground cable installation at Road crossings, if required.
- j. Requirement of additional poles to meet sag/clearance/span at site.
- k. Details and types of existing poles/towers and healthiness of the poles/towers.
- l. Details of overhead cables/conductors presently string on the route.
- m. Frequency and type of faults of towers/poles and cables/conductors of the route.
- n. Snow fall period and snow load of the area as per Metrological departments data.

### 2.2.8 Cable Ends

Both cable ends (the beginning end and end of the cable reel) shall be sealed and readily accessible. Minimum 5 meter of the cable of the beginning end of the reel shall accessible for testing. Both ends of the cable shall be kept inside the drums and shall be located so as to be easily accessible for the test. The drum (confirming to GR No. G/CBD-01/02 Nov. 94 and subsequent amendments if any) should be marked to identify the direction of rotation of the drum. Both ends of cable shall be provided with cable pulling (grip) stocking and the anti twist device (free head hook).

Anti-twist device (Free head hook) shall be provided attached to the both end of the cable pulling arrangement. The arrangement of the pulling eye and its coupling system along with the anti twist system shall withstand the prescribed tensile load applicable to the cable.

### 2.2.9 The nominal drum length

Generally, the length of aerial optical fibre cable in each drum shall be **2 km  $\pm$  5 %**. However, the cable drum lengths shall be supplied as per the approved drum schedule. The drum shall be marked with arrows to indicate the direction of rotation. **Packing list supplied with each drum** shall have at least the following information: Drum no., Type of cables, Physical Cable length, No. of fibres, Length of each fibre as measured by OTDR, The cable factor – ratio of fibre/cable length, Attenuation per km. of each fibre at 1310 & 1550 nm, User"s/consignee"s name, Manufacturer"s Name, Month, Year and Batch no., Group refractive index of fibres, Name of the route.

### 2.2.10 Optical Fibre Strain

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The following shall be ensured:

- (a) The Maximum Working Tension (MWT) is defined as the maximum cable tension at which there is no fibre strain.
- (b) The cable strain margin is defined as the maximum cable strain at which there is no fibre strain.
- (c) The maximum allowable tension (MAT) is defined as the maximum tension experienced at worst wind load and snow load conditions.
- (d) The Cable everyday tension (EDT) is defined as the maximum cable tension at 32 degree C, no wind load and no ice load.
- (e) The ultimate/ rated tensile strength test is defined as the maximum tensile load applied and held constant for one minute at which the specimen shall not break.

The Contractor shall offer suitable aerial optical fibre cable and submit the sag-tension chart for various spans for the aerial FO cable meeting the following conditions for Employer's approval:

- (i) The MAT / maximum strain shall be less than or equal to the MWT / strain margin of the cable.
- (ii) The sag shall exceed the conditions specified in clause 2.5.5.
- (iii) The MAT shall be less than or equal to 0.4 times the rated UTS of the cable.
- (iv) The EDT shall not exceed 20 % of the rated UTS of the cable.
- (v) The ground clearance shall be met for the actual site conditions.

### **2.2.11 Cable Marking**

The cable marking shall be imprinted and indelible (indented). The marking on the cable shall be indelible of durable quality and at regular intervals of one meter length. The alternatively permanent printing with the laser shall also be acceptable. In case of laser printing method; the impression shall not exceed the depth of 0.15 mm. The accuracy of the sequential marking must be within -0.25% to +0.5% of the actual measured length. The markings on the cable must not rub off during normal installation.

The marking shall be of clearly contrast colour on the black HDPE sheath in case hot foil indentation method is used. The colour used must withstand the environmental influences experienced in the field.

Two orange colour (UV stabilized) lines of minimum 3 mm width diametrically opposite to each other, continuous over the length of the cable shall be applied (marked) for easy identification of this cable from other cables.

The type of legend marking on O.F. cable shall be as follows:

- (i) Company Legend
- (ii) Legend containing international acceptable Laser symbol

- (iii) Type of cable i.e. Slotted or Loose Tube or Uni-tube (Central Tube)
- (iv) Type of Fibre ie. DWSM
- (v) Number of Fibres
- (vi) Year of manufacturer
- (vii) Sequential length marking
- (viii) Owner's Name i.e. " "

### **2.2.12 Installation ,Accessories and Fixtures for Aerial Cable**

The scope of supply of the Self Supporting Metal Free Aerial Optical Fibre Cable includes the assessment, supply and installation of all required installation accessories and fixtures. The Contractor shall provide documentation justifying the adequacy and suitability of the hardware used. To ensure their satisfactory performance, the Contractor shall determine the exact requirements of all accessories and fixtures used to install and secure the cable.

The cable hardware accessories and fixtures shall follow the general requirements regarding design, materials, dimensions & tolerances and markings etc. as specified in TEC spec. No. GR NO.G/OAF-01/01. FEB 98 and subsequent amendments, if any. The cable accessories & fixtures drawing & Data Requirement Sheets (DRS) document shall consist of three parts: (1) A technical particulars sheet (2) An assembly drawing i.e. level 1 drawing and (3) Component level drawings i.e. level 2 & lower drawings. All component reference numbers, dimensions and tolerances, bolt tightening torques & shear strength and ratings such as UTS, slip strength etc shall be marked on the drawings.

The required joint box shall also be provided by the Contractor and the details of which shall be submitted for Employer's approval. The joint box shall comply to ingress protection class IP 66 or better. The in-line splice support mechanical opening and closing.

The required strengthening of existing structures/towers/poles shall be carried out by the Contractor for installation of offered aerial cable. As the aerial cable is designed for 100 m span for self supporting condition and for the span greater than 100 m , the additional strength wire along with the clipping arrangement and/or poles to support the aerial cable for installation of aerial cable system shall also be provided by the Contractor at no additional cost to the Employer. However, the actual span lengths may vary at site and the fittings & accessories shall be provided as per site requirement.

The above requirement of additional poles, strength wires, strengthening of existing structure/poles/towers shall be submitted by the Contractor for Employer's approval and same shall be provided as per approval.

### **2.3 Optical Fibre Splices**

Splicing of the optical fibre cabling shall be minimized through careful planning. There shall be no mid-span splices allowed. All required splices shall be planned to occur within facilities or on tower structures. All optical fibre splicing shall comply with the following:

- (a) All fibre splices shall be accomplished through fusion splicing.

- (b) Each fibre splice shall be fitted with a splice protection sheath fitted over the final splice.
- (c) All splices and bare fibre shall be neatly installed in covered splice trays. No more than six (6) fibres shall be installed in each splice tray.
- (d) For each link, bi-directional attenuation of single mode fusion splices measured at 1550 nm shall not average more than 0.05 dB. The bi-directional splice loss of each splices shall not exceed 0.1 dB when measured at 1550 nm.
- (e) For in-line splicing, fibre optic cable service loops of adequate length shall be provided so that all splices occurring at tower structures can be performed at ground level.

## **2.4 Optical Fibre Termination and Splicing**

All fibre optic cables shall be terminated in Fibre Optic Distribution Panels (FODP) designed to provide protection for fibre splicing of preconnectorized pigtails and to accommodate connectorized termination and coupling of the fibre cables. The Contractor shall provide rack mounted Fibre Optic Distribution Panels (FODPs) sized as indicated in the appendices and shall terminate the fibre optic cabling up to the FODPs. The location of FODP shall be proposed by the Contractor during the survey and shall be submitted for Employer's approval.

### **2.4.1 Fibre Optic Distribution Panels**

At each location requiring the termination of fibres of a cable, all fibres within that cable shall be connectorised and terminated in Fibre Optic Distribution Panels in a manner consistent with the following:

- (a) All fibre optic terminations shall be housed using FODPs provisioned with splice organizers and splice trays. All fibres within a cable shall be fusion spliced to preconnectorized pigtails and fitted to the "Back-side" of the provided fibre optic couplings.
- (b) FODPs shall be suitable for use with each of the cable types provided as part of this contract. FODPs shall support fibre terminations as well as pass-through splicing.
- (c) FODPs shall be supplied in suitable wall mounted type enclosures or in sub racks which shall be mounted in SDH cabinets.
- (d) In case of wall mounted FODP shall be corrosion resistant, robust construction and shall allow both top or bottom entry for access to the splice trays. Specific selection of the entry points shall be made at the time of installation. Ground lugs shall be provided on all FODPs and the Contractor shall ensure that all FODPs are properly grounded. The FODP shall meet or exceed ingress protection class IP51 specifications.

- (e) Flexible protection shall be provided to the patch cord bunches going out from FODP to other equipment.

#### **2.4.2 Optical Fibre Connectors**

Optical fibres shall be connectorised with FC-PC type connectors. Fibre optic couplings supplied with FODPs shall be appropriate for the fibre connectors to be supported. There shall be no adapters.

#### **2.5 Service Loops**

For purposes of this specification, cable and fibre service loops are defined as slack (extra) cable and fibre provided for facilitating the installation, maintenance and repair of the optical fibre cable plant.

- (a) Outdoor Cable Service Loops: In-line splice enclosures installed outdoors and mounted on the utility towers, shall be installed with sufficient fibre optic cable service loops such that the recommended minimum bend radius is maintained while allowing for installation or maintenance of the cable to be performed in a controlled environment at ground level. At least tower/pole height plus five meters length of FO cable is to be considered for service loop in each direction at splicing location. After splicing the extra length shall be coiled with the recommended bending radius and joint suitably fixed at top of the tower.
- (b) Indoor Cable Service Loops: FODPs shall provide at least five (5) metres of cable service loop. Service loops shall be neatly secured and stored, coiled such that the minimum recommended bend radius' are maintained.
- (c) Fibre Units Service Loops: For all fibre optic cable splicing, the cable shall be stripped back a sufficient length such that the fan-out of fibre units shall provide for at least two (2) metre of fibre unit service loop between the stripped cable and the bare fibre fan-out.
- (d) Pigtail Service Loops: Connectorised pigtails spliced to bare fibres shall provide at least 1 metre of service loop installed in the FODP fibre organizer and at least two (2) metre of service loop to the couplings neatly stored behind the FODP coupling panels.
- (e) Fibre Service Loops: At least 1 metre of bare fibre service loop shall be provided on each side of all fibre splices. The bare fibre service loops shall be neatly and safely installed inside covered splice trays.
- (f) Sufficient service loop is to be kept at all crossing location(railways, culverts, river etc.) through under ground installations (if applicable) in the overhead FO cable routes. At least 5 meters on each side of the crossing is to be considered for the same.

#### **2.6 Methodology for Installation and Termination**

All optical fibre cable termination, installation, stringing and handling plans, guides and procedures, and engineering analysis (e.g. tension, sag, vibration etc.) shall be submitted to the Employer for review and approval in the engineering/design phase of the project, prior to establishing the final cable lengths for manufacture. Installation procedures including details of personnel and time required shall be documented in detail and submitted to Employer for approval. All installation practices shall be field proven and ISO accredited.

All cable segments shall include service loops as specified in 2.5. The maximum allowable stringing tension, maximum allowable torsional shear stress, crush strength and other physical parameters of the cable shall not be exceeded. The preventative measures to be taken shall be documented in detail and submitted to Employer in advance of installation.

Optical fibre attenuation shall be measured after installation and before splicing. Any increase in attenuation or step discontinuity in attenuation shall not be acceptable and shall constitute a cable segment failure. In the event of cable damage or any fibre damage, the complete section (tension location to tension location) shall be replaced as mid-span joints are not acceptable.

Any or all additional steel work or modifications required to attach the fibre cabling to the overhead transmission/ distribution line towers shall also be carried out by the Contractor. It shall be the Contractors responsibility to provide adequate communications among all crew members and support staff to ensure safe and successful installations.

## **2.7 Cable Raceways**

To the extent possible, existing cable raceways shall be utilised. The Contractor is required to provide and install any additional indoor cable raceways which may be required for proper implementation of the fibre optic cabling system. This requirement shall be finalised during survey. The cable raceways shall conform to the following:

- (a) All cable raceways shall be sized to support full loading requirements plus at least a 200% safety loading factor.
- (b) Indoor cable raceways shall be fabricated from construction grade aluminium, galvanized iron or anodized sheet metal or any other suitable material approved by the Employer. Suitable anti-corrosion measures shall be provided. Steel fabricated raceways shall be finished inside and out, treated to resist rust and to form a metal-to-paint bond.
- (c) Mechanical construction drawings of the cable raceways shall be submitted for Employer's information & review.

## **2.8 Required Optical Fibre Characteristics**

This section describes the characteristics of optical fibre to be provided under this specification.



### 2.8.1 Physical Characteristics

Dual-Window Single mode (DWSM) optical fibres shall be provided in the quantities specified in the Appendices. DWSM optical fibres shall meet the requirements defined in Table 4-1(a).

### 2.8.2 Attenuation

The attenuation coefficient for wavelengths between 1525 nm and 1575 nm shall not exceed the attenuation coefficient at 1550 nm by more than 0.05 dB/km. The attenuation coefficient between 1285 nm and 1330 nm, shall not exceed the attenuation coefficient at 1310 nm by more than 0.05 dB/km. The attenuation of the fibre shall be distributed uniformly throughout its length such that there are no point discontinuities in excess of 0.10 dB. The fibre attenuation characteristics specified in table 2-1 shall be “guaranteed” fibre attenuation of any & every fibre reel.

The overall optical fibre path attenuation shall not be more than calculated below:

Maximum attenuation @ 1550nm:  $0.23\text{dB/km} \times \text{total km} + 0.05 \text{ dB/splice} \times \text{no. of splices} + 0.5 \text{ dB/connector} \times \text{no. of connectors}$

Maximum attenuation @ 1310nm:  $0.35\text{dB/km} \times \text{total km} + 0.05 \text{ dB/splice} \times \text{no. of splices} + 0.5 \text{ dB/connector} \times \text{no. of connectors}$

**Table 2-1**  
**DWSM Optical Fibre Characteristics**

<b>Fibre Description:</b>	Dual-Window Single-Mode
<b>Mode Field Diameter:</b>	8.6 to 9.5 $\mu\text{m}$ ( $\pm 10\%$ of the nominal value)
<b>Cladding Diameter:</b>	125.0 $\mu\text{m} \pm 2 \mu\text{m}$
<b>Mode field concentricity error</b>	$\leq 1.0 \mu\text{m}$ at 1310 nm
<b>Cladding non-circularity</b>	$\leq 2\%$
<b>Cable Cut-off Wavelength</b>	$\leq 1260 \text{ nm}$
<b>1550 nm loss performance</b>	As per G.652
<b>Proof Test Level</b>	$\geq 100 \text{ kpsi}$
<b>Attenuation Coefficient:</b>	@ 1310 nm $\leq 0.35 \text{ dB/km}$ @ 1550 nm $\leq 0.23\text{dB/km}$
<b>Chromatic Dispersion; Maximum:</b>	20 ps/(nm x km) 1550 nm 3.5 ps/(nm x km) 1288-1339nm 5.3 ps/(nm x km) 1271-1360nm
<b>Zero Dispersion Wavelength:</b> <b>Zero Dispersion Slope:</b>	1300 to 1324nm -0.093 ps/(nm <sup>2</sup> xkm) maximum
<b>Polarization mode dispersion coefficient</b>	$\leq 0.5 \text{ ps/km}^{1/2}$

**Table 2-1**  
**DWSM Optical Fibre Characteristics**

<b>Temperature Dependence:</b>	Induced attenuation $\leq 0.05$ dB (-60 °C - +85 °C )
<b>Bend Performance:</b>	@ 1310 nm (75±2 mm dia Mandrel), 100 turns; Attenuation Rise $\leq 0.05$ dB/km @ 1550 nm (75±2 mm dia Mandrel), 100 turns; Attenuation Rise $\leq 0.10$ dB/km @ 1550 nm (32±0.5 mm dia Mandrel), 1 turn; Attenuation Rise $\leq 0.50$ dB/km
End of Table	

## 2.9 Test and Inspection

### 2.9.1 Type Testing

The bidder shall submit earlier carried out type test reports for the offered fibre optic cable, fibre, joint box and fittings. The Contractor shall submit the type test report as per the requirement specified below. Type Tests shall be performed for all equipment/cable types for which certification is not provided, or if it is determined by the Employer that the certification provided is not acceptable. If any of the type tests are required to be carried out, the same shall be carried out by the Contractor at no additional cost to the Employer.

#### 2.9.1.1 Type Tests For Optical Fibres

The type tests listed below in Table 2.1 are applicable to all types of F.O. cables and shall be conducted on DWSM fibres. The tests specific to the cable type are listed in subsequent sections.

**Table 3.1**  
**Type Tests For Optical Fibres**

S.No.	Test Name	Acceptance Criteria	Test procedure
1	Attenuation	Table 2-1(a)	EIA/TIA 455- 78A
2	Attenuation Variation with Wavelength	Table 2-1(a)	EIA/TIA 455- 78A
3	Attenuation at Water Peak	Table 2-1(a)	EIA/TIA 455- 78A
4	Temp. Cycling (Temp dependence of Attenuation)		EIA/TIA 455- 3A, 2 cycles
5	Attenuation With Bending (Bend Performance)		EIA/TIA 455- 62A
6	Mode Field diameter		EIA/TIA 455- 164A/167A/174
7	Chromatic Dispersion		EIA/TIA 455- 168A/169A/175A
8	Cladding Diameter		EIA/TIA 455-176
9	Point Discontinuities of attenuation		EIA/TIA 455-59

**Table 3.1**  
**Type Tests For Optical Fibres**

S.No.	Test Name	Acceptance Criteria	Test procedure
10	Core -Clad concentricity error		EIA/TIA 455-176
11	Polarisation Mode Dispersion		
-End Of table-			

### 2.9.1.2 Type Testing on Aerial Optical Fibre Cable

The mechanical and testing parameters of the cable shall meet the requirements defined in Table 3.2 below:

**Table 3-2**

S. N.	Name of Test	Objective	Test Method & Procedure	Requirement
1	Tensile strength Test	To test the tensile strength Self Supporting Metal Free aerial Optical Fibre cable in order to examine the behaviour of the attenuation as a function of the load on a cable during installation and while the aerial optical fibre cable encounters the excess ice loading and the winds at high speed and to check its design parameters.	IEC 794-1-E1  The cable shall sufficient strength to withstand UTS load.  The load shall be sustained for 10 minutes and the strain of the fibre and the attenuation shall be monitored at MWT, Max installation load & UTS. MWT & UTS shall be derived from SAG-TENSION data for aerial cable.	The load shall produce no strain ( $\leq 0.05\%$ is to be treated as no strain) up to MWT and fibre strain shall not exceeding 0.25% in the fibre upto max installation load. At UTS fibre shall not break and shall not cause any permanent physical and optical damage to any component of the cable. The attenuation shall be noted before strain and after the release of strain. The change in attenuation of each fibre after the test shall be $\leq 0.05\text{dB}$ both for 1310 nm and
2	Abrasion Test	To test the abrasion resistance of the sheath and the marking printed on the surface of the cable.	IEC-794-1-E2 or by any other international test method The cable surface shall be abraded with needle (wt. 150 gm) having diameter of 1mm	There shall be no perforation & loss of legibility of the marking on the sheath.

S. N.	Name of Test	Objective	Test Method & Procedure	Requirement
			with 500 grams weight (Total weight more than equal 650 gms.) No. of cycles : 100 Duration : One minute (nominal)	
3	Crush Test (Compressive Test)	The purpose of this test is to determine the ability of an optical fibre cable to withstand crushing.	IEC 794-1-E3  The fibres and component parts of the cable shall not suffer permanent damage when subjected to a compressive load of 2000 Newtons applied between the plates of dimension 100 x 100 mm. The load shall be applied for 60 Secs. The attenuation shall be noted before and after the completion of the test.	The change in attenuation of the fibre after the test shall be $\leq 0.05$ dB both for 1310 nm and 1550 nm wavelength.
4	Impact Test	The purpose of this is to determine the ability of an optical fibre cable to withstand impact.	IEC 794-1-E4  The cable have sufficient strength to withstand an impact caused by a mass weight of 50 Newtons, when falls freely from a height of 0.5 meters. The radius R of the surface causing impact shall be 300 mm. Ten such impacts shall be applied at the same place. The attenuation shall be noted before and after the completion of the test.	The change in attenuation of the fibre after the test shall be $\leq 0.05$ db both for 1310 nm and 1550 nm wavelength.
5	Repeated Bending	The purpose of this test is to determine the ability of an optical fibre cable to withstand repeated bending.	EIA-455-104  The cable sample shall be of sufficient length (5 m minimum to permit radiant power measurements as required by this test. Longer lengths may be used if required. Parameters : Weight : 5 kg Minimum distance from Pulley Centre:216mm	During the test no fibre shall break and the attenuation shall be noted before and after the completion of the test. The change in attenuation of the fibre after the test shall be $\leq 0.05$ dB both for 1310 nm and 1550 nm wavelength.

S. N.	Name of Test	Objective	Test Method & Procedure	Requirement
			<p>To holding device Minimum distance from Wt. To Pulley Centre : 457 mm</p> <p>Pulley Diameter: 20 D (D-cable diameter)</p> <p>Angle of Turning: 90°</p> <p>No. of cycles: 30</p> <p>Time Required for 30 cycles : 2 min</p>	
6	Torsion Test	The purpose of this test is to determine the ability of an optical fibre cable to withstand torsion.	<p>IEC 794-1-E7</p> <p>The length of the specimen under test shall be 1 meters and the load shall be 75 N. The sample shall be mounted in the test apparatus with cable clamped in the fixed clamp sufficiently tight to prevent the movement of cable sheath during the test. One end of the cable shall be fixed to the rotating clamp, which shall be rotated in a clockwise direction for one turn. The sample shall then be returned to the starting position and then rotated in an anti-clockwise direction for one turn and returned to the starting position. This complete movement constitutes one cycle. The cable shall withstand ten such complete cycles.</p>	The cable shall be examined physically for any cracks, tearing on the outer sheath and for the damage to other component parts of the cable. The twist mark shall not be taken as damage. The change in attenuation of the fibre after the test shall be $\leq 0.05$ dB both for 1310nm and 1550 nm wave length.
7	Kink Test	The purpose of this test is to verify whether kinking of an optical fibre cable results in breakage of any fibre, when a loop is formed of dimension small enough to induce a kink on the sheath.	<p>IEC 974-1-E10</p> <p>The small length shall be 10 times the minimum bending radius of the cable. The sample is held in both hands, a loop is made of a bigger diameter and by stretching both the ends of the cable in opposite direction, the loop is made to the minimum bend radius and no</p>	The kink should disappear after the cable is brought to normal position. The change in attenuation of the fibre after the test shall be $\leq 0.05$ dB both for 1310nm and 1550 nm wavelength.

S. N.	Name of Test	Objective	Test Method & Procedure	Requirement
			kink shall form. The cable is then normaled and attenuation reading is taken.	
8	Cable Bend Test	The purpose of this test is to determine the ability of an optical fibre cable to withstand repeated flexing. The procedure is designed to measure optical transmittance changes and requires an assessment of any damage occurring to other cable components.	IEC 794-1-E11 (Procedure-I) The fibre and the component parts of the cable shall not suffer permanent damage when the cable is repeatedly wrapped and unwrapped 4 complete turns of 10 complete cycles around a mandrel having diameter of 20 D, where D is the diameter of the cable. The attenuation shall be noted before and after the completion of the test.	The change in attenuation of the fibre after the test shall be $\leq 0.05$ dB both for 1310nm and 1550 nm wave length. Sheath shall not show any cracks visible to the naked eye when examined whilst still wrapped on the mandrel.
9	Snatch Test	This test is to determine the ability of the cable to withstand a sudden snatch load.	IEC 794-1-E9  The sample is terminated in a manner that the fibres, sheathing and any strength member/members are clamped together firmly.  A hook of dimension ahs a shaft capable of bearing variable loads applied to it. The cable of 4.5 meters length is taken and firmly clamped at the two ends so that a sag of 300 mm., is formed. The attenuation is then measured.  Testing load shall be 300 N and the radius of impacting surface of the crown of the hook shall be 12.5 mm. The hook with the mass attached, is held or supported over the cable so that the crown of the hook is centered over the lowest point of the cable at a height of 100 mm. The hook is then released so as to catch the cable after dropping from the height of 100	There shall be no permanent physical damage to the cable and the change in attenuation of the fibre after the test shall be $\leq 0.05$ dB both for 1310nm and 1550 nm wave length.

S. N.	Name of Test	Objective	Test Method & Procedure	Requirement
			mm. It shall be repeated ten times. The attenuation is measured. The load is then removed from the cable and attenuation is noted.	
10	Cable Bend Test at High & Low Temperature	To determine the ability of a optical fibre cable to withstand bending at low and high temperatures which might be encountered during cable placement.	EIA RS-455-37 Test Temperature : -30 °C to +70 °C Mandrel dia : 20D (D – dia of the cable) No of turns : 4 Conditioning time duration : 24 hours at each temperature.	Visual test for damage of the sheath shall be checked. The change in attenuation of the fibre after the test shall be $\leq 0.05$ dB/Km both for 1310 nm and 1550 nm wave length. The attenuation shall be noted before and after the completion of the cycle.
11	Temperature Cycling	To determine the stability behaviour of the attenuation of a cable subjected to temperature changes which may occur during storage, transportation and usage.	IEC 794-1-F1 (To be tested on 2 Km $\pm 5\%$ of cable)  The permissible temperature range of the cable for storage shall be from -40 °C to +70 °C. The rate of change of temperature during the test shall be 1 degree/minute approx. The cable shall be subjected to temperature cycling for 12 hours at each temperatures as given below: TA2 : -20 °C TA1 : -10 °C TB1 : +60 °C TB2 : +70 °C The test shall be conducted for 2 cycles at the above temperatures.	The change in attenuation of the fibre under test after the test shall be $\leq 0.05$ dB both for 1310nm and 1550 nm wave length for entire range of temperature.
12	Cable Aging Test	To check the cable material change dimensionally as the cable ages.	At the completion of temperature cycle test, the test cable shall be exposed to 85 $\pm 2$ degree C for 168 hours. The attenuation measurement at 1310 & 1550 nm wavelengths to be made after stabilisation of the test cable at ambient temperature for	The increase in attenuation allowed : $\leq 0.05$ dB at 1310 & 1550 nm wavelengths. <i>(Note: The attenuation changes are to be calculated with respect to the base line</i>

S. N.	Name of Test	Objective	Test Method & Procedure	Requirement
			24 hours.	<i>attenuation values measured at room temperature before temperature cycling.)</i>
13	Water Penetration Test	To ensure that the installed optical fibre cable will not allow water passage in the cable.	IEC 794-1-F5 (Fig. B) 1992.  A circumferential portion of the cable end shall face the water head. The water tight sleeve shall be applied over the cable. The cable shall be supported horizontally and one meter head of water, containing a sufficient quantity of water soluble fluorescent dye for the detection of seepage, shall be applied over the inner sheath for seven days at ambient temperature. No other colour dye is permitted.	No dye shall be detected when the end of the 3m length is examined with UV light detector.
14	Test of Figure of Eight on the cable	To check of easiness in formation of figure of 8 of the cable during installation in the field.	1000 meters (approx) length of the cable shall be uncoiled from the cable reel and shall be arranged in figure of 8. The diameter of each loop of the figure of 8 shall be maximum 2 meters.	It shall be possible to make figure of 8 of minimum 1000 meter length of the cable uncoiled from the cable reel without any difficulty. No visual damage shall occur.
15	Cable Jacket Yield Strength and Ultimate Elongation	To check the yield strength and elongation of polyethylene (HDPE) cable sheath.	FOTP –89 or ASTM D1248 Type III Class.  (a) Sample shall be taken from the completed cable (The nylon to be removed for this test). The aged sample shall be conditioned at $100 \pm 2$ °C for 120 hours before testing. The cross-head speed shall be 50 mm per minute.	Refer Table E-6.2 below.
16	Drip Test	To determine the ability of jelly in the cable to withstand a temperature of 70 °C.	Take a sample of 30 cm length of cable with one end sealed by the end cap. Remove nylon jacket, black sheath binder tape for 5 cm from open end of the sample. Clean the jelly. Then the sample is kept vertically	There should be no jelly drip or oil impression on the paper.



S. N.	Name of Test	Objective	Test Method & Procedure	Requirement
			with open end downwards in the oven for 24 hours at 70 °C with a paper under the sample. Examine the paper placed below the cable sample inside the oven for dripping of the jelly after 24 hours.	
17	ECSR Test	To check the outer sheath of the cable for ECSR.	ASTM D 1693.	There should not be any visible cracks on the surface of the outer sheath, when examined with the help of a magnifying glass.
18	UV Resistance Test	To check the effect of UV radiation on the following:  (i) On the outer sheath material (HDPE) (ii) On the Orange colour lines. (iii) On the meter and other legend marking.	ASTM G-53-96  Duration : 2000 hours  Four test samples of the finished cable of required length (as per test chamber specifications) are to be prepared. 2 samples shall be kept inside and these test samples are to be compared after test with the other 2 samples kept outside.	There should not be any fading or change in the colour of the marking and that of sheath.  <i>(Note: Earlier Carried out test certificates may be accepted for same raw material and similar design/construction of the cable).</i>
19	Embrittlement Test of Loose Tube	To check the embrittlement test of the loose tube	The minimum length of the test sample depends of the outside diameter of the loose tube and should be 85mm for tubes up to 2.5mm outside dia. The length of the bigger tubes should be calculated by using the following equation :  $L_o > 100 \times ((D^2 + d^2)/4)^{1/2}$ Where $L_o$ = Length of tube under test $D$ = Outside dia of loose tube. $d$ = inside dia of loose tube.  Both the ends of a buffer tube test sample may be mounted in a tool which is clamped in jaws of a tensile machine	The tube should not get embrittled. No ink should appear on the tube up to the safe bend dia of tube (20 D) where D is the outside diameter of the loose tube. There should not be any physical damage or mark on the tube surface.

S. N.	Name of Test	Objective	Test Method & Procedure	Requirement
			which exert a constant rate of movement. The movable jaw may move at a rate of 50 mm per minute toward the fixed jaw. Under load the tube will bend, so that the tube is subjected to tensile and compressive stresses. The fixture for holding the tube should be designed in a manner that the tube might bend in all directions without further loading.	
20	Kink Resistance Test on the Loose Tube	To check the kink resistance of the loose tube during installation and in splicing operation	A longer length of the loose tube is taken (with fibre and gel), a loop is made and loop is reduced to the minimum bend radius of loose tube i.e. 20 D. (where D is the outside dia of the loose tube). This test is to be repeated 4 times on the same sample length of the loose tube.	No damage or kink should appear on the surface of the tube.
21	Drainage Test for Loose Tube	To check drainage of the loose tube	A tube length to 40 cm shall be cut and filled with filling gel ensuring there are no air bubbles and the tube is completely full. The filled tube is placed in a horizontal position on a clean worktop and cut 5 cm from each end so that the finished length of the sample is 30 cm. The filled tube shall be left in a horizontal position at an ambient temperature for 24 hrs. The sample tube is then suspended vertically in an environment heat oven over a weighed beaker. It is left in the oven at a temperature of 70 °C for a period of 24 hrs. At the end of the 24 hrs. period the beaker is checked and weighed to see if there is any gel in the beaker.	There shall be no gel or oil in the beaker.
22	Check of	To check the easy	The sheath shall be cut in	It shall be possible to

S. N.	Name of Test	Objective	Test Method & Procedure	Requirement
	Easy removal of Sheath	removal of sheath of the optical fibre cable by using normal sheath removal tool.	circular way using a sheath removal tool and the about 300 mm length of the sheath should be removed in one operation. It should be observed during sheath removal process that no undue extra force is applied and no component part of the cable is damaged.	remove the sheath easily. Easy removal of both the outer jacket and the inner sheath shall be checked separately.
23	Check of the effect of Aggressive Media on the Cable	To check the effect of aggressive media solutions of PH4 and PH10 on the cable.	ISO 175.  The two test samples of the finished cable each of 600 mm in length are taken and the ends of the samples shall be sealed. These test samples are put in the PH4 and PH10 solutions separately. After 30 days these samples are taken out from the solutions and examined for any corrosion etc. on the sheath and other markings of the cables.	The sample should not show any effect of these solutions on the sheath and other marking of the cable.  <i>(Note: Earlier Carried out test certificates may be accepted for same raw material and similar design/construction of the cable).</i>
---End of Table ---				

Table 2.2

Jacket material	Minimum Yield Strength		Minimum Elongation (%)
	(Mpa)	(psi)	
HDPE unaged	16.5	2400	400
HDPE aged	12.4	1800	375

#### 2.9.1.3 Type Tests on Aerial FO cable Accessories & fixtures

The accessories and fixtures shall subject to the following tests. The applicability of the tests for the particular type of accessories and fixtures shall be as given below:

##### 2.9.1.3.1 Visual examination : Applicable to all fittings

Objective: To check the quality and the workmanship.

Visual examination shall be carried out for all the accessories and fixtures for quality and workmanship which is required to be of the high order with super quality finish without any manufacturing defects.

#### **2.9.1.3.2 Verification of dimensions : Applicable to all fittings**

Objective: To check the dimensions of the accessories and fixtures : shall be checked as per approved DRS/drawings.

#### **2.9.1.3.3 Tensile strength test : Applicable to tension & suspension clamp assemblies**

Objective: To assess the mechanical performance of fixtures under ultimate tensile strength.

Requirement: Cable UTS with factor of safety 1.5

All the load bearing metal fittings except those of elastomer pads and helically formed fittings shall be tested to meet the above requirement.

#### **2.9.1.3.4 Tensile strength test for helically formed product**

This test shall be applicable to terminating Helix, Protective Helix and Armour grip suspension helix.

Objective : To check the tensile strength for the helically formed items.

Requirement : The tensile strength test shall be carried out to the method specified in the respective standards for wires and shall meet the requirements listed in earlier clauses.

#### **2.9.1.3.5 Slip Strength Test**

This test shall be applicable to the Terminating helix and Armoured grip suspension fittings.

Objective : To check the tensile load strength of the formed fittings to assess the performance for withstanding the guaranteed load.

Requirement : The helically formed terminating fittings shall not slip up to 90 % of the Cable UTS. The helically formed suspension fittings shall withstand the load up to a minimum of 25 % of cable UTS and shall slip before 50 % of cable UTS.

#### **2.9.1.3.6 Resilience Test**

This test shall be applicable to terminating Helix.

Objective : To check the resilience of the helically formed fittings (Terminating Helix)

Requirement : The helically formed fittings shall pass the resilience test while helically formed fittings are wrapped and unwrapped on a piece of optical fibre cable three times successfully. The helical fittings should not lose its resilience even after three applications and shall be able to pass the slip strength test after third application.

#### **2.9.1.3.7 Galloping / Fatigue test**

This shall be applicable to a complete assembly of one set of tension fittings together with one set of suspension fittings and spiral damper.

Objective : To assess the fatigue performance of fixtures and accessories and the performance of optical characteristics of the optical fibre cable under galloping conditions.

Requirement of test methods:

Length of the span : 25 – 30 meters  
Minimum vibration cycles : 1 million  
Frequency : > 30 Hz to 100 Hz.  
Amplitude : Amplitude of vibration at antinodal points shall not be less than 100 % of the cable diameter.

Requirement : The accessories and fixtures shall pass the test when tested for the test conditions as above and shall meet the requirement given below:

1. Change in attenuation shall not exceed more than 0.1 dB after the recovery period.
2. No damage on the accessories and fixtures.
3. No physical damage to optical fibre cable.

#### **2.9.1.3.8 Aeolian Vibration Test**

Objective : To assess the fatigue performance of accessories and fixtures and the optical characteristics of the optical fibre cable under Aeolian vibration.

Requirement of test method :

Minimum length of span : 25 meters.  
Minimum vibration cycles : 1 million  
Frequency : 10 Hz to 100 Hz.  
Amplitude : Free loop peak to peak antinode amplitude shall be maintained at a level equal to one half of the cable diameter.

Requirement :

1. Change in attenuation shall not exceed more than 0.1 dB after the recovery period.
2. No visual damage observed on the accessories and fixtures.
3. No physical damage to optical fibre cable.

#### **2.9.1.3.9 Tension and Attenuation Test (Dead End Assembly)**

Objective : To assess the attenuation and the optical characteristics of the optical fibre cable after fixing and installing dead end assembly on the optical fibre cable.

Requirement of test method :

---

Minimum length of span : 25 meters

The test shall meet the following:

- a. Change in attenuation shall not exceed more than 0.1 dB after the recovery period.
- b. Any visual damage observed on the accessories and fixtures.
- c. No physical damage to optical fibre cables.

#### **2.9.1.3.10 Wrapping Test**

Objective : To check quality of the aluminum alloy wires.

Test Method : The formed fittings made of aluminum alloy wires shall be wrapped on a wire of its own diameter to form a close helix.

Requirement : The wires should not break or show fracture and shall meet the requirement specified above.

#### **2.9.1.3.11 Galvanising Test**

Objective : To check galvanized coating and the quality of galvanizing on accessories and fixtures

Test method : IS 2633-1972 for uniformity.

Requirement : The fittings shall meet the requirement of the specifications.

#### **2.9.1.3.12 Hardness Test of Elastomer pad**

Objective : To check the Polychloroprene compounded elastomer pads of the suspension and cable jumper clamp.

Requirement : The Polychloroprene compounded elastomer pads of the suspension unit shall be subjected for the test parameters as listed earlier in these specifications. The compounded material should meet the minimum properties specified therein.

#### **2.9.1.4 Type Tests for In Line Splice Enclosure**

Following Type tests shall be demonstrated on the In Line Splice Enclosure(s) (Splice Enclosure/Box). For certain tests, lengths of the fibre optic cable shall be installed in the splice box, and the fibres must be spliced and looped in order to simulate conditions of use. The attenuation of the fibres shall be measured, during certain tests, by relevant Fibre Optic Test Procedures (EIA/TIA 455 or IEC 794-1 procedures).

##### **2.9.1.4.1 Temperature Cycling Test**

FO cable is installed in the splice enclosure and optical fibres spliced and looped. The box must be subjected to 5 cycles of temperature variations of  $-40^{\circ}\text{C}$  to  $+65^{\circ}\text{C}$  with a dwell time of at least 2 hours on each extreme.

Fibre loop attenuation shall be measured in accordance with EIA 455-20/ IEC 794-1-C10. The variation in attenuation shall be less than  $\pm 0.05\text{dB}$ . The final humidity level, inside the box, shall not exceed the initial level, at the closing of the box.

#### **2.9.1.4.2 Humid Heat test**

The sealed splice enclosure, with fibres spliced and looped inside, must be subjected to a temperature of  $+55^{\circ}\text{C} \pm 2^{\circ}\text{C}$  with a relative humidity rate of between 90% and 95% for 5 days. The attenuation variation of the fibres during the duration of the test shall be less than  $\pm 0.05\text{dB}$ , and the internal humidity rate measured, less than 2% .

#### **2.9.1.4.3 Rain Withstand Test**

The splice enclosure with optical fibres cable installed and fibres spliced fixed, shall be subjected to 24 hours of simulated rain in accordance with IEC 60 testing requirements. No water seepage or moisture shall be detected in the splice enclosure. The attenuation variation of the fibres after the test shall be less than  $\pm 0.05\text{dB}$ .

#### **2.9.1.4.4 Vibration Test**

The splice enclosure, with fibres united inside, shall be subjected to vibrations on two axes with a frequency scanning of 5 to 50 Hz. The amplitude of the vibrations shall be constant at 0.450mm, peak to peak, for 2 hours, for each of the vibrations' axes. The variation in attenuation, of the fibres, shall be less than  $\pm 0.05\text{dB}$ . The splice enclosure shall be examined for any defects or deformation. There shall be no loosening or visible damage of the FO cable at the entry point.

#### **2.9.1.4.5 Bending and Torsion test**

The splice enclosure, with fibres spliced inside, shall be firmly held in place and be subjected to the following sequence of mechanical stresses on the cable:

- a) 3 torsion cycles of  $\pm 180^{\circ}$  shall be exercised on the cable. Each cycle shall be less than one minute.
- b) 3 flexure cycles of the cable, of  $\pm 180^{\circ}$  with one cycle less than one minute.

The variation in the attenuation, of the fibres, shall be less than  $\pm 0.05\text{dB}$ . The cables connection ring shall remain securely fixed to the box with the connection maintained firmly. No defects/fissures shall be noted on the joint ring or on the splice enclosure.

#### **2.9.1.4.6 Tensile test**

The splice enclosure with cable fixed to the boxes shall be subjected to a minimum tension of 448 Newton for a period of two minutes. No fissure shall be noted in the connections or on the box.

#### **2.9.1.4.7 Drop Test**

With 2 lengths of 10 metres of cable fixed to the box, it shall be dropped five times from a height of 1 metre. There shall be no fissure, at all, of the box, and the connections shall remain tight. The test shall be carried out in accordance with procedure described in IEC-68-2-32.

### **2.9.2 Factory Acceptance Tests**

Factory acceptance tests shall be conducted on randomly selected final assemblies of all equipment to be supplied. Factory acceptance testing shall be carried out on Aerial fibre optic cable, Aerial FO cable accessories & fixtures, splice enclosures, FODP etc.

Equipment shall not be shipped to the Employer until required factory tests are completed satisfactorily, all variances are resolved, full test documentation has been delivered to the Employer, and the Employer has issued despatch Certificate. Successful completion of the factory tests and the Employer approval to ship, shall in no way constitute final acceptance of the system or any portion thereof.

Factory acceptance tests shall not proceed without the prior delivery to and approval of all test documentation by the Employer.

The factory acceptance test shall demonstrate the technical characteristics of the equipment in relation to this specifications and approved drawings and documents. A list of factory acceptance tests for fibre optic cables and FO cable hardware fittings & accessories etc. are given below. This list of factory acceptance tests shall be supplemented by the Contractor's standard FAT testing program.

For the FO cable **hardware fittings & accessories**, the minimum sampling rate, and batch acceptance criteria shall be as defined in IS 2486.

The factory acceptance tests for the splice enclosures, FODP and other items shall be proposed by the Contractor in accordance with technical specifications and Contractor's (including Sub-Contractor's /supplier's) standard FAT testing program. In general the FAT for other items shall include at least: Physical verification, demonstration of technical characteristics, various operational modes, functional interfaces, alarms and diagnostics etc.

For Test equipment, FAT tests shall include supply of proper calibration certificates, demonstration of satisfactory performance, evidence of correct equipment configuration and manufacturer's final inspection certificate/ report.

#### **2.9.2.1 Factory Acceptance Tests On Fibre Optic Cables**

The Factory acceptance tests shall be conducted on random sampling of fibre optic cable to be supplied for the present procurement, prior to any shipment.

##### **2.9.2.1.1 FAT On Fibre: Optical Acceptance Tests**

The Optical acceptance tests listed in table E-8.1 below are applicable for the fibres of all types of Fibre Optic Cables to be supplied. The listed tests follow testing requirements set forth in IEEE standards 1138 section 4.2.2.1 and section 5.2.2.1 . The referenced sections



specify the detailed test description. The acceptance norm shall be as specified in the above mentioned IEEE standard unless specified otherwise in the technical specifications.

**Table 3.5.1**  
**Factory Acceptance Tests for Fibres of all FO cables: Optical Tests**

S.No.	Test Name	Acceptance Criteria	Test procedure
1	Attenuation Coefficient	Table 2-1(a)	EIA/TIA 455- 78A
2	Point Discontinuities of attenuation	Table 2-2(a)	EIA/TIA 455-59
3	Attenuation at Water Peak	Table 2-2(a)	EIA/TIA 455- 78A
4	Chromatic Dispersion		EIA/TIA 455-168A/169A/175A
5	Core - Clad Concentricity Error		EIA/TIA 455-/176
6	Cladding dia.		EIA/TIA 455-176
7	Fibre Tensile Proof Testing		
-End Of table-			

The manufacturer carried out test certificates for fibres shall be produced during FAT on FO cable and the test reports shall be submitted along with the FO cable FAT reort.

#### **2.9.2.1.2 Factory Acceptance Tests on Self-supporting metal free aerial optical fibre cable**

The tests listed in Table 3.6 shall be carried out as Factory Acceptance Test for Self-supporting metal free aerial optical fibre cable meeting the requirements specified in this section.

Table 3.6  
**Factory Acceptance Tests on Self Supporting Metal Free Optical Fibre Cable**

S. No.	Factory Acceptance Test
1	Attenuation Coefficient (1310, 1550): By EIA/TIA 455- 78A or OTDR
2	Point discontinuities of attenuation: By EIA/TIA 455- 78A or OTDR
3	Visual Material verification and dimensional checks as per approved drawings
4	Water Ingress test

<b>5</b>	Tensile strength test / Strain test
<b>6</b>	Impact test
<b>7</b>	Kink test
<b>8</b>	Environmental test
<b>9</b>	Crush Test
<b>10</b>	Drip test

Note : Sampling

For test sl. No. 1 & 2 (10% drums of the lot offered). Test shall be conducted on all fibres of the selected drums.

For test Sl. No. 3, 4, 5, 6, 7, 9 & 10 shall be one drum per lot.

For test No. 8 one drum for the design/total project requirement.

#### **2.9.2.2 Factory Acceptance Tests on Aerial FO cable accessories & fixtures**

The FAT on accessories & fixtures of Self-supporting metal free aerial optical fibre cable shall be carried out as specified in Table 3.6.2.

Table 3.6.2

Factory Acceptance Tests on Fittings for Self Supporting Metal Free Optical Fibre Cable

<b>S. No.</b>	<b>Factory Acceptance Test</b>
<b>1</b>	Visual and dimensional checks of all components
<b>2</b>	Tensile test
<b>3</b>	Slip test
<b>4</b>	Galvanising test
<b>5</b>	Wrapping test
<b>6</b>	Hardness test

#### **2.9.2.3 Factory Acceptance Test on In Line Splice Enclosures**

The factory acceptance tests for In Line Splice Enclosures as specified below in Table 7.1:

Table 3.7.1

Factory Acceptance Tests on In Line Splice Enclosures

<b>S. No.</b>	<b>Factory Acceptance Test</b>

<b>1</b>	Visual check Kit Quantities and Specific Component Number for each component of In Line Splice Enclosure and dimensional checks against the approved drawings.
<b>End of Table</b>	

#### **2.9.2.4 Factory Acceptance Test on Fibre Optic Distribution Panel (FODP)**

The factory acceptance tests for FODP as specified below in Table 3.8

**Table 3.8**  
**Factory Acceptance Tests on FODP**

<b>S. No.</b>	<b>Factory Acceptance Test</b>
<b>1</b>	Visual check Kit Quantities and Specific Component Number for each component of FODP and dimensional checks against the approved drawings.
<b>End of Table</b>	

### **2.9.3 Production Testing**

Production testing shall mean those tests which are to be carried out during the process of production by the Contractor to ensure the desired quality of end product to be supplied by him. The production tests to be carried out at each stage of production shall be based on the Contractor's standard quality assurance procedures. The production tests to be carried out shall be listed in the Manufacturing Quality Plan (MQP), alongwith information such as sampling frequency, applicable standards, acceptance criteria etc.

The production tests would normally not be witnessed by the Employer. However, the Employer reserves the right to do so or inspect the production testing records in accordance with Inspection rights specified for this contract.

### **2.9.4 Sampling for FAT**

From each batch of equipment presented by the Contractor for Factory acceptance testing, the Employer shall select random sample(s) to be tested for acceptance. Unless otherwise agreed, the Sampling rate for the Factory acceptance tests shall be 10% (Minimum 1) of the batch size. The physical verification shall be carried out on 100% of the offered quantities as per the approved FAT procedure. In case any of the selected samples fail, the failed sample is rejected and additional 20% samples shall be selected randomly and tested. In case any sample from the additional 20% also fails the entire batch may be rejected.

### **2.9.5 Site Acceptance Tests**

The Contractor shall be responsible for the submission of all equipment supplied in this contract for site tests and inspection as required by the Employer. All equipment shall be tested on site under the conditions in which it will normally operate.

The tests shall be exhaustive and shall demonstrate that the overall performance of the contract works satisfies every requirement specified. A minimum Site Acceptance Testing requirement is outlined in following section. This testing shall be supplemented by the Contractor's standard installation testing program, which shall be in accordance with his quality plan(s).

During the course of installation, the Employer shall have full access for inspection and verification of the progress of the work and for checking workmanship and accuracy, as may be required. On completion of the work prior to commissioning, all equipment shall be tested to the satisfaction of the Employer and Purchaser to demonstrate that it is entirely suitable for commercial operation.

#### **2.9.5.1 Minimum Site Acceptance Testing Requirement for FO Cabling**

Prior to installation, every spooled fibre optic cable segment shall be tested for compliance with the Pre-shipment data previously received from the manufacturer. This requirement will preclude the installation of out of specification cable segments that may have been damaged during shipment.

#### **2.9.5.2 Phases of Site Acceptance Testing of FO cabling system**

SAT shall be carried out link by link from FODP to FODP.

The tests, checks, adjustments etc conducted by the Contractor prior to offering the equipment for SAT shall be called Pre-SAT activities. The Pre-SAT activities shall be described in the installation manuals and Field Quality Plan documents.

**Sag and tension of Aerial cable** shall generally be as per approved sag-tension chart and during installation, sag and tension of Aerial shall be documented. Upon completion of a continuous cable path (equipment to equipment locations), all fibres within the cable path shall be demonstrated for acceptance of the cable path. Fibre Optic cable site testing minimum requirements are provided in Tables 2-2 (a) through 2-2(c).

**Table 2-2 (a):  
Fibre Optic Cable Pre-Installation Testing**

<b>Item:</b>	<b>Description:</b>
<b>1.</b>	Physical Inspection of the cable assembly for damage
<b>2.</b>	Optical fibre continuity and fibre attenuation with OTDR at 1310 /1550 nm

<b>Table 2.2 (b): Fibre Optic Cable Splice Testing</b>	
<b>Item:</b>	<b>Description:</b>
<b>1.</b>	Per splice bi-directional average attenuation with OTDR
<b>2.</b>	Physical inspection of splice box/enclosure for proper fibre / cable routing techniques
<b>3.</b>	Physical inspection of sealing techniques, weatherproofing, etc.
<b>Table 2-2 (c): Fibre Optic Cable Commissioning Testing</b>	
<b>Item:</b>	<b>Description:</b>
<b>1.</b>	End to End (FODP to FODP) bi-directional average attenuation of each fibre at 1310 nm and 1550 nm by OTDR.
<b>2.</b>	End to End (FODP to FODP) bi-directional average attenuation of each fibre at 1310 nm and 1550 nm by Power meter.
<b>3.</b>	Bi-directional average splice loss by OTDR of each splice as well as for all splices in the link (including at FODP also).
<b>4.</b>	Proper termination and labelling of fibres & fibre optic cables at FODP as per approved labelling plan.
<b>-End of Table-</b>	

## **Section 5**

### **Technical Specifications for Underground Fibre Optic Cable**

Utility shall use Fiber optic leased line communication system provided telecom service provider in the project area. In case, the same is not available then utility may use Fiber optic option as envisaged in this section.

This section describes the functional requirements, major technical parameters and Type testing and Factory Acceptance Testing requirements for underground fibre optic cables, HDPE pipes. Marking, packaging, transportation installation requirements have also been described. The distance of the underground FO cable route length has been specified in the BOQ. The payment will be made for the executed route length only. However, specified service loops and lengths for wastage, installation/working for FO cable & HDPE ducts shall be considered as required by the bidder for which no additional payment will be made. The unit rate (per Km) quoted shall include the required FO cable, **pair of HDPE** ducts and all other installation items/accessories including manholes, GI/Hume pipes for crossings, markers, duct jointing accessories etc. for one km of FO cable route irrespective of the type of soil along the route. Bidders are advised to survey at their own expenses to assess the requirement before bidding if desired by them.

#### **3.1 Under Ground FO Cable**

##### **3.1.1 General**

The underground fibre optic cable shall be unarmoured and shall be suitable for underground installation in pipes. The cable should be of low weight, small volume and high flexibility. The mechanical design and construction of each unit shall be inherently robust and rigid under all condition of operation, adjustment, replacement, storage and transport.

##### **3.1.2 Applicable Standards**

The cable shall conform to the standards named below and the technical specifications described in the following sections.

- i). ITU-T Recommendations G.652
- ii). Electronic Industries Association, EIA/TIA 455-78A, 455-3A, 455-62A, 455-164A/167A/174, 455-168A/169A/175A, 455-176, 455-59, EIA/TIA 598, EIA 455-104.
- iii). International Electro technical Commission standards, IEC60304, IEC60794-1-2, IEC60811-5-1.
- iv). Bellcore GR-20
- v). TEC-spec no-G/OFC-01/03. Aug 99 (including all amendments up to September 2000)

##### **3.1.3 Fibre Type(s) and Counts**

The cable shall contain at least 6 nos. of Dual Window Single Mode (DWSM) fibres conforming to G.652 as per the Bill of the Quantity and the Technical parameters stipulated in the following sections.

##### **3.1.4 Optical Characteristics**

The attenuation coefficient for wavelength between 1525nm and 1575nm shall not exceed the attenuation coefficient at 1550nm by more than 0.05dB/km. The attenuation coefficient between 1285nm and 1330nm, shall not exceed the attenuation coefficient at 1310nm by more than 0.05dB/km. The attenuation of the

fibre shall be distributed uniformly throughout its length such that there are no point discontinuities in excess of 0.1dB. The fibre attenuation characteristics specified in table 3-1 shall be “guaranteed” fibre attenuation of any & every fibre reel.

DWSM fibres shall conform to the requirements specified in Table 3-1 below:

**Table 3-1**  
**DWSM Optical Fibre Characteristics**

<b>Fibre Description:</b>	Dual-Window Single-Mode
<b>Mode Field Diameter:</b>	8.6 to 9.5 $\mu\text{m}$ ( $\pm 10\%$ of the nominal value)
<b>Cladding Diameter:</b>	125.0 $\mu\text{m} \pm 2\mu\text{m}$
<b>Mode field Concentricity Error:</b>	$\leq 1.0\mu\text{m}$ at 1310 nm
<b>Core-Clad concentricity error:</b>	$\leq 1.0\mu\text{m}$
<b>Cladding non-circularity</b>	$\leq 2\%$
<b>Cable Cut off Wavelength:</b>	$\leq 1260$ nm
<b>1550 loss performance</b>	As per G.652
<b>Proof Test Level</b>	$\geq 0.35$ Gpa (50.76 Kpsi )
<b>Attenuation coefficient</b>	@1310nm $\leq 0.35$ dB/Km @1550nm $\leq 0.23$ dB/Km
<b>Attenuation at water peak (1383nm)</b>	$\leq 2.1$ dB/Km
<b>Attenuation variation with wavelength</b> 1285 nm - 1330 nm 1525 nm – 1575 nm	Attenuation coefficient @1310 $\pm 0.05$ dB Attenuation coefficient @1550 $\pm 0.05$ dB
<b>Point discontinuities</b>	$\leq 0.1$ dB
<b>Chromatic Dispersion; Maximum:</b>  <b>Zero Dispersion Wavelength:</b> <b>Zero Dispersion Slope:</b>	20 ps/(nm x km) @ 1550 nm 3.5 ps/(nm x km) @ 1288-1339nm 5.3 ps/(nm x km) @ 1271-1360nm  1300 to 1324nm -0.093 ps/(nm <sup>2</sup> xkm) maximum
<b>Polarization mode dispersion coefficient</b>	$\leq 0.5$ ps/km <sup>1/2</sup>
<b>Temperature Dependence:</b>	Induced attenuation $\leq 0.05$ dB (-60 $^{\circ}\text{C}$ - +85 $^{\circ}\text{C}$ )
<b>Bend performance:</b>	@1310nm (75 $\pm$ 2 mm dia Mandrel), 100 turns; Attenuation rise $\leq 0.05$ dB @1550nm (75 $\pm$ 2 mm dia Mandrel), 100 turns; Attenuation rise $\leq 0.10$ dB @1550nm (32 $\pm$ 0.5 mm dia Mandrel), 1 turn; Attenuation rise $\leq 0.50$ dB
<b>End of Table</b>	

### **3.1.5 General Construction**

The optical cable shall consist of a central fibre optic unit protected by one or more layers of helically wound anti-hygroscopic tape or yarn. The central fibre optic unit shall be designed to house and protect the fibres from damage due to forces such as crushing, bending, twisting, tensile stress and moisture, wide temperature variations, hydrogen evolution etc. The fibre shall be of loose tube construction. The inner polyethylene jacket and outer sheath jackets shall be free from pinholes, joints, splits or any other defects. All fibre optic cable shall have a minimum service life span of 25 years.

#### **3.1.5.1 Colour Coding & Fibre Identification**

Individual optical fibres within a fibre unit, and fibre units shall be identifiable in accordance with EIA/TIA 598 or IEC 60304 or Bellcore GR-20 colour-coding scheme. The colour coding system shall be discernible throughout the design life of the cable. Colouring utilized for colour coding optical fibres shall be integrated into the fibre coating and shall be homogenous. The colour shall not bleed from one fibre to another and shall not fade during fibre preparation for termination or splicing. Each cable shall have tracability of each fibre back to the original fibre manufacturer's fibre number and parameters of the fibre. If more than the specified number of fibres are included in any cable, the spare fibres shall be tested by the cable manufacturer and any defective fibre shall be suitably bundled, tagged, and identified at the factory by the vendor. The colouring scheme shall be submitted along with the cable DRS/drawing for employer's approval.

#### **3.1.5.2 Strength Members**

The central fibre optic unit should include a central strength member of Fibre Reinforced Plastic (FRP) or other suitable material. Peripheral strength members and aramid yarns are also acceptable. The central FRP strength member may be of slotted type with SZ lay (reverse oscillation lay) of fibre units or it may be cylindrical type with helical lay of fibre units.

#### **3.1.5.3 Filling Compound**

The interstices of the central fibre optic unit and cable shall be filled with a suitable compound to prohibit any moisture ingress or any longitudinal water migration within the fibre optic unit or along the fibre optic cable. The water tightness of the cable shall meet or exceed the test performance criteria as per **IEC60794-1-2-F5**. The filling compound used shall be a non-toxic homogenous waterproofing compound that is free of dirt and foreign matter, anti-hygroscopic, electrically nonconductive and non-nutritive to fungus. The compound shall also be fully compatible with all cable components it may come in contact with and shall inhibit the generation of hydrogen within the cable. The filling compound shall remain stable for ambient temperature up to +70°C and shall not drip, flow or leak with age or at change of temperature. Reference method to measure drip point shall be as per **IEC 60811-5-1** and drip point shall not be less than 70°C.

#### **3.1.5.4 The Sheath / Inner jacket**

The sheath shall be black, smooth, concentric, and shall be free from holes, splits, blisters and other surface flaws. The sheath shall be extruded directly over the central fibre optic unit and shall also be non-hygroscopic. The cable sheath design shall permit easy removal without damage to the optical fibres or fibre units. The sheath shall be made from good quality of weather resistant polyethylene compound (Black High Density Polyethylene- HDPE) and thickness shall be  $\geq 1.8\text{mm}$ .

#### **3.1.5.5 The Outer Jacket/ Termite protection**



A circular jacket of not less than 0.65mm Polymide-12 (Orange Nylone-12) material should be applied over the sheath as an outer jacket. The outer jacket shall have smooth finish and shall be termite resistant.

**3.1.5.6 Rip Cord:** Suitable rip cord(s) shall be provided to open the outer sheath of the cable. The rip cord(s) shall be properly waxed to prevent wicking action and shall not work as a water carrier.

### 3.1.6 Mechanical Parameters & Tests

(A) **Tensile Strength:** The cable shall be of sufficient strength to withstand a load of value  $T(N)=9.81 \times 2.5 \times W$  Newton or 2670 N whichever is higher (where W is the mass of 1Km cable in Kg). The load shall be sustained for 10 minutes and the strain of the fibre monitored. The load shall not produce a strain exceeding 0.25% in the fibre and shall not cause any permanent damage to any constituent part of the cable. The change in optical attenuation during or after the application of the rated tensile load in accordance with **IEC60794-1-2-E1** procedure shall not exceed 0.05dB/Km both for 1310nm and 1550nm wavelength. The attenuation shall be noted before strain, during strain and after release of strain for all the fibres.

(B) **Crush test (Compressive Strength):** The cable shall withstand a compressive force of at least 2000 N, applied for at least 60 seconds between two plates of 100mm X 100mm in accordance with IEC60794-1-2-E3 procedure. This compressive load applied in accordance with **IEC60794-1-2-E3** shall not cause any permanent damage to any constituent part of the cable. The change in optical attenuation during or after the application of the compressive load shall not exceed 0.05dB both for 1310nm and 1550nm wavelength. The attenuation shall be noted before, during and after the test for all fibres.

(C) **Bend Radius:** The cable bend radius under no load shall be less than or equal to 20 times the cable diameter. The test method shall be according to the **IEC60794-1-2-E11 (procedure-1)**. The fibres and component parts of the cable shall not suffer permanent damage when the cable is subjected to 10 cycles of wrapping and unwrapping of 4 complete turns around a mandrel of dia equal to 20 times the cable diameter. The change in optical attenuation after the test shall not exceed 0.05dB both for 1310nm and 1550nm wavelength. The attenuation shall be noted before and after the test for all fibres. Outer Jacket shall not show any cracks visible to the naked eye when examined whilst still wrapped on the mandrel.

(D) **Cable Bending test (Repeated bending):** The cable shall withstand repeated bending when tested in accordance with **EIA-455-104** and shall not cause any permanent damage to any constituent part of the cable. The cable sample shall be at least 5 meters or more. The change in optical attenuation during or after the application of the repeated bending test shall not exceed 0.05dB. The attenuation shall be noted before and after the test for all the fibres. The test requirement shall be as mentioned below: -

Weight	5kg
Minimum distance from pulley centre to holding device	216mm
Minimum distance from weight to pulley centre	457mm
Pulley diameter	20 times to the cable dia
Angle of turning	90°
Number of cycles	30
Time required for 30 cycles	2 min.

(E) **Impact Test:** The cable shall withstand at least 10 impacts of 50N load from a 0.5 metre height with impacting surface radius of 300mm. The 10 impacts when applied at the same place in accordance with **IEC60794-1-2-E4** shall not cause any permanent damage to any constituent part

of the cable. The change in optical attenuation during or after the application of the impact load shall not exceed 0.05dB. The attenuation shall be noted before, during and after the test for all fibres.

- (F) **Torsion test:** The cable shall withstand 10 cycles of  $\pm 180^\circ$  torsion with 100N load applied on a 2m sample. This load cycle applied in accordance with **IEC60794-1-2-E7** shall not cause any permanent damage to any constituent part of the cable. The change in optical attenuation during or after the application of the torsion load shall not exceed 0.05dB for all fibres. The attenuation shall be noted before, during and after the test.
- (G) **Kink test (Resistance):** When a cable of sample length 10 times the minimum bend radius as defined above is subjected to kinking, it shall not result in any fibre breakage and the kink shall disappear after normalising the cable. The change in optical attenuation after the application of the kink in accordance with **IEC60794-1-2-E10** shall not exceed 0.05dB for all the fibres.
- (H) **Water ingress test (Resistance to water penetration):** The water ingress test of the cable shall meet or exceed the test performance criteria as per **IEC60794-1-2-F5** method B. Before applying the water tight seal at one end the outer jacket shall be stripped. A water-soluble fluorescent dye shall be used for testing. The duration of test shall be 7 days. In addition after the test the cable shall be ripped open and the distance up to which water has seeped shall be noted.
- (I) **Drip Test (Seepage of Filling Compound):** For testing, a sample of 30 cm length of the cable with one end sealed by the end cap will be taken and outer jacket, sheath, binder tapes shall be removed by 5cms from open end of the sample. The filling compound will be wiped thoroughly and the sample be kept vertically with open end down ward in the oven for 24 hours at  $70^\circ\text{C}$  temperature with a filter paper under the sample. The filter paper should not indicate any sign of drip or oily impression. The reference test specification shall be as per **IEC60811-5-1** to measure drip point.
- (J) **Environmental Test:** Temperature cycling test shall be carried out on one drum length of the cable to ensure stability of attenuation parameter of the cable when subjected to temperature change which may occur during storage, transportation, and operation. The permissible temperature range for storage and operation will be from  $-20^\circ\text{C}$  to  $+70^\circ\text{C}$ . The rate of change of temperature during test shall be  $1^\circ\text{C}$  per minute. The cable shall be kept for 12 hours at each of the following temperature and should follow the specification **IEC60794-1-2-F1**. Two cycles shall be performed.

TA2	: $-20^\circ\text{C}$
TA1	: $-10^\circ\text{C}$
TB1	: $+60^\circ\text{C}$
TB2	: $+70^\circ\text{C}$

The attenuation shall be measured at the end of each temperature range both at 1310nm & 1550nm. The change of attenuation of the fibre used shall be  $\leq 0.05\text{ dB/km}$  for 1310 & 1550nm for entire range of temperature for all the fibres in each cycle.

- (K) **Termite Resistance Test:** 3 (Three) Samples of optical fibre cables of 2(Two) meter length each shall be taken from the selected drums for Optical Fibre cable and the ends shall be sealed with metallic caps. These test samples will be sent to the reputed test lab for termite resistance test. The test Procedure and period shall be as per CAZRI, Jodhpur. All Samples shall be checked for any termite attack over the Nylone-12 jacket. The outer jacket shall be demonstrated to be termite resistant. Attack by termites shall be disregarded but termite should not penetrate or damage the Nylone-12 jacket of any sample.

Observation on any damage of the cable shall be recorded.

- (L) **Abrasion Test:** To be conducted as per IEC 60794-1-E2 or equivalent international test method.
- (M) **Flexure Rigidity Test:** To be conducted as per ASTM D-790. The test shall not cause any permanent damage to any constituent part of the cable. The change in optical attenuation after the test shall not exceed 0.05dB/Km. The attenuation shall be noted before and after the test for all the fibres.
- (N) **Figure of Eight Test:** 1000m of cable shall be uncoiled from the drum and arranged in figure of eight, each loop having a maximum dimension of 2m. It shall be possible to arrange cable in figure of 8 with relative ease and the cable shall not show any visible damages.
- (O) **Cable Ageing Test:** After Environmental test the cable shall be subjected to a temperature of  $85 \pm 2$  °C for 168 hours. Cable shall then be brought to ambient temperature and stabilised for 24 hours. The change in optical attenuation after the test shall not exceed 0.05dB/Km for 1310 as well as 1550 nm wavelengths. The attenuation shall be noted before and after the test for all the fibres.
- (P) **Embrittlement Test of Loose tube:** The minimum length of the test sample depends of the outside diameter of the loose tube and should be 85mm for tubes upto 2.5mm outside dia. The length of the bigger tubes should be calculated by using the following equation :

$$L_o > 100 \times ((D^2 + d^2)/4)^{1/2}$$

Where

$L_o$  = Length of tube under test

$D$  = Outside dia of loose tube.

$d$  = inside dia of loose tube.

Both the ends of a buffer tube test sample may be mounted in a tool which is clamped in jaws of a tensile machine which exert a constant rate of movement. The movable jaw may move at a rate of 50 mm per minute toward the fixed jaw. Under load the tube will bend, so that the tube is subjected to tensile and compressive stresses. The fixture for holding the tube should be designed in a manner that the tube might bend in all directions without further loading. The tube should not get embrittled. No ink should appear on the tube upto the safe bend dia of tube (20 D) where D is the outside diameter of the loose tube. There should not be any physical damage or mark on the tube surface.

- (Q) **Kink Resistance test on the loose tube:** A longer length of the loose tube is taken (with fibre and gel), a loop is made and loop is reduced to the minimum bend radius of loose tube i.e. 20 D. (where D is the outside dia of the loose tube). This test is to be repeated 4 times on the same sample length of the loose tube. No damage or kink should appear on the surface of the tube.
- (R) **Drainage test for loose tube:** A tube length to 40 cm shall be cut and filled with filling gel ensuring there are no air bubbles and the tube is completely full. The filled tube is placed in a horizontal position on a clean worktop and cut 5 cm from each end so that the finished length of the sample is 30 cm. The filled tube shall be left in a horizontal position at an ambient temperature for 24 hrs. The sample tube is then suspended vertically in an environment heat oven over a weighed beaker. It is left in the oven at a temperature of 70°C for a period of 24 hrs. At the end of the 24 hrs. period the beaker is checked and weighed to see if there is any gel in the beaker. There shall be no gel or oil in the beaker.

- (S) **Check of easy removal of sheath :** The sheath shall be cut in circular way using a sheath removal tool and the about 300 mm length of the sheath should be removed in one operation. It should be observed during sheath removal process that no undue extra force is applied and no component part of the cable is damaged. It shall be possible to remove the sheath easily. Easy removal of both the outer jacket and the inner sheath shall be checked separately.
- (T) **Effect of aggressive media on the cable surface (Acidic and alkaline behaviour)** The test shall be conducted as per method no. ISO175. The two test samples of the finished cable each of 600 mm in length are taken and the ends of the samples shall be sealed. These test samples are put in the PH4 and PH10 solutions separately. After 30 days these samples are taken out from the solutions and examined for any corrosion etc. on the sheath and other markings of the cables. The sample should not show any effect of these solutions on the sheath and other marking of the cable.

### **3.1.7 Cable drums, Marking, Packaging and Transport**

All optical fibre cable shall be supplied on strong wooden drums provided with lagging with adequate strength, constructed to protect the cabling against all damage and displacement during transit, storage and subsequent handling during installation. The cable drum shall be suitable to carry underground fibre optic cable of length upto 4 Km  $\pm 10\%$  or 2 km  $\pm 10\%$ . The Contractor may offer higher cable drum length in straight routes subject to transportation, handling and installation limitations. However, the exact lengths for drums to be supplied for each link shall be determined by the Contractor during detailed engineering/survey. Drum schedule shall be approved by the Employer before manufacturing the FO cable. Both cable ends in the drum shall be sealed and shall be readily accessible. The drum shall be marked with arrows to indicate the direction of rotation. Both the ends of the cable shall be provided with pulling eye. The pulling eye and its coupling system should withstand the same tensile load as applicable to the cable. The following marking shall be done on each side of the cable drums.

- i) Drum number
- ii) Consignee's name and address
- iii) Contractor's name and address
- iv) Type of cable
- v) Number of fibres
- vi) Type of fibres
- vii) Year of manufacturing, month & batch no
- viii) Name of manufacturer
- ix) Total cable length
- x) Inner end marking and Outer end marking

Packing list supplied with each drum shall have all the information provided on marking on the respective cable drum and following additional information: OTDR length measurement of each fibre and Ratio of fibre and cable length.

#### **3.1.7.1 Optical fibre cable marking**

A suitable marking shall be applied in order to identify this cable from other cables. Marking on the cable shall be indelible, of durable quality, shall last long and shall be applied at regular interval of one-meter length. Marking shall be imprinted and must clearly contrast with the surface and colors used must withstand the environmental influences experienced in the field. The accuracy of the sequential marking must be within  $\pm 0.5\%$  of the actual measured length. The sequential length marking must not rub off during normal installation. In case laser printing

is used the marking shall not exceed 0.15 mm depth. The optical fibre cable shall have the following markings in every meter.

- i) Type of Cable
- ii) Running meter length
- iii) Number of fibres
- iv) Type of fibre
- v) Laser symbol & caution notice
- vi) Year of manufacture and batch no.
- vii) Manufacturer's name
- viii) Owner's Name “ ”

### 3.1.7.2 Operating Instructions

Complete technical literature in English with detailed cable construction diagram of various sub-component with dimensions and test data of the cable shall be provided. All aspects of installation shall also be covered in the handbook.

### 3.1.8 Test and Inspection:

The general conditions for Type and Factory Acceptance Testing shall be as per section 7.

#### 3.1.8.1 Type Testing

The cable to be supplied should have been type tested either as per the requirement specified in this section or relevant TEC specifications including latest amendments. The Bidder shall submit along with their bid the earlier carried out type test reports and/or TEC certificates for the offered fibre optic cable meeting the requirement. The fibre should have been type tested as per relevant International standards for the tests listed in Table 3-2 and the Bidder shall submit the test reports and certificates along with the bid. The Contractor shall submit the type test reports of fibres meeting the minimum requirement specified in Tables 3-2 below. If the test reports are not submitted or if the submitted test reports do not meet the requirement, the Contractor shall carry out the type testing on the fibres as per requirement specified in Table 3-2 and on the FO cable as per 3.1.6 of this chapter with no additional cost to the Employer.

**Table 3-2: Type Tests For Optical Fibres**

S.N.	Test Name	Acceptance Criteria	Test procedure
1	Attenuation	TS Table 3-1	EIA/TIA 455- 78A
2	Attenuation Variation with wavelength	TS Clause 3.1..4	EIA/TIA 455- 78A
3	Attenuation at Water Peak	TS Table 3-1	EIA/TIA 455- 78A
4	Point Discontinuities of attenuation	TS Table 3-1	EIA/TIA 455-59
5	Attenuation With Bending (Bend Performance)	TS Table 3-1	EIA/TIA 455- 62A Method/procedure A/B
6	Mode Field diameter	TS Table 3-1	EIA/TIA 455- 164A/167A/174
7	Chromatic Dispersion	TS Table 3-1	EIA/TIA 455- 168A/169A/175A

**Table 3-2: Type Tests For Optical Fibres**

S.N.	Test Name	Acceptance Criteria	Test procedure
8	Cladding Diameter	TS Table 3-1	EIA/TIA 455-176
9	Core -Clad concentricity error	TS Table 3-1	EIA/TIA 455-176

**3.1.8.2 Factory Acceptance Testing**

The tests listed in Table 3-3 shall be carried out as Factory Acceptance Test for Underground fibre optic cable meeting the requirements specified in this section.

**Table 3-3**  
**Factory Acceptance Tests on Underground Fibre Optic Cable**

S. No.	Factory Acceptance Test
1	Attenuation Coefficient (1310, 1550): By EIA/TIA 455- 78A or OTDR
2	Point discontinuities of attenuation: By EIA/TIA 455- 78A or OTDR
3	Visual Material verification and dimensional checks as per approved drawings
4	Water Ingress test
5	Tensile strength test / Strain test
6	Impact test
7	Kink test
8	Environmental test
9	Crush Test
10	Drip test

Note: Sampling:

For test sl. No. 1 & 2 (10% drums of the lot offered). Test shall be conducted on all fibres of the selected drums.

For test Sl. No. 3, 4, 5, 6, 7, 9 & 10 shall be one drum per lot.

For test No. 8 one drum per design/total project requirement.

**3.2 PLB HDPE DUCT and ACCESSORIES**

The following paragraphs describes the functional requirements & major technical parameters for Permanently Lubricant High Density Polyethylene (PLB HDPE) duct. PLB HDPE duct shall be suitable for underground fibre optic cable installation by blowing as well as conventional pulling. The PLB HDPE duct shall be suitable for laying in trenches by directly burying, laying through G.I./RCC hume pipe and laying through trench less horizontal directional drilling. The expected service life of HDPE duct and accessories shall not be less than 50 years.

The Bidder shall quote unit rates for each of the items mentioned in the price schedule. However, the quantities indicated in the BoQ are indicative only and the actual quantity will be governed by the quantity variation clause as defined in Conditions of Contract.

### 3.2.1 Construction of PLB HDPE duct

The PLB HDPE duct shall have two concentric layers viz. outer layer and inner layer. The outer layer shall be made of HDPE material and the inner layer of solid permanent lubricant. **These** concentric layers shall be co-extruded and distinctively visible in cross-section under normal lighting conditions and generally conform to IS-9938. The colour of the PLB HDPE duct shall be orange and uniform throughout. In the finished PLB HDPE duct, the co-extruded inner layer of solid permanent lubricant shall be continuous and integral part with HDPE outer layer and preferably be **white** in colour. The inner layer of solid permanent lubricant shall not come out during storage, usage and throughout the life of the duct. The duct shall be supplied in a continuous minimum length of 1000 (one thousand) meters in coil form, suitable for transportation, installation and handling purposes.

Bidders may offer HDPE duct of a homogeneous construction (i.e. without a separate inner layer) as **an** alternative, meeting all the requirements of this specification.

The finished duct shall be of good workmanship such that the duct is free from blisters, shrink **holes**, flaking, chips, scratches, roughness, break and other defects. The duct shall be smooth, clean and in round shape, without eccentricity. The ends shall be cleanly cut and shall be square with axis of the duct.

### 3.2.2 General

The HDPE duct shall conform to the following standard and the technical specifications **described** in the following sections.

- (A) IS: 4984 - Specification for HDPE duct
- (B) IS: 2530 - Method for tests for polyethylene molding materials and compounds.
- (C) IS: 14151(part1) -Polyethylene pipes for sprinkler irrigation systems (part-1, pipes).
- (D) IS: 9938-Recommended colors for PVC insulation for LF wires and cables.
- (E) TEC-spec no G/CDS-08/01/Dec-99-HDPE duct for use as duct for optical fibre cable.
- (F) IS:7328 -HDPE material for moulding and extrusion
- (G) ASTM D 1693 -Test method for environmental stress cracking of ethylene plastics.
- (H) IS12235 (Para 9) - Method of tests for unplasticized PVC pipe for portable water supplies , impact strength at zero degree centigrade.
- (I) ASTM D 1505 -Test method for density
- (J) ASTM D 3895 - Method for Oxidation Induction test

### 3.2.3 Material

The raw material used for the PLB HDPE duct shall meet the following

requirements:-

- (i) The anti-oxidant establisthers, color master batch and other additive used shall be physiologically harmless and shall be used only to minimum extent necessary to meet the specification.
- (ii) Usage of any additives used separately or together, should not impair the long-term physical and chemical properties of the PLB HDPE duct.
- (iii) Suitable Ultra Violet stabilizers may be used for manufacture of the PLB HDPE duct to protect against UV degradation when stored in open for a minimum period of Eight months.
- (iv) The base HDPE resin used for manufacturing outer layer of duct shall conform to any grade of IS-7328 or to any equivalent standard meeting the following requirement.

**Density** *940 to 958kg/m<sup>3</sup> at 27 °C*  
**Melt Flow Rate(MFR)** *0.2 to 1.1 g/10 minutes at 190 °C & 5 kg load*

- (v) In case of PLB HDPE duct of two concentric layer construction, the friction reducing, polymeric material to be used as the inner layer lubrication material shall be integral with HDPE layer. The lubricant materials shall have no toxic or dermatic hazards for safe handling.

### 3.2.4 Dimension of duct

The nominal size of the duct shall be 40mm and shall meet the following requirements.

- (i) Outside diameter 40 mm + 0.4 mm
- (ii) Wall thickness 3.5 mm (+0.2 mm/ -0.00 mm)
- (iii) Standard length 1000 meters ± 100 meter
- (iv) Thickness of permanent lubricant, ≥ 0.4 mm
- (v) Maximum outer diameter of FO cable 16 mm or offered cable dia that can be installed by blowing technique (whichever is higher)

### 3.2.5 Accessories of PLB HDPE duct

The following accessories are required for jointing the duct and shall be supplied along with the duct. The manufacturers shall provide complete design details, procedure for method of installation and type of the material used for the accessories.

- i) Plastic coupler: The coupler shall be used to join two PLB HDPE ducts. The coupling shall be able to provide a durable water tight joint between two ducts without deteriorating the strength of the ducts. The strength of coupler shall match the primary strength of the PLB HDPE duct and threaded coupler is not acceptable.
- ii) End plug: This shall be used for sealing the ends of empty duct, prior to installation of FO cable and shall be fitted immediately after laying of the PLB



- HDPE duct, to prevent entry of any unwanted elements such as dirt, water, moisture, insects/rodents etc.
- iii) End cap: This cap is made of hard rubber, shall be fitted with both ends of PLB HDPE duct to prevent the entry of any unwanted elements such as dirt, water, moisture, insects/rodents during transportation and storage. No separate payment will be admissible for providing end caps with each piece of PLB HDPE duct supplied.
- iv) Cable sealing plug: This is used to hold the cable and prevent entry of any unwanted elements, as specified above.
- v) **Empty PLB HDPE duct with draw rope inside it :** A draw rope shall be provided in each PLB HDPE duct. The rope will have a braided multi-strand construction, 4mm diameter, polypropylene raw material and having breaking load strength of not less than 200kg. The PLB HDPE duct should be sealed at both ends with suitable sealing caps with hooks to tie the inner rope at both ends.
- vi) Colour of each of the accessories shall be black or white.

### **3.2.6 Workmanship**

The duct shall be free of blisters, shrink holes, break and other defects. The PLB HDPE duct ends shall be cut as square as possible to longitudinal aspects. The internal and external PLB HDPE duct surfaces shall be smooth. The color should be uniform throughout.

### **3.2.7 Marking**

All the duct, shall be clearly marked at intervals of 1 meters with the following data which is not less than 5 mm high. The details of marking on duct shall be approved by Owner/Employer before commencement of manufacturing.

- i) "Name of utility" with logo
- ii) Manufacture's name or trade mark
- iii) Year of manufacturing
- iv) Type of PLB HDPE duct and size
- v) Running length marking .

### **3.2.8 Packing and condition of delivery**

The duct may be supplied in reels or coils after sealing both ends by end caps. The following marking shall be provided on each packing:-

- (a) Code of product
- (b) Name of Manufacturer
- (c) Date of manufacturing
- (d) Length of PLB HDPE duct
- (e) Dimension of Outer Dia and Inner Dia
- (f) Owner's name "Name of utility"

### **3.2.9 Type Tests and Factory Acceptance Tests**

The Bidder shall enclose in the bid valid type approval certificate from Telecom Engineering Centre (TEC), New Delhi of Department of telecommunication according to TEC specification no. G/CDS-08/01 or latest TEC for the proposed PLB HDPE duct meeting the specified requirements. The cable is liable to be considered non-compliant to the technical specifications in absence of type approval certificates as stipulated above as no separate type testing is envisaged for the material to be supplied by the Contractor (i.e. the successful Bidder).

The dimensional and marking checks of each reel or coil of PLB HDPE duct and their accessories as per the approved DRS shall be carried out as Factory Acceptance Test (FAT) which may be witnessed by the Employer. However, visual inspection of 100% of the item/material may be carried out by Employer/Owner on receipt of material at site and any visual damage observed on site inspection on the supplied item/material would make the consignment liable for rejection.

### **3.3 INSTALLATION OF UNDERGROUND FIBRE OPTIC CABLE SYSTEM**

This section describes the installation procedures and methods including survey, clearances, excavation of trenches and pits, trenchless digging, installation of PLB HDPE pipes, installation of RCC hume pipes and GI Pipes, marking, backfilling, installation of underground cable, construction of manholes, splicing, termination and site acceptance testing requirements of the underground fibre optic cabling system.

#### **3.3.1 Survey**

The choice of route is most important aspect in planning an underground cable system. The correct choice is essential to reduce the cost of laying pipes, keeping the pipes safe from damage and to attain their maximum utilisation when they have been laid. The broad guidelines to be taken into consideration while choosing a route for the installation of underground fibre optic cable are given hereunder.

The Owner/Employer will provide the details of the existing PLB HDPE pipe routes to the extent possible. However, to carry out the fibre optic cable installation, the Contractor shall carry out the required survey of the routes at no additional cost to the Owner/Employer. The Contractor shall submit the survey report of these routes furnishing all details regarding position of joint boxes, manholes (existing and proposed), section distances etc.

##### **3.3.1.1 Survey for underground fibre optic cable links:**

The survey shall be carried out by the contractor for the proposed under ground FO cable routes defined in the Appendices for selection of most optimal route. The contractor shall arrange topographical maps and the details of facilities belongs to other utilities along the proposed route. The route shall be selected considering the following guidelines:

- a. The route shall be as straight and as short as possible.
- b. The route shall have minimum obstacles in order.

- c. Clearances required from other authorities/bodies are minimum and that the clearances can be obtained expeditiously.
- d. Wet or unstable ground shall be avoided to the extent possible.
- e. The route for the pipes shall be away from the carriage-way of the road to the extent possible.
- f. The route shall be suitable for placing manholes wherever required.
- g. Future expansion of roads shall be taken into consideration.
- h. Road, rail, river, culvert (nallah) crossings.
- i. As far as possible underground fibre optic cable route shall be on the opposite side of the existing cables laid by DOT/BSNL or other utilities. Wherever both routes fall on the same side of the road, sufficient spacing shall be maintained, to the extent possible.
- j. Care must be taken to avoid choosing routes, roads, areas that are **rat infected** and prone to floods etc.

Trial pits shall be dug at suitably selected locations to assess the obstacles. It is necessary to locate the trial pits at proposed manhole locations for the pipe. If required, more trial pits shall be dug carefully to assess the existing underground facilities and the same shall be recorded in the inspection note of the trial pit along with suitable sketch. The type of soil condition is also recorded.

### 3.3.1.2 Survey Report

The Contractor shall submit the survey report with the most suitable routes for all the fibre optic links along with details described above for owner/employer's approval FO cable route. The owner/employer will give the preliminary approval for the route, subject to obtaining the required clearances. Up on approval Contractor shall carry out detail survey for the selected routes and submit the final survey report for approval before implementation. The final survey report shall include at least the following:

- a. A drawing of the proposed route indicating all details of the route including relevant details of soil strata, bridges, culverts, causeways, rail over/under bridges, defence area, underground gas / oil / water pipe line, power and communication cables routes, other important landmarks etc.
- b. The distance of the fibre optic cable route from the centre of the road/rail/river/bridge/culvert etc. shall be indicated on the route maps as well as documented in tables.
- c. Sections of the links where trenchless digging may be required.
- d. Sections where GI or RCC hume pipe may be required.
- e. Location and number of permanent and temporary manholes.
- f. Location of all turns, bends and major landmarks.
- g. Type, quantity and location of all the joint boxes. Care must be taken to minimise the number of splicing and joint boxes.
- h. Section lengths of the underground fibre optic cable, total length of each link and drum scheduling for all the links.
- i. List of authorities from which clearance shall be required to be obtained for each relevant section.
- j. **Sections of unavoidable rat infected areas along the proposed route, for which armored FO cable is required.**
- k. All the information required for obtaining clearance.
- l. It may be noted that the reinstatement of the facilities/properties damaged during the installation is the responsibility of the Contractor for which there will be no additional cost implication to the Owner/Employer.

It shall be the responsibility of the contractor to propose the alternate route, if the proposed route is not suitable for installation due to the condition of soil or non availability of clearances or any other reasons. The final survey report shall have to be approved by the Owner/Employer and requisite clearances need to be obtained before the cable installation work is commenced by the contractor..

The Contractor shall prepare and submit for approval by the Owner/Employer, specific construction drawings for all types of soil strata/crossings taking into consideration the guidelines given in this specification. The construction/implementation shall be carried out as per the approved drawings.

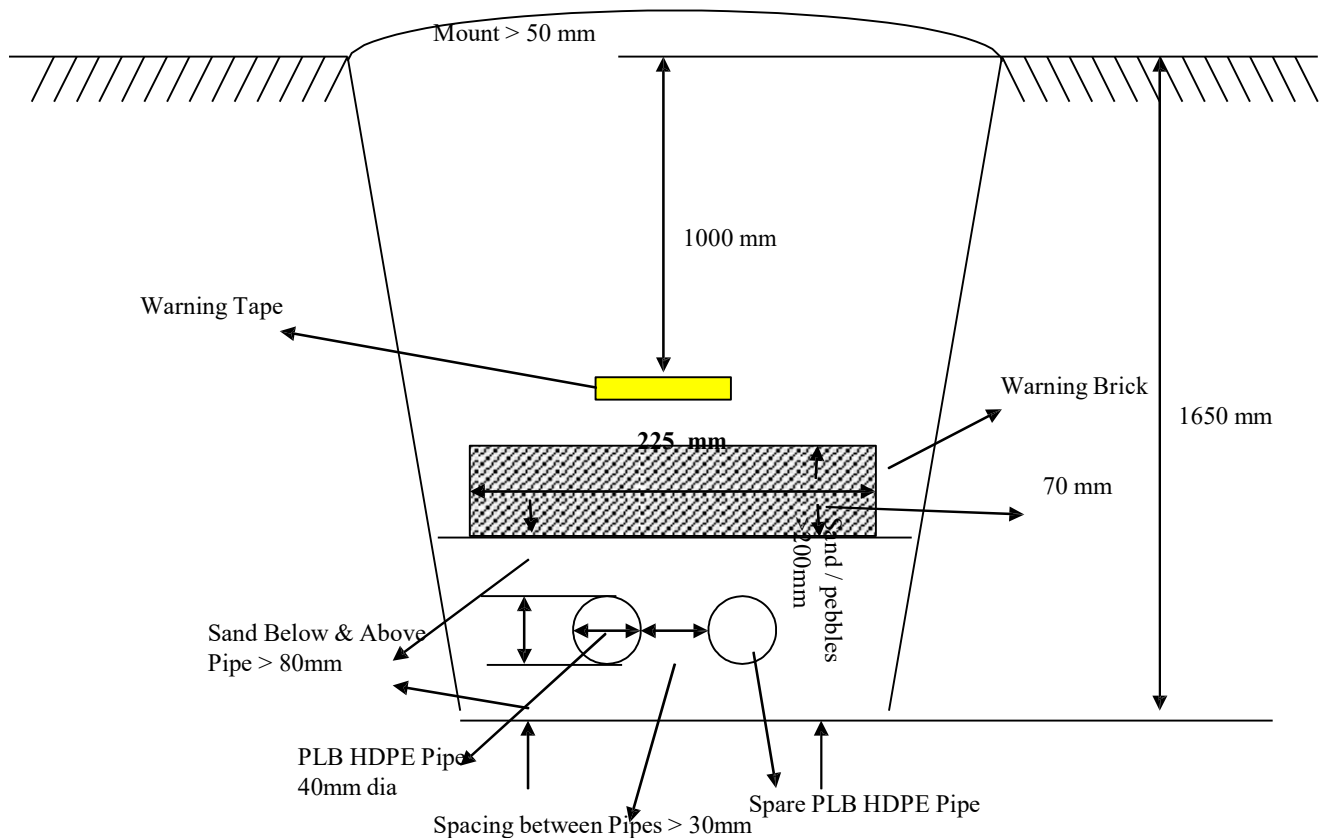
The construction drawings shall interalia include the longitudinal sectional diagram of the trench for different soil strata and detail arrangement of crossings, number of pipes, size of pipe, locations and position of manholes, other details as per the technical specifications. Route maps shall be drawn to the scale of 1:20,000. For convenient handling in the field, the map shall be made on 300mm(W) and lengths not exceeding 1190mm sheets with 30 mm overlap shown on subsequent sheets.

#### **3.3.1.3 Clearances**

The Contractor shall be responsible for obtaining necessary clearances for excavation work from the authorities on behalf of the Owner and provide requisite copies of information, maps, survey report etc to the authorities. The Owner/Employer shall assist the Contractor in obtaining such clearances by providing the authority letter or any other relevant document. The Contractor shall make an all out effort with the concerned authority to get clearances expeditiously and to negotiate the least cost to the Owner/Employer. The Owner/Employer shall furnish all required bank guarantees and make payments to the concerned authorities directly based on the demand letter obtained by the Contractor from the concerned authorities. The Contractor shall ensure quick and speedy clearances in order to implement the project within stipulated schedule. In case the authorities have some objections on certain sections of routes proposed and are unwilling to provide clearances, the Contractor shall propose an alternate route, promptly carry out the survey and submit specific survey report for that and reapply for clearance after taking into account the comments/objections of the authority.

#### **3.3.2 Excavation and Backfilling**

The Contractor shall carry out excavation and backfilling of trenches in all kinds of soil strata such as normal soil, soft rock, hard rock for laying PLB HDPE pipe, RCC hdpe pipe and GI pipe.



**Figure 3-1: Trench in Normal Soil for 2 PLB HDPE pipes (Not To Scale)**

### 3.3.2.1 Excavation

The cable trenches shall be dug as per route plan and detail trench drawings (indicating the various dimensions and other details of the trench) approved by the Owner/Employer for each type of soil strata. The Contractor shall take due care and precaution during excavation to avoid possible damage of other underground plants/facilities in the proposed underground fibre optic cable route and shall indemnify the Owner/Employer for all damages and shall be solely responsible for all the damages and losses. The Owner/Employer shall not be liable for any damages/losses.

Fig 3-1 shows the dimensional view of excavation of trench and other details of installation in normal soil for 2 PLB HDPE pipes. For the purpose of this specification, soil strata types are defined below:

Normal Soil	All type of soil {i.e. dry, wet (partially or fully submerged)} except soft rock or hard rock as defined below.
Soft Rock	Lime stone, laterite, hard conglomerate or other fissured rock which can be quarried or split with crow bars, wedges or pickaxes. However, if required light blasting may be resorted to for loosening the material, but this will not in any way entitle the material to be classified as hard rock.
Hard Rock	Any rock excavation other than specified under Soft Rock, for which blasting, drilling, chiselling are required.

Depth of trench shall be at least 1650 mm in normal soil. However, for rail & road crossings the trench depth shall be at least **1000** mm. Depth of trench shall be at least 1000 mm in soft rock from the depth soft

rock is encountered i.e. in case soft rock is encountered at say 500 mm then the actual depth of the trench shall be  $500 + 1000 = 1500$  mm limited to a maximum depth of 1650mm. Depth of trench shall be at least 800 mm in hard rock from the depth hard rock is encountered i.e. in case hard rock is encountered at say 300 mm then the actual depth of the trench shall be  $300 + 800 = 1100$  mm limited to a maximum depth of 1650mm. For excavation in hard rock, controlled blasting can be resorted to. The Contractor shall obtain necessary permissions from the statutory authorities for blasting and the use of explosives for this purpose. No blasting is permitted near permanent work or dwellings. Blasting shall be so made that pits are as near to the designed dimensions as practicable. Jackhammers can also be used for the excavation. The width of trench at the top and bottom shall be adequate for proper installation of PLB HDPE pipes, RCC hume pipes, GI pipes Warning tape, route marker and joint markers. The contractor shall submit the construction drawing for approval. The trench depth shall be measured from the bottom of the trench. Trench shall be located at the lowest point of lower area if possible. Trench shall not be constructed at field boundary or any up-heap. In case of uneven ground, the Contractor ensure that the bottom of the trench is not uneven, the Contractor shall maintain minimum depth of the trench as per specifications and may be required to increase the depth at some locations and provide a suitable gradient in the trench.

During the construction of trenches, the Contractor shall be responsible for shoring and strutting the walls of the trench on either side by using suitable means such as wooden planks to avoid subsidence of soil. The Contractor shall also be responsible for supporting the exposed plant/facilities of other utilities such as water, gas and oil pipes, electric, telephone or fibre optic cables etc to avoid any possible damage. The Contractor shall also be responsible for any dewatering of the trench during digging and installation of pipes.

In case it is necessary to get around a large obstacle such as a boulder or an underground plant/facility, which has not been anticipated earlier the trench may be given a gentle bend within permissible radius or by construction of a manhole. Wherever possible, it is preferable to avoid additional manholes.

The **Owner/Employer's Project Manager or his/her authorized representative** will be the authority to decide the classification of the soil i.e. normal soil, soft rock or hard rock. In few cases where the required depth is not achievable, the Project manger may allow the lesser depth subject to providing the suitable protection such as providing the concrete casing of the installed ducts. For such cases, the contractor shall propose the suitable protection arrangement along with the reasons for non achievability of the required depth and obtain the specific approval of the project manager before execution of the work. The decision of the Project Manager shall be final and binding on the Contractor.

### **3.3.2.2 Backfilling**

After installation of PLB HDPE pipes, RCC hume pipes or GI pipes, the backfilling of the trench shall be done. The PLB HDPE pipes shall be sandwiched with sand as per the Figures 3-1. Backfilling shall normally be done with the excavated soil, unless it consists of large boulders/stone in which case the boulders/stone shall have to be broken to a maximum size of 80mm. The backfilling should be clean and free from organic matter or other foreign material. The earth shall be deposited in maximum 200 mm layers levelled and wetted and tamped properly before another layer is deposited. The earth filling is done with a suitable mount to allow for any shrinking of soil at the later date. In case of regular footpath, temporary reinstatement shall be done after backfilling. The left out earth if any has to be disposed by the Contractor to a suitable location as indicated by authorities at his own cost. It is advisable to start backfilling of the trench from one end or after padding of the pipe to avoid uplifting. In case of soft rock as well as hard rock, the PLB HDPE pipe shall be covered with 1:2:4 concrete. The cross section of the concrete shall be 100 mm (depth) x 200 mm (width). The Contractor shall properly cure the concrete for four days. The backfilling of the remaining portion shall be done as stipulated for normal soil.

Final inspection of the backfilling shall be done jointly by the Contractor and Owner/Employer

immediately after first monsoon and the Contractor shall rectify the defects, if any, without any cost to the Owner/Employer.

### 3.3.3 Marking

The Contractor shall provide markers, warning bricks and warning tape as stipulated below for the routes where new PLB HDPE pipes are installed under this package.

#### A) Markers

Route markers made of RCC (1:2:4) of length 1450 mm and a bottom cross section of 150mmx200mm tapering to 75mmx125mm at top shall be provided. Route markers shall be provided at 500 mm from the trench and away from the road centre, at an average of 200 m. Markers shall also be provided at major directional changes in route (from straight) and at both sides of all types of crossings. 900 mm of the marker shall be underground and 550 mm shall be above the ground. The portion of route markers above ground shall be painted with brown synthetic enamel paint.

Joint Markers shall be provided at each joint location and shall be same as route markers except that they shall be blue in colour. In case joint markers and route markers fall at the same location, route marker shall not be installed and only joint marker shall be provided.

All Markers shall be Engraved vertically as “ NAME OF UTILITIY” in 500 mm portion above the ground area and filled with fluorescent white colour. The marking shall face the road.

#### B) Warning Bricks

Bricks class designation-5(50) of the actual size 225 mm (Length) x 111 mm (Width) x 70 mm (Thick) shall be laid breadth-wise as per Figure : 5-1(average 9 bricks per metre) in city area (municipality limits) immediately above the sand layer in which PLB HDPE pipe is installed. Stone slabs of suitable size may also be used in place of warning bricks with the approval of the Owner/Employer.

#### C) Warning Tape

A warning tape, made of HDPE or LDPE (Low Density Poly Ethylene) other suitable inert material, containing a printed message "**WARNING :” Name of utility’s “ Fibre Optic Cable below**" shall also be laid over the pipe, throughout the cable route at a depth of 1000mm in normal soil (the depth in soft rock and hard rock shall be proposed by the Contractor and approved by the Owner/Employer), for warning the person who is excavating the trench. The width of the tape shall be at least 100 mm and thickness of the tape shall be at least 500 micrometer. The life of the warning tape shall be at least 25 years.

### 3.3.4 Installation of PLB HDPE Pipe

Two PLB HDPE pipes two PLB HDPE pipes (**one spare for future use**) shall be laid. Two PLB HDPE pipes shall be laid side by side (minimum spacing 30 mm) at bottom of the trench after making the surface smooth and providing 80 mm of sieved, stone free sand bedding. After laying the pipe additional sieved sand shall be added to increase the height of the sand layer to a total of 200 mm hence positioning the PLB HDPE pipe in the middle of the layer. In case of unavoidable rat infected areas along the finalised route, pebbles of dia 20 mm (nominal) shall be used in place of the sand. Other important steps are described as under:

- a. PLB HDPE Pipe shall be laid in a flat bottom trench free from stones, sharp edged debris. Pipe shall not be laid in water filled trenches.
- b. The Pipe shall be placed in trenches as straight as possible. Minimum bending radius of pipe and fibre optic cable shall always to be taken into account.
- c. The ends of pipes shall always be closed with end plugs to avoid ingress of mud, water or dust i.e. all pipe opening shall be sealed to avoid entry of foreign material.
- d. The pipes shall be joined tightly & properly through plastic couplers and the joint shall be smooth and free from steps. The joints shall be made properly so that it passes the duct integrity test specified in section 3.3.12.4 . All joints shall be assembled with proper tools only.
- e. Coupler shall not be placed along the bend portion of the pipe and hacksaw shall never be used to cut the pipe.
- f. Cable sealing plugs shall be provided at all manhole locations and at locations cable is coming out of the pipe and empty pipe ends i.e. all pipe openings shall be sealed to avoid entry of foreign objects.
- g. PLB HDPE pipes shall be installed in a manner that fibre optic cable can be pulled, blown, de-blown without damaging the fibre optic cable due to stresses.

The Contractor shall get inspected, by a representative of Owner/Employer, all joints before carrying out the backfilling. Joints shall be visually inspected and checked for tightness.

### 3.3.5 Manholes

Manholes shall be provided at every joint location to house Joint Box and Optical Fibre cable service loops. The location for Joint boxes shall be decided during detailed engineering. The manhole shall be pre cast RCC Cylindrical pipe with minimum internal diameter of 1000 mm, minimum height of 1100 mm and minimum thickness of 80 mm. The height of the manhole where only the service loop of the cable to be kept at road/culvert/bridge crossings shall be minimum 500 mm. It shall be made by spun concreting method and shall include 8mm steel reinforcement. The base of the manhole shall be minimum 80 mm thick, RCC. The cover shall be pre cast RCC, minimum 50mm thick with a diameter suitable for the manhole. The cover shall include two permanently fixed iron hooks of sufficient size for reopening purpose. Minimum 3 mm thick GI strip rings shall be used inside and outside of the top edge of the manhole cylinder. To avoid direct concrete contact between manhole cylinder and top cover as well as for protection of the concrete edge, the outer edge and the edge having contact with inner side of the manhole cylinder shall also have minimum 3 mm thick GI strip rings. The above mentioned GI strip rings shall be suitably fixed with the reinforcements. The bottom of the manhole shall be at depth equal to the depth of the trench. The Manhole shall be able to withstand a live load of 20ton vehicle plus 30% for impact from moving vehicle. The Contractor shall propose a suitable procedure for **proto testing** of the manhole for approval by **Employer** & shall carry out the proto test if the offered manhole is not type approved earlier by the Owner/Employer. Manholes type approved by the Owner/Employer only shall be acceptable. The manhole shall include sufficient number of suitable entries for installing PLB HDPE Pipes. The manhole shall have two holes in each four perpendicular directions for PLB HDPE pipe entries and exits. Fixtures for placing cable and spliced Joint Box inside the manhole shall be provisioned. The joint box shall be mounted vertically on the wall of the manhole. The contractor shall carry out the required excavation and backfilling for the construction of the manhole. All PLB HDPE pipe entries including spare HDPE pipes, cable entries and spare holes shall be properly sealed. The Contractor shall submit construction drawings and installation procedures for the Manholes (all different configurations) for approval by the Owner/Employer.

The Contractor shall get inspected, by a representative of the Owner/Employer, all manholes before carrying out the backfilling. Pipe & cable sealing, installation of joint box and cable service loops as per approved drawings shall be visually inspected and checked for tightness.



### **3.3.6 Reinstatement**

The contractor shall be required to carry out reinstatement of the excavated area in case the concerned authority requires so. Reinstatement shall include all works necessary (such as reconstruction of metalled/asphalt road, footpath etc) to restore the excavated area to original quality and shape.

### **3.3.7 Installation of GI Pipe**

The GI pipe of nominal bore of minimum 100 mm shall be laid wherever road crossings, bridge crossings, railway crossings are encountered on the route as well as on wall/floor crossings in a building. Both two PLB HDPE pipes shall be inserted into one GI pipe. Whenever it is not possible to install the FO cable underground due to non availability of the right of way or any other unavoidable reasons, the HDPE ducts along with FO cable shall be installed in GI pipe on the wall inside the sewerage pipe and or on the existing rock/concrete/brick wall/surface with suitable fixing arrangement and concreting, if necessary, with specific approval of the Owner/Employer in case to case basis. The GI pipe shall conform to at least medium class and conform to IS : 1239 (Part –I). In regard to bridge and culvert crossing, GI pipe may be installed by concreting the GI pipe along the bridge or by using supporting brackets or by laying underneath the existing footpath etc. The PLB HDPE pipes shall be installed through this GI pipe. Wherever underground fibre optic cable is required to be spliced to overhead fibre optic cable using the outdoor FODPs / Joint Boxes installed on towers/pole (at a height of 6 to 10 meters), GI pipes shall be used to protect the complete exposed portion of the cable and shall be extended in the ground up to suitable depth of the trench so that minimum bending radius of the cable is maintained. The GI pipe shall be properly clamped/fixed on the tower leg/pole. The Contractor shall supply and install all necessary accessories as part of the installation work.

The Contractor shall propose the exact methods and procedures for implementation of crossings taking into consideration the following guidelines, for approval by the Owner/Employer:

- a. The GI pipe shall be extended at least 5 meters on each side of crossing subject to availability of space and approval of the Owner/Employer.
- b. Two GI pipes shall be joined using proper tools, sockets and accessories etc.
- c. Proper arrangements shall be made to seal the ends of GI pipe after installation of PLB HDPE pipes.
- d. Minimum bending radius of optical fibre cable shall always be taken into consideration.
- e. 1:2:4 concrete shall be used.
- f. The floor of the trench shall be levelled by laying at least 50 mm of soft soil or sieved sand before installing the GI pipe.
- g. The GI pipes shall be supplied in standard lengths of 6m or as approved by Owner/Employer's Project Manager.
- h. The GI pipe shall be sealed at both ends.
- i. The GI pipe of suitable length shall be provided at road crossings, bridge crossings, railway crossings encountered on the route as well as on wall/floor crossings in a building.

### **3.3.8 Installation of RCC Hume Pipe**

Minimum inside diameter 100 mm, NP3 RCC hume pipe shall be laid wherever river, nallah crossing encountered on the route. The RCC pipe shall conform to IS:458. Both PLB HDPE pipes shall be inserted into RCC hume pipe. The Contractor shall propose the exact methods and procedures for implementation of crossings taking into consideration the following guidelines, for approval by the Owner/Employer.

- a. The RCC hume pipe shall be extended at least 5 meters on each side of river, nallah subject to availability of space and approval of the Owner/Employer.
- b. Two RCC hume pipes shall be joined using RCC collar and properly cemented.
- c. Proper arrangements shall be made to seal the ends of RCC hume pipe after installation of PLB HDPE pipes.
- d. Minimum bending radius of optical fibre cable shall always be taken into consideration.
- e. 1:2:4 concrete shall be used.
- f. The RCC hume pipes shall be supplied in standard lengths of 2m or as approved by Owner/Employer's Project Manager.
- g. The RCC hume pipe shall be sealed at both ends.

### **3.3.9 Underground Fibre Optic Cable Installation**

The cable shall be installed inside one of the 40mm diameter PLB HDPE pipes installed under this package along the route(s). The cable shall be installed by compressed air blowing technique. The cable blowing machine shall be suitable for blowing the proposed section lengths of fibre optic cables.

As various utilities have already installed their fibre optic cables in the existing PLB HDPE pipe routes, the Contractor shall take due care and precaution during installation of fibre optic cable and the rectifications work to avoid possible damage of ducts / OFC of other utilities. The Contractor shall indemnify the Owner/Employer for all the damages and the Contractor shall be solely responsible for the damages and losses. The Owner/Employer shall not be liable for any such damages.

Bidder shall provide armored fibre optic cable (TEC approved design) in some of the sections, which are not suitable for unarmored cable installation in ducts (example: highly rat infected sections). The armored fibre optic cable shall also be installed inside the PLB HDPE pipe / GI pipe / RCC pipe, as applicable. The routes and types of installation shall be finalised during project execution based on the site survey report and actual requirements.

The Contractor shall propose the exact methods and procedures for installation taking into consideration the following guidelines, for approval by the Owner/Employer.

- a. The Optical Fibre Cable Drums shall be handled with utmost care. The drum shall not be subjected to shocks by dropping etc. They shall not be normally rolled along the ground for long distance and when rolled, shall in the direction indicated by the arrow. The battens shall be removed only at the time of actual laying.
- b. A blowing machine in association with an appropriate compressor shall be used for blowing.
- c. Temporary blowing chambers (if required) shall be constructed and then backfilled after blowing operation is completed.
- d. Locations along the route, which provide easy access points for blowing machine and compressor, shall be determined.
- e. Before starting the cable blowing, both PLB HDPE pipes installed under this package shall be checked for obstacles or damage. The already installed PLB HDPE pipe wherein cable are to be installed under this package shall also be checked for obstacles or damage. Checking shall be done by using a proper sized mandrel equipped with a transmitting device.
- f. Always blow downhill wherever possible.
- g. Multiple blowing machines may be used in tandem if so required.

Installation by pulling may be permitted by the Owner/Employer in specific cases where installation by blowing is not feasible. In case pulling is used, the pulling speed shall be determined considering the site condition. Care must be taken not to violate the minimum bending radius applicable for the fibre optic

cable. Tension in the cable during laying shall not exceed tension limit of the offered FO cable and the cable should not be damaged during or after the pulling.

While installing the cable, excess length of about 10 meters shall be stored at each joint location for each side. Excess length of 10 m shall be kept at one ends of a road crossing, culvert crossing and 20 meters at one end of bridges.

### **3.3.10 Trenchless Digging**

Trenchless digging may be used in short section for crossing National highways, important road or rail crossings etc, where the concerned authorities do not permit open cut method, for which no additional cost shall be provided by the Employer.

### **3.3.11 Optical fibre termination Splicing and Service**

Termination and splicing of optical fibre cables are described in chapter 2 of Section 5. Unless other wise specified in this chapter, service loop requirements specified in chapter 2 of section 5 shall be provided.

### **3.3.12 Site Acceptance Testing (SAT)**

General conditions for testing shall be as per Section 7 of this specification. The tests, checks, adjustments etc conducted by the Contractor prior to offering the equipment/material for SAT shall be called Pre-SAT activities. The Pre-SAT activities shall be described in the installation s and Field Quality Plan documents.

#### **3.3.12.1 Underground Fibre Optic Cable**

SAT for optical fibre cable shall be carried out link by link from FODP to FODP.

Prior to installation, every spooled fibre optic cable segment shall be tested for compliance with the Pre-shipment data previously received from the manufacturer. This requirement will preclude the installation of cable segments that may have been damaged during shipment. Test requirements are as per table 3-1.

Optical fibre attenuation shall be measured after installation and before splicing. Any increase in attenuation or step discontinuity in attenuation shall not be acceptable and shall constitute a cable failure. The Contractor shall have to either replace the concerned cable span at its own cost or provide additional splicing, joint box and manholes required to rectify the fault at its own cost. The fibre attenuation shall be tested again after replacement or rectification of fault.

During the installation, spliced cable segments shall be tested and documented. In case it is found that the splices are bad (loss is unacceptable as per approved test procedures), the Contractor shall have to do re-splicing and provide new Joint Box wherever required at no additional cost to the Owner/Employer. After re-splicing the end to end testing shall be repeated. The splice testing requirements are indicated in table 3-2.

Upon completion of a continuous cable path (FODP to FODP locations), all fibres within the cable path shall be demonstrated for acceptance of the cable path. Test requirements are indicated in table 3-3 and in no case losses attributed due to other factors viz. extra splice, kinks, will be acceptable to the limit determine by the following formula:

Max attenuation @ 1550nm:  $0.23\text{dB/km} + 0.05\text{dB} \times \text{total no of splices} + 0.5\text{dB} \times \text{connector}$

Max attenuation @ 1310nm:  $0.35\text{dB/km} + 0.05\text{dB} \times \text{total no of Splices} + 0.5\text{dB} \times \text{connector}$

As averaged over 100 km of fibre.

**Table 3-1:**  
**Fibre Optic Cable Pre-Installation Testing**

Item:	Description:
1.	Physical Inspection of the cable assembly for damage
2.	Optical fibre continuity and fibre attenuation with OTDR at 1550 nm

**Table 3-2:**  
**Fibre Optic Cable Splice Testing**

Item:	Description:
1.	Per splice attenuation with OTDR (bi-directional average) at 1550 nm
2.	Physical inspection of Joint Box for proper fibre routing techniques
3.	Physical inspection of sealing techniques, weatherproofing, etc.

**Table 3-3:**  
**Fibre Optic Cable Commissioning Testing**

Item:	Description:
1.	Fibre continuity and link attenuation (bi-directional) between FODP connectors at two ends for each fibre at 1310 & 1550 nm by OTDR
2.	Fibre continuity and link attenuation (bi-directional) between FODP connectors at two ends for each fibre at 1310 & 1550 nm by Power Meter & Laser Source
3.	Average splice loss (bi-directional) for each splices and average splice loss for the link by OTDR at 1550 nm
-End of Table-	

### 3.3.13 SAT for Joint Box

20% Joint Box shall be tested for water penetration. Installed joint box shall be completely immersed in water for 1 hour under 1 meter head, then opened and observed for water/moisture ingress. The Joint Box shall then be sealed and installed again. In case any water/moisture is detected, test shall be declared failed and all the Joint Boxes shall be tested, all failed joint boxes shall have to be re spliced and resealed.

#### 3.3.13.1 SAT for PLB HDPE pipe

For the new PLB HDPE pipes to be installed under this package, duct integrity tests shall be carried out as described below. The **Duct cleaning (Sponge test)** test shall be carried out on all the ducts before blowing/pulling of the cable while all other tests shall be carried out on spare ducts only. If Duct cleaning (sponge) test fails in the duct in which cable to be laid then other tests may be carried out to clean and rectify the problem, if any. The tests as described below shall be carried out between two consecutive manholes on the PLB HDPE pipes.

##### a. Duct cleaning (Sponge test)

Compressed air should be blown through the PLB HDPE pipe in order to remove dirt and water, if any, with the help of suitable Air Compressor. A short blast of air about 2-3 Bar shall be blown through the PLB HDPE pipe for about 2 minutes. Sponge shall be blown through the duct to thoroughly clean the duct from inside.

**b. Crush and deformity test**

Place a shuttle of length <15cm and O.D. 80% of the inner diameter of the offered PLB HDPE pipe. Connect the compressor pipe with a suitable flexible wire grip at the other end to catch the shuttle and start blowing operation to the pipe and check if shuttle reaches at the other end. If shuttle gets stuck perform the Radio transmitter detection test.

**c. Radio Transmitter detection test**

For this test, a Radio shuttle shall be blown by a compressed air which shall also be stuck at the point of earlier shuttle. The place and position of the radio shuttle shall be identified with help of detector and obstruction (kink/deformation/ sharp bend) is removed and the test procedure shall be repeated, until the whole duct section is found cleaned for blowing.

**d. Pressure testing**

For this test, seal one end of the PLB HDPE pipe with end coupler and connect valve with coupler at the other end and then pressurise the pipe up to 5 Bar with a compressed air from valve end coupler. After 30 minutes pressure drop shall not exceed by 0.5 Bar.

**3.3.13.2SAT for other items**

Tests for other components such as FODP etc. shall be done as per approved Field Quality Plan.

## **Section 5**

### **SPECIFICATION FOR VHF UHF & 900MHz LICENSED NARROWBAND FIXED WIRELESS IP/SERIAL DATA SYSTEM Remote and Redundant Base Station**

#### **4.0 WIRELESS MODEM GENERAL REQUIREMENTS**

Integrated wireless modem hardware shall be supplied which complies with applicable FCC requirements for 12.5 kHz, 25 kHz. The radio and modem must be internally integrated.

- i. The radio modem shall be manufactured to RoHS standards
- ii. The radio will have the capability to be programmed for multiple frequency channels and switched to other channels under program control.
- iii. Wireless modem will be equipped with both an Ethernet port and serial data connectors. The wireless modem should be capable of receiving data from either the Ethernet port or the serial data connector, or all connections simultaneously.
- iv. The Ethernet port shall be capable of configuration as an IP Bridge, IP gateway, or an IP router.
- v. AES 128-bit data encryption, password protection, and both data and IP header compression shall be provided with the wireless modem as standard product features.
- vi. The RF data rate of the wireless modem will be 32 @ 25 kHz; 16.9 kbps @ 12.5 kHz and 8 kbps @ 6.25 kHz (user selectable). Frequency tolerance shall be +/- 1.0 ppm.
- vii. Serial Ports: The wireless modem will be equipped with 2 RS-232, DE-9F serial ports that support communications at 300 – 19200 bps. At least one port shall support RTS/CTS control signal operation.
- viii. Ethernet Port: RJ-45 10 BaseT, auto-MDIX
- ix. The radio modem shall provide transparent serial data-to-Internet terminal server operation, eliminating the need for any external hardware or modifications.
- x. Radio shall have front panel Indicators: LAN Link, LAN Activity, Tx/Rx, Status, and power.

#### **4.1 WIRELESS MODEM OPERATION**

- a. The wireless modem shall operate as a Base, Master or Remote utilizing IP routing capabilities within the modem software and within the customer required frequency band.

- b. Routing mode must support Neighbor Discovery for the purpose of detecting the most efficient route between units. Neighbor discovery shall be automatic for small system shall require operator interaction on large system. Manual configuration will be available for user specific setups. When adding a new site, existing sites shall automatically update their database listings.
- c. The radio modem will have multiple frequency channels available, allowing a switch to these preprogrammed channels under programmed control.
- d. Separate data ports must be provided for both application data and on-line, non-intrusive diagnostic monitoring as well as IP-capable access through assigned IP ports. All ports shall be operable simultaneously.
- e. The wireless modem shall have the capability to operate as an IP router repeater (store and forward) for sites that are "over the horizon". This repeater feature shall be configurable in an on-demand basis by web browser interaction. The IP bridge configuration will allow repeater communications in a relay point mode to avoid data collisions.
- f. The wireless modem shall be fully compatible in operation with a remote site wireless modem and provide an access point, back-to-back repeater capability with operation in either bridge or router mode.

#### **4.2Radio Transmitter Requirements:**

- i. Input Power: 10 to 30 VDC, 90 watts max.
- ii. RF Output Power: 1-10 watt and must be adjustable between 1 to 10 watts.
- iii. Frequency: VHF or UHF or 900MHz licensed bands.

#### **4.3Radio Receiver Requirements**

Input Frequency: VHF or UHF or 900MHz licensed bands

#### **4.4Supported Protocols:**

The wireless modem will support the following protocols:

- Ethernet IEEE 802.3
- ICMP
- IGMP
- TCP
- UDP
- Dynamic Routing (RIP version 2)
- IPSec and other transport protocols encapsulated within IP
- IP Fragmentation
- ARP (Address Resolution Protocol)
- IP directed broadcast
- IP limited broadcast

- IP multicast relay
- DHCP Client and Server
- NAT (Network Address Translation)

#### **4.5 Remote Configuration**

The unit will provide the capability to program the parameters of the wireless modem from anywhere on the wireless network, or an internal LAN network with access to the wireless network.

Access to the internal web server of a wireless modem unit will be controlled by a username and password to restrict unwanted access to information contained on the wireless modem's internal web server.

Diagnostics: The wireless modem shall be capable of passing both on-line, non-intrusive system diagnostic information, as well as off-line diagnostic information with loop-back testing. Diagnostics reported shall include:

- Receive signal strength in dBm at local and remote ends of link
- Internal Temperature
- Power supply voltage
- Forward and reflected RF power
- Packet Error Rate (PER)

Diagnostics shall include the capability to acquire usage analysis from both the local unit and a specified or series of specified remote units.

The diagnostics information shall be available via an Ethernet connection and a defined IP port number or as a local output from one of the user defined serial ports.

#### **4.6 Physical Requirements:**

- Temperature range: -30 to +60 Celsius. An optional fan shall prevent or minimize the transmitter power output back off by keeping the unit cooler providing improved performance in a 100% duty cycle, high ambient temperature environment.
- Humidity range: 0 to 95% relative humidity at 40 °C, non-condensing.
- Design: The radio design shall make use of surface mount PC board components.

#### **4.7 Radio Modem Specifications:**

- Frequency Band : 136 to 174 MH or 400 to 500 MHz (900MHZ also included)
  - Radio modem should have both interface : Ethernet : 10 /100 Base T and RS232 both on same radio .
  - Through put should be 32 kbps on Ethernet and 19.2 Kbps on RS232 .
  - Frequency Stability : 1 PPM
- Radio Modem should have inbuilt On-line , RF network diagnostic and should provide necessary MIB files for third part network management softwares : SNMP / Web Interface etc.



- Radio Modem should have Off line diagnostics to monitor the RF network when system is offline .
- Radio Modem should be able to program for Bridge or Router Mode . Routing mode must support Neighbor Discovery for the purpose of detecting the most efficient route between units. Neighbor discovery shall be automatic for small system shall require operator interaction on large system. Manual configuration will be available for user specific setups. When adding a new site, existing sites shall automatically update their database listings.
- It should have built in store and forward feature .
- Radio Modem should support : most of the industries Ethernet protocols.
- Radio modem : Should be Simplex/Half Duplex .
- Radio modem should be able to operate in Star or Mesh Topology .
- Same radio modem should work as a Master , Repeater and Remote .
- RF Power Output should be 10 / 25 watt .
- Modulation Type: 2 FSK , 4 FSK
- Supply Voltage : 10 to 30 VDC
- RF Connector : TNC
- Radio Modem should have built in 128 bit AES Encryption for Data Security . password protection, and both data and IP header compression
- Radio modem should be able to program over the air .
- Duty cycle : 100 %
- The radio modem shall be manufactured to RoHS standards
- The radio will have the capability to be programmed for multiple frequency channels and switched to other channels under program control.
- Wireless modem will be equipped with both an Ethernet port and serial data connectors. The wireless modem should be capable of receiving data from either the Ethernet port or the serial data connector, or all connections simultaneously.
- Radio Modem should support IEC 101 and IEC 104 protocols
- Radio Modem should have built in Dynamic routing feature .
- Radio shall have front panel Indicators: LAN Link, LAN Activity, Tx/Rx, Status, and power.
- Bit error rate should be :  $1 * 10^{-6}$  at -111 dBm
- Radio modem should support both RTS/CTS and DOX mode at RS232 port .
- RX to TX attack time : less than or equal to 3 to 4 msec.
- Temperature range: -30 to +60 Celsius.
- Suitable antennas with atleast 7.5 dBi gain should be used ( Omni / Yagi ) Antennas should be designed with DC grounded .
- Suitable Low loss coaxial cable should be used ( LMR/CNT- 400 / 600 )
- Suitable Multi Strike capability Lightning Protection Units should be used
- Power supply to the radio should have a facility of battery charging with auto changeover facility in case of power failure .
- Supplier has to get required frequency allocation .
- Supplier will supply required Towers . Tower should be self supported and galvanized and should be designed for present location weather conditions . Supplier should quote for Suitable 3/6/9/12 /15 / 18 /21/24/27/30 MTR Mast /towers . Based on Radio survey the appropriate tower height will be selected .
- Supplier has to carry out the detailed radio survey and should submit radio survey report.

## 4.8 Detailed Technical Specifications

These specifications are typical and subject to change without notice.

GENERAL	UHF		VHF	
Frequency Range (MHz)	406.125-470 MHz, 450-511.975 MHz		136 – 174 MHz	
Frequency Stability	1.0 ppm		1.0 ppm	
Modes of Operation	Simplex, Half-Duplex			
Channel Bandwidth	6.25 kHz; 12.5 kHz; 25 kHz			
Frequency Increment	1.25 kHz			
Power Source	10-30 VDC, Negative GND			
RF Impedance	50 Ω			
Operating Temperature	-30° to + 60° C			
Storage Temperature	-40° to + 85° C, 95% non-condensing RH			
Operating Humidity	5% to 95% non-condensing RH			
Rx Current Drain at 25°C		DC Input 10V	DC Input 20V	DC Input 30V
		520 mA (max) 450 mA (typ)	270 mA (max) 240 mA (typ)	190 mA (max) 170 mA (typ)
Tx Current Drain at 25°C	Power Out	DC Input 10V	DC Input 20V	DC Input 30V
	40 dBm (10W)	5.8 A (max) 3.6 A (typ)	2.5 A (max) 1.8 A (typ)	1.6 A (max) 1.2 A (typ)
	30 dBm (1W)	1.6 A (max) 1.2 A (typ)	0.8 A (max) 0.6 A (typ)	0.6 A (max) 0.4 A (typ)
Cold start	20 seconds			
Nominal Dimensions	5.50" W x 2.125" H x 4.25" D (13.97 x 5.40 x 10.8 cm)			
Shipping Weight	2.4 lbs. (1.1 Kg)			
Mounting Options	Mounting plate/pattern & DIN Rail			
Fan Output	5VDC, 400mA max.			

TRANSMITTER	UHF	VHF
Tx Frequencies	406.125-470 MHz, 450-511.975 MHz	136-174 MHz
Carrier Output Power	1-10W Adjustable	
Duty Cycle	100% (Power Foldback Allowed for High Temperatures)	
Radiated Spurious Emissions	Per FCC/Regulatory	
Conducted Spurious Emissions	<-65 dBc	
Transmitter Stability into VSWR:	> 10:1 (Power Foldback Allowed)	
RX to TX Time	< 2ms	
Channel Switching Time	< 15 ms (Band-End to Band-End)	

<b>RECEIVER</b>	<b>UHF</b>		<b>VHF</b>
RX Frequencies	406.125-470 MHz, 450-511.975 MHz		136-174 MHz
	<b>25 kHz Channel</b>	<b>12.5 KHz Channel</b>	<b>6.25 kHz Channel</b>
Data Sensitivity @ $10^{-6}$ Bit Error Rate (BER) (Maximum)	-111 dBm @ 16kb/s -103 dBm @ 32kb/s	-114 dBm @ 8kb/s -106 dBm @ 16kb/s	-112 dBm @ 4kb/s -103 dBm @ 8kb/s
Data Sensitivity @ $10^{-6}$ Bit Error Rate (BER) (Typical)	-114 dBm @ 16kb/s -106 dBm @ 32kb/s	-116 dBm @ 8kb/s -109 dBm @ 16kb/s	-115 dBm @ 4kb/s -106 dBm @ 8kb/s
Adjacent Channel Rejection	> 75 dB	> 60 dB	> 45 dB
Spurious Response Rejection	> 75 dB		
Intermodulation Rejection	> 75 dB		
TX to RX Time	< 1ms		
Channel Switching Time	< 15ms (Band-End to Band-End)		
Receive Input Power	17 dBm (50mW) max.		

<b>MODEM/LOGIC</b>	<b>25 kHz Channel</b>	<b>12.5 KHz Channel</b>	<b>6.25 kHz Channel</b>
Data Rate (Selectable)	16 kbps, 32 kbps	8 kbps, 16 kbps	4 kbps, 8 kbps
Modulation Type	2FSK, 4FSK		
Addressing	IP		

<b>SETUP and COM Port</b>	
Interface	EIA-232F DCE
Data Rate	Setup Port: 300 – 19,200 bps (Default: 19.2 Kbps) Com Port: 300 – 115,200 bps (Default: 9.6 Kbps)

<b>Display</b>	
5 Tri-color status LEDs	Power, Status, Activity, Link, Rx/Tx

<b>Connectors</b>		
Antenna Connector	TNC female (Tx/Rx)	
Serial Setup Port	DE-9F	
Serial Terminal Server	DE-9F	
Ethernet RJ-45	10 BaseT auto-MDIX	
Power - I/O	<b>Power Header</b>	<b>Power Plug</b>
	DRL p/n 415-7108-113 (Weidmüller p/n 1615550000) 4 Pin, 3.5mm, Power Header	DRL p/n 897-5008-010 (Weidmüller p/n 1639260000) 4 Pin, 3.5mm, Power Plug Cable: 60 inches Connections: Fan Output, Ground, Power, Enable

<b>Diagnostics</b>	
Message elements	Temperature, Voltage, Local RSSI, Remote RSSI, Forward Power, Reverse Power, Packet Error Rate

<b>FCC / IC / UL Certifications</b>			
	FCC	IC (DOC)	UL
136 – 174 MHz	NP4-5018500	773B-5018500	Pending
406.1 - 512 MHz	NP4-5048300	773B-5048300	Pending

#### **4.9 OMNIDIRECTIONAL ANTENNA(S) FOR HOST or MASTER STATION WIRELESS MODEM**

Omni-directional antennas for Host or Master Station Wireless Modems must meet the following requirements:

- Frequency Range: 406-470 or 450-512 MHz band
- Gain: Per user system requirements and system design
- SWR: Less than 1.5:1
- Surge and impulse protection: Direct ground protection
- Connector: 18-inch flexible extension TNC with neoprene housing

#### **4.10 TRANSMISSION CABLE & MISCELLANEOUS FOR WIRELESS MODEM**

Vendor shall provide transmission cable of the low-loss foam-dielectric type to connect the master station radio antenna port to the antenna.

Vendor shall provide a three-foot section of „super-flex“ transmission cable at the master wireless modem antenna port. Provide standard TNC connectors for connection to a continuous piece of cable extending to the antenna.

Vendor shall provide weatherproof transmission cable suitable for direct environmental exposure. Use „O“ ring seals on connectors.

Vendor provided materials shall utilize appropriate bulkhead RF transmission cable surge and impulse suppression devices at cable entrances, Polyphaser® or equivalent.

Vendor shall include specifications on cable hangers and ground kits, as required in the particular installation.

All installations are to be performed by a professional installer.

#### **4.11 DIRECTIONAL ANTENNA FOR REMOTE STATION WIRELESS MODEM**

The Directional Antenna for Remote Stations must meet the following requirements:

- Frequency Range: Appropriate to frequency of operation
- Gain: Per user system requirements and system design
- Surge and impulse Protection: Direct ground protection
- Front-to-Back Ratio: 20 dB, minimum
- Connector: 18 inch flexible extension TNC with neoprene housing to appropriate connector type of antenna cable

- Mounting Hardware: Weatherproof clamp suitable for direct mount to 2 inch, schedule 40 steel pipe
- Antenna Hardware Kits: items should be supplied from the equipment provider in a complete, easy-to-use kit providing all the necessary items to properly connect the wireless modem to the antenna and field install the antenna assembly.
- The contractor (professional installer) shall provide all masts, lightning suppressors, and any other apparatus required to assemble a complete, operable, and reliable fixed wireless data system.

#### **4.12 SPARE PARTS**

The vendor shall provide a complete itemized list of radio system spare parts including pricing.

#### **4.13 TEST EQUIPMENT**

The vendor shall provide a complete list of all test equipment, extender boards, and interface equipment for maintenance and diagnostic testing.

#### **4.14 BASE STATION OVERVIEW**

##### **4.14.1 Ethernet Redundant Base Station Overview**

The Ethernet Redundant Base Station shall have two Ethernet radios with identical RF and Ethernet MAC addresses, a controller board, an RF power sensor, and an RF antenna relay inside the 19 inch rack mount chassis. The Ethernet Redundant Base Station shall give the user access to two Ethernet Ports, the Setup Port and the Com Port of the active Ethernet base station. Both external Ethernet connections shall be connected internally with an embedded Ethernet switch the radios. The Ethernet, Setup and Com Ports shall be routed automatically by the controller board to whichever Ethernet is currently in use. It shall have two separate power supplies. Each power supply shall be able to power the entire base station. The Ethernet Redundant Base Station radios shall be identical to the remote radio.

##### **4.14.2 Ethernet Failure Detection**

The controller board shall have a microprocessor that shall continually monitor the status of the active Ethernet radio via an Ethernet connection. The controller board shall measure the transmit power of the Ethernet when it is sending data. The controller board also shall have the ability to send out a ping to a remote unit when necessary to verify if the active Ethernet is still capable of transmitting and receiving data.

##### **4.14.3 Monitor the Base Station with Ethernet Connection**

The base station shall be able to establish a telnet connection to the Ethernet radio currently in use. IP address, user name and password must be used  
The following are the minimum parameters that shall be monitored.

- Diagnostic Forward Power
- Diagnostic Reverse Power
- Radio Temperature
- Foldback Status

- Error Status Message
- Externally Measured Forward Power
- Externally Measured Reverse Power

#### **4.14.4 Monitor Receive and Transmit Data / Send Pings**

The Ethernet Base shall be able to monitor the number of received and transmitted packets that go to/from the Ethernet radio. If there are no new received packets or if there are no new transmitted packets for a set period of time (Inactivity Time) the controller board shall generate its own traffic to verify the Ethernet is working correctly.

#### **4.14.5 When a Failure Is Detected**

When a failure is detected, and the base station is set to Automatic Mode, the first radio shall be powered off and the backup radio shall be powered on. The backup Ethernet radio boot up shall not be more than 25 seconds before being able to send and receive data. All ports shall be function with the backup Ethernet radio.

When an error is detected, the red Error LED on the base station's front panel shall turn on indicating which radio (Radio A or Radio B) the fault was detected with. The controller's Diagnostic web page shall report an error message showing which fault occurred. If the alarm is enabled, the buzzer shall sound two short chirps every 5 seconds indicating there is a failure. If enabled, the relays on the Alarm Port shall switch indicating an error has been detected.

Since both the Ethernets in the base station have identical Ethernet and RF MAC addresses, when the radios are switched neither the Local Area Network nor any remote Ethernets shall notice that the Base Station has switched to the backup Ethernet.

#### **4.14.6 Ethernet Radio Setup for a Redundant System**

In a redundant Ethernet system both Radio A and Radio B shall be setup identically.

##### **4.14.6.1 Bridge Mode Setup:**

The two Ethernet radios shall have identical Ethernet IP addresses.

##### **4.14.6.2 Router Mode Setup:**

The two radios shall have identical Ethernet IP and RF IP addresses. The two radios shall have identical neighbor tables. When a new remote units shall be added to a field, both the current radio and the backup radio shall update their neighbor tables.

#### **4.14.7 BASE STATION WEB MANAGEMENT**

Status monitoring shall be possible from any browser-equipped computer, either locally or remotely. A password-protected shall be used.

Both the configuration parameters and operating firmware shall be possible to updated remotely, even over the RF network itself, using the webpages..

#### **4.1.14.8 Navigating the Network Management System**

The Web Interface shall be subdivided in two frames: the left frame shall allow the user to navigate the main menu, while the right main frame shall display the selected page.

#### **4.14.9 Main Menu**

Base Station's homepage shall allow the user access to Controller Settings, Radio Settings, Diagnostics, Routing Table, System Monitor Settings/Statistics, User Port and Firmware Updates. User shall be able to do as a minimum the following functions:

- Cancel operation
- Save
- Refresh
- Rest unit



## **SECTION- 6 SUPPORT SERVICES**

### **Training**

This section describes general requirements that apply to all training courses. The Contractor shall submit the training proposal along with the bid. The training content, schedule and location shall be finalised during project execution. This section also describes the project's spares and maintenance (FMS) requirements.

#### **1.0 General**

- (a) Training will be conducted by Contractors personnel, who are experienced instructors and speak understandable English.
- (b) All necessary training materials shall be provided by the Contractor. Each trainee shall receive individual copies of all technical manuals and all other documents used for training.
- (c) Class materials, including the documents sent before the training courses as well as class handouts, shall become the property of owner. Employer/owner reserves the right to copy such materials, but for in-house training and use only.
- (d) Hands-on training shall utilize equipment similar to that being supplied under the contract.
- (e) For all training courses, the travel and per-diem expenses will be borne by the owner.
- (f) The Contractor shall quote training prices under project management cost. & shall be included in the bid
- (g) The schedule, location, and detailed contents of each course will be finalized during employer and Contractor discussions shortly after placement of the award. The Consultant/Employer shall review and approve the contents of the overview training prior to the start of the training.

#### **1.1 Training Course Requirements**

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Employer's training course requirements are described below in terms of the contents of each course to be provided. Training shall be provided on actual database for the application software course and the associate training courses.

#### **1.1.1 Database, Display Building & Report generation Course**

The database and display building course shall be the first course to be given in the overall training sequence. It shall be a hands-on course using the hardware and software to be supplied by the contractor. The course shall be designed to train owner personnel in how to develop the databases, displays, reports, and logs for the offered system.

Course objectives shall include:

- (a) How to set up a database & display development system
- (b) How to identify database fields, entries, records, tables, and contents
- (c) How to structure RTU /FRTU table definitions
- (d) How to build tables, arrays, and report formats and displays.
- (e) How to perform database maintenance
- (f) How to generate the database from source information
- (g) How to maintain symbol libraries, display colour groups, and display string lists.

On course completion, all participants shall be able to prepare the necessary input data to define the system operating environment, build the system database and displays, and prepare the database administrator to maintain and modify the database and its structures.

#### **1.1.2 Computer System Hardware & Software Course**

The computer system hardware & Software course shall be offered, at the system level only. The training course shall be designed to give owner hardware & software personnel sufficient knowledge of the overall design and operation of the system so that they can correct obvious problems, configure the hardware, perform preventive maintenance, run diagnostic programs. The following subjects shall be covered:

- (a) System Hardware Overview: Configuration of the system hardware.
- (b) Operating System: Including the user aspects of the operating system, such as program loading and integrating procedures; scheduling, management service, and utility functions; and system expansion techniques and procedures
- (c) System Initialization and Fail over: Including design, theory of operation, and practice
- (d) Equipment Maintenance: Basic theory of operation, maintenance techniques and diagnostic procedures for each element of the computer system, e.g., processors, auxiliary memories, LANs, routers and printers. Configuration of all the hardware equipments.
- (e) Diagnostics: Including the execution of diagnostic procedures and the interpretation of diagnostic outputs,
- (f) System Expansion: Techniques and procedures to expand and add equipment such as loggers, monitors, and communication channels.
- (g) System Maintenance: Theory of operation and maintenance of the hardware configuration, fail over of redundant hardware etc.
- (h) Operational Training: Practical training on preventive and corrective maintenance of all equipment, including use of testing tools.

### **1.1.3 Application Software Course**

The Contractor shall provide training on Application software courses covering all applications other than those already covered above. The training shall include:

- (a) Overview: Block diagrams of the application software and data flows. Programming standards and program interface conventions.
- (b) Application Functions: Overview of Functional capabilities, design, and algorithms. Associated maintenance and expansion techniques.
- (c) System Programming: An introduction to software architecture, Effect of tuning parameters (OS software, Network software, database software and Application Software etc.) on the

performance of the system. Administration of Database (both real-time and RDBMS),

- (d) Software Documentation: Orientation in the organization and use of system software and Application software documentation.
- (e) Hands-on Training: shall be provided with allocated computer time for trainee performance of unstructured exercises and with the course instructor available for assistance as necessary.

#### **1.1.4 RTU/FRTU Course**

The Contractor shall provide an RTU/FRTU course that covers the following subjects as a minimum:

- (a) Theory of operation of all RTU/FRTU functions
- (b) Operational procedures for various modes of operation, including diagnostic tests and interpretation of the associated test results
- (c) Implementing and maintaining multiple communication ports
- (d) Converting an RTU/FRTU from one protocol to a different protocol
- (e) Demonstration of complete RTU/FRTU test set use, including test set connection and set up for all possible modes of operation, all operational procedures, the exercise of each command or feature associated with each mode of operation, the interpretation of results, and how to use the test set to diagnose and isolate RTU problems
- (f) Disconnection and replacement of all RTU/FRTU equipment, including all modules within the RTU/FRTU

#### **1.1.5 Operator Training Course**

This training course shall provide training to Owner's operators on SCADA/DMS and Billing & Customer Care Systems so that operators can manage the system effectively.

The training shall include:

- (a) System Overview: Configuration of the system, a functional overview, and an overview of system capabilities and performance.
- (b) General Operating Procedures: Hierarchical structure of displays, display capabilities and features, user procedures, log-on and user access restrictions, and error messages.
- (c) System Applications: Theory of operation, capabilities, and operating procedures for each application function.
- (d) Handling of Equipment: Minor maintenance operations, such as removal of stuck paper in printers etc., which do not require spares/specialised skills.
- (e) Operator Documentation: Orientation in the organization and application of all user documentation for Operator and verification of the information contained therein.

The course shall focus on hands-on training on the system. The trainees shall perform instructor-defined procedures with the help of the dispatcher documentation. In addition there shall be training for Instructor to use DTS.

#### **1.1.6 Communication System Training:**

The training shall focus on critical aspects associated with installation, testing & commissioning of fibre optic system, radio. Leased network equipment is however, responsibility of service provider & contractor who has signed SLA with utility, but required level of knowledge for troubleshooting, upkeeping the equipment will be required. This shall include the state-of-the art techniques employed in laying, splicing & testing of fibre optic cable & terminal equipments etc. The owner's personnel shall be trained in such a way that the basic maintenance of terminal equipments & cable etc. can be carried out effectively.

#### **1.1.7 Auxiliary Power Supply Training**

The training shall cover various aspects covering installation, testing & commissioning of DC power supply, & UPS system. Proper emphasis of the training shall be for effective operation & maintenance of Auxiliary Power Supply System on routine/emergency basis by the owner's personnel.

## **SECTION- 6 SUPPORT SERVICES**

### **FMS**

This section describes general requirements describes the project's spares and maintenance requirements.

#### **2.0 INTRODUCTION**

The Contractor shall be required to provide the services through Facility Management Service provider so as to manage SCADA / DMS system including all equipments, installations including hardware, software & networks installed & commissioned by Contractor for the utility in order that they meet the availability requirement as specified in the document.

System Management Services shall be provided by FMS Contractor in order that maximum uptime & performance levels of SCADA systems installed are ensured. As such, FMS Contractor is expected to provide services as per ITIL (IT Infrastructure Library) standards with performance levels meeting or exceeding those mentioned in Service Level Agreement (SLA) agreed between utility & Contractor.

To achieve the desired Service Levels, the Contractor may need to interact, coordinate and collaborate with the other Service Providers as required. The Contractor will act as the Single Point of Contact for all issues relating to the Service Levels. The Contractor will have the responsibility to deal with the other vendors (during warranty period) /other vendors as selected by utility (after warranty period) as the case maybe, to provide the services at agreed service levels. However, the prime responsibility of providing desired services shall be that of lead Contractor during warranty period. The role of FMS Contractor shall start immediately after systems are installed, commissioned and handed over to the owner after Operational acceptance of the SCADA/DMS System.

#### **2.1 SCOPE OF WORK**

The Scope of Work shall include the software and hardware maintenance support to be provided by the Contractor in respect of the system supplied under this project during five year Facility Management Services (FMS) period alongwith Supervision & Operationalizing five year warranty of the SCADA/DMS System after the Operational Acceptance of the SCADA/DMS System.

The maintenance of the SCADA-DMS System under FMS period shall be comprehensive, as set forth herein, in nature and would broadly include but not be limited to diagnosis and rectification of the hardware and software failures. The Scope also includes:

- Co-ordination with equipment supplier for Repair/ replacement of defective equipments

- Configuration of the replaced hardware/software, periodic routine checking as part of a preventive maintenance program (as described in further detail in this document) which would include checking of functionality of hardware and software,
- Services to bring up any or all SCADA-DMS systems upon its failure and to restore the functioning of SCADA-DMS system including Control Centres etc. .
- Database sizing and CFE card addition for new RTUs/FRTUs
- The support for the RTU's /FRTUs
- All Software modules under the SCADA-DMS System and the associated Hardware supplied under this project .

Routine works like database building, addition of analog and status points and other such day-to-day operational activity would primarily be the responsibility of Utility and in case of any difficulty in this regard the same shall be referred to the Contractor for support. Contractor

### **2.1.1 Hours of Cover**

The Contractor's on-site support standard hours of service the timings for Emergency Software Support would be 24 hours a day, 7 days a week throughout the year( i.e. 24x365). At least three Engineers including Site Manager alongwith One on-site support personnel for Hardware and one on-site personnel for Software shall be deployed at each control center. The support personnel so deployed shall be qualified personnel having experience in the delivered SCADA/DMS system. The Contractor shall submit the CV's of all such personnel to Utility for approval before deployment at site.

The Contractor shall be responsible for 24\*7\*365 management of all the systems as per scope of work with services rendered at least as per Service Level Agreement between utility & Contractor. The Scope does not include management of physical security for access to the said facilities, The following facilities will be provided at the start of contract to FMS Contractor by Utility for carrying out the FMS responsibilities:

- Appropriately secured lockable storage/setup area
- Sufficient Sitting/office space in neat & clean environment
- PC (other communication facilities like P&T telephone & internet facility are to be arranged by FMS Contractor)

## **2.1.2 Essence of the Agreement**

The essence of the Agreement (to be entered) is to provide FMS for the designated hardware and software, with the goal of meeting the Availability as set forth herein and to provide system tuning and configuration to accommodate a growing system.

### **2.1.2.1 SERVICE DELIVERY MANAGEMENT**

FMS Contractor shall provide detailed description for service delivery management for the complete project including transition plan and deliverables and project management methodology.

#### **a. Project Management**

FMS Contractor will assign a Project Manager for the entire State who will provide the management interface facility and has the responsibility for managing the complete service delivery during the contractual arrangement between utility and the FMS Contractor. Project Manager will be responsible for preparation and delivery of all monthly/weekly reports as well as all invoicing relating to the service being delivered. Project Manager's responsibilities should essentially cover the following:

- Overall responsibility for delivery of the Statement of Work/s (SOW) and Service Level Agreement (SLA).
- Act as a primary interface to Utility for all matters that can affect the baseline, schedule and cost of the services project.
- Maintain project communications through Utility's Project Leader.
- Provide strategic and tactical recommendations in relation to technology related issues
- Provide escalation to FMS Contractor's senior management if required
- Resolve deviations from the phased project plan.
- Conduct regularly scheduled project status meetings.
- Review and administer the Project Change Control Procedure with utility Project Leader.
- Identify and resolve problems and issues together with utility Project Leader.
- Responsible for preparation and delivery of all monthly reports as well as all invoicing relating to the services being delivered

#### **b. Transition Management**

During initial two weeks viz. initial period of taking over by FMS Contractor after completion of all installation & commissioning jobs by consortium members, FMS Contractor shall provide minimum agreeable services. Formal SLA shall be enforced only after initial transition period.



### **c. Install, Moves, Adds, Changes (IMAC) Services**

This Service provides for the scheduling and performance of install, move, adds, and change activities for Hardware and Software. Definitions of these components are as follows:

- i. **Install:** Installation of desktop machines/workstations, servers, peripheral equipment, and network-attached peripheral equipment, which form part of the existing SCADA/DMS System (new equipment needs to be procured by the Utility).
- ii. **Move:** Movement of desktop machines/workstations, servers, peripheral equipment, and network-attached peripheral equipment.
- iii. **Add:** Installation of additional hardware /software after initial delivery
- iv. **Change:** Upgrade to or modification of existing hardware or software on desktop/workstations and servers etc.

Requests for IMAC shall be prepared by FMS Contractor depending on customer/ system requirements & shall be approved by utility. Utility shall formulate guidelines for IMAC & communicate it to FMS Contractor. All procurements shall be done by utility.

### **d. Contractor Management Services**

As part of this activity , for efficient and effective warranty implementation, the FMS Contractor's team will:

- 1. Manage the vendors for escalations on support
- 2. Logging calls and co-ordination with Contractors
- 3. Contractor SLA tracking
- 4. Management of assets sent for repair
- 5. Maintain database of the various vendors with details like contact person, Tel. Nos., response time and resolution time commitments. Log calls with vendors, Coordinate and follow up with the vendors and get the necessary items exchanged.
- 6. Analyze the performance of the Contractors periodically (Quarterly basis)
- 7. Provide MIS to utility regarding tenure of completion of warranty/AMC with outside vendors for software, hardware & networks maintenance in order that utility may take necessary action for renewal of warranty/AMC. FMS Contractor shall also provide MIS regarding performance of said Contractors during existing warranty/AMC.
- 8. Since during initial five years, warranty is in scope of OEM vendors there will be no AMC for SCADA/DMS system. During such period, FMS Contractor has to interact with such vendors for maintenance services and spares. After warranty period, if required Utility can award the suitable AMC

and FMS Contractor has to interact with Contractors as selected by utility for providing AMC for the said system on mutually agreed terms & conditions.

#### **e) FMS Contractor's Responsibilities**

1. Provide a single-point-of-contact for responding to Utility's queries or accepting its problem management requests. **FMS Contractor's** specialist will respond to utility's initial request within agreed service level objectives set forth.
2. Monitor availability & Escalate to service provider and Notify Utility for communication failures.
3. Review the service levels of the service provider (as per pre-defined schedules on SLA performance) along with utility.
4. Provide network availability incident reports severity wise to utility in a format mutually agreed.
5. Provide SLA performance management report of the Service Provider.
6. **Fault Detection and Notification** : The Contractor shall diagnose problems that could arise as part of the LAN/WAN network. These include connectivity problems due to failures in communication transport links, routing configuration points, or from software bugs etc.
7. **Fault Isolation and Resolution** : All faults that have been identified need to be isolated and rectified appropriately. The resolution measures undertaken by the Contractor and results produced accordingly shall be documented in the report.
8. **Carrier Coordination** : Carrier Coordination implies providing a single point of contact to resolve network related problems involving carrier circuits, whether equipment or circuit related. When a problem is diagnosed because of a WAN circuit, the Contractor must coordinate with the corresponding carrier to test and restore the circuit. The Contractor must take the responsibility and ensure that the problem is resolved.
9. **Hardware/Software Maintenance and Monitoring**: This would include problem determination, configuration issues, and hardware and software fault reporting and resolution. All such issues would need to be recorded and rectified.
10. **24x7 Network Monitoring and reporting**: The Contractor shall monitor the network on a continuous basis using the NMS and submit reports on a monthly basis with instances from the NMS system. System performance is to be monitored independently by the Contractor and a monthly report mentioning Service up time etc. is to be submitted to Utility. The report shall include:
  - Network configuration changes

- Network Performance Management including bandwidth availability and Bandwidth utilization
  - Network uptime
  - Link uptime
  - Network equipment health check report
  - Resource utilization and Faults in network
  - Link wise Latency report (both one way and round trip) times.
- o Historical reporting for generation of on-demand and scheduled reports of Business Service related metrics with capabilities for customization of the report presentation.
- o Generate SLA violation alarms to notify whenever an agreement is violated or is in danger of being violated.
- o Any other reports/format other than the above mentioned reports required by utility

#### **f) Backup/Restore management**

FMS Contractor will perform backup and restore management in accordance with mutually FMS Contractor shall ensure:

1. Backup and restore of data in accordance to defined process / procedure.
2. 24 x 7 support for database restoration requests
3. Maintenance and Upgrade of infrastructure and/or software as and when needed.
4. Performance analysis of infrastructure and rework of backup schedule for optimum utilization.
5. Generation and publishing of backup reports periodically.
6. Maintaining inventory of onsite tapes.
7. Forecasting tape requirements for backup.
8. Ensuring failed backups are restarted and completed successfully within the backup cycle.
9. Monitor and enhance the performance of scheduled backups
10. Real-time monitoring, log maintenance and reporting of backup status on a regular basis.
11. Management of storage environment to maintain performance at optimum levels.
12. Periodic Restoration Testing of the Backup
13. Periodic Browsing of the Backup Media
14. Management of the storage solution including, but not limited to, management of space, volume, RAID configuration, configuration and management of disk array etc.,
15. Interacting with Process Owners in developing / maintaining Backup & Restoration Policies / Procedures
16. To provide MIS reports as per agreement

#### **g) Restoration of Control Centre in case of Failure**

The FMS Contractor shall ensure that all the relevant data is transferred from control centre at regular frequency to Data Recovery Centre (DR) which is required for restoration of Control Centre in case of complete failure of Control centre. The FMS Contractor shall carry out system build in order to build the SCADA/DMS system at Control centre from scratch utilizing DR Centre.

#### **h) Performance Monitoring & Reporting**

- Regularly monitor and maintain a log of the performance monitoring of servers including but not limited to monitoring CPU, disk space, memory utilization, I/O utilization, Central Storage etc.
- Regular analysis of events and logs generated in all the sub systems including but not limited to servers, operating systems, databases, applications etc. The system administrators shall also ensure that the logs are backed up and truncated at regular intervals.
- The administrators shall undertake actions in accordance with the results of the log analysis to ensure that the bottlenecks in the infrastructure are identified and fine-tuning is done for optimal performance
- Reporting to utility for all system performance monitoring

The Contractor must adhere to well-defined processes and procedures to deliver consistent quality services throughout its contractual period. Any hardware/software to meet the requirements under this section must be provided by the Contractor. The Contractor is expected to have the following system management controls in place:

#### **i) AVAILABILITY MANAGEMENT**

- a. The Contractor must define the processes/procedures which ensure the service delivery as per the required SLAs or exceed it. It should cover various equipments such as all the servers, networks, switches, routers, Modems & other site specific services, and the critical services and their supporting hardware, and software components, as defined in scope of work. Industry standard SLA management tools should be deployed and shall have following essential features:
- b. Ability to create an escalation for an SLA.
- c. Ability to workflow the SLAs.
- d. Ability to create new action types, if needed.
- e. Ability to define sets of actions that are grouped together in a specific sequence.
- f. Ability to associate an escalation point with one or more actions through the action group.

ii) **PERFORMANCE MANAGEMENT**

The recording, monitoring, measuring, analyzing, reporting, and forecasting of current levels, potential bottlenecks, and enhancements of performance characteristics for the services, networks, applications, system software, and equipment within the scope shall be required. System tuning and optimization is an inherent part of this contract. Where warranted, the Contractor will utilize capacity management data in combination with performance management data to identify ways to improve performance levels of the resources, extend their useful life, and request utility to approve revisions/upgrades to the computing and communications hardware, software and other equipments such that higher levels of performance of the resources are obtained.

iii) **SECURITY MANAGEMENT**

The protection from unauthorized usage, detection of intrusions, reporting as required and proactive prevention actions are to be provided by the Contractor.

## **2.2 Support Services**

### **2.2.1 Emergency Support**

The severity levels are defined under clause [2.3](#) of this chapter . Emergency Support for Severity 1 issues are to be provided 24 hours a day, seven days a week. The on-call support team shall include all key technical competencies so that any aspect of a system failure can be attended. The team comprise of experienced technical staff that are skilled in troubleshooting SCADA / DMS systems. Severity 1 problems shall be reported by telephone for rapid response; target response times are defined in clause [2.5](#). The Contractor shall **submit the process details** to meet the above requirements along with the offer. For severity 1 problems, the key objective is to restore the system to an operational state as quickly as possible, including by a temporary workaround. Resolution of the defect may be completed during standard hours.

Severity 2, 3, and 4 problems shall be reported by Utility through a call tracking system to be provided by the Contractor. The Emergency Support service goal is to meet the availability targets greater than specified in this document (minimum 99% for Overall SCADA/DMS System). Resolution of problems may also be provided by an individual fix that will be installed by the Contractor at no extra cost to Utility.

#### **2.2.2 Monitoring**

The Contractor shall conduct the following monitoring, for the supplied SCADA/DMS System .

### 2.2.2.1 Error Log Monitoring

To monitor the performance of SCADA/DMS system on a bi-weekly basis, the Contractor shall review the following, analyse the results, and communicate to Utility:

- System logs for a selected day
- System history log
- Aggregate data collection
- Events Collection

During monitoring if any defect is found, the Contractor shall undertake corrective action for the same. The Contractor shall **submit the process details** to meet the above along with the offer

### 2.2.2.2 Resource Monitoring

Resource Monitoring services comprises checking the system's major node resources, gather log data, analyse results, and advise Utility on the appropriate actions to be taken and undertake any agreed upon actions. A tool will be created to continuously collect the following information:

- CPU loading (Peak and Average)
- System error log
- Disk utilization (Peak and Average)
- Operating system error reports
- LAN utilization (Peak and Average)
- Bandwidth utilisation
- Memory utilisation (Peak and Average)

The Contractor shall submit the procedures details to meet the above along with the offer.

### 2.2.3 Support for System expansion

New RTUs, RMUs & FPIs etc per year are likely to be added to match the growing Power system. The services to be provided by the Contractor will include the Communication Front End (CFE) port/card addition/expansion, database resizing, interface addition in CFE and support for integration conforming to the IEC standards / existing application. This would not include the cost of equipments/card required for expansion.

## 2.3 Problem Severity Levels

The problems will be categorized as follows:

Category	Definition
Severity 1 – Urgent	Complete system failure, severe system instability, loss or failure of any major subsystem or system component such as to cause a significant adverse impact to system availability, performance, or operational capability (as described at 2.3.1).
Severity 2 – Serious	Degradation of services or critical functions such as to negatively impact system operation. Failure of any redundant system component such that the normal redundancy is lost (as described at 2.3.1. Non-availability of Man-power at control centre during working hours
Severity 3 – Minor	Any other system defect, failure, or unexpected operation (as described at 2.3.1.
Severity 4 – General/Technical Help	Request for information, technical configuration assistance, “how to” guidance, and enhancement requests. (as described at <a href="#">2.3.1</a> .

The details of the system under different severity level are as below:-

### 2.3.1 Severity of the system under different Severity level.

#### a) Severity-1 (Urgent support)

This support is required when there is a complete system failure, severe system instability, the loss/ failure of any major sub-system / system or its components, which may significantly impact the system availability, performance, or operational capability at Control centre. For example, loss of data to the operator due to any problem in SCADA-DMS system, loss of ICCP system (software/Hardware related), Loss/failure of DR Centre, outages of both the CFEs attributable to any software/hardware related problem, outage of any important software functionality (on both the servers) which is required to disperse Distribution management functions, , Failure of both GPS clock and time synchronization and outage of both routers, failure of both LAN system, outage of both main and backup servers of any system, firewall would be included under this category. Initially Utility's Engineers shall attempt to restore the system. In case the system does not come up and/or the problem is not resolved then Utility's Engineer shall intimate the problem to the Contractor. Upon receiving intimation, the representative of the Contractor would immediately attend to the problem and if required, any other authorized representative the

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Contractor may log on to the system. The problem shall be attended by the Contractor at the earliest, within the response/Resolution time as specified in the Agreement. The Contractor shall take all steps to restore the SCADA functionality at the earliest to avoid data loss.

#### **b) Severity-2**

The support services not defined under Severity-1 are included under this category. Failure of one SCADA/DMS/FEP Server/ICCP server, failure of VPS , Stoppage of data collections for archiving, real time calculations, failure in Acquisition of SOE at the respective Control-Centre, outage of Real Time Network and distribution applications, and other applications are included in this category. Coverage under this severity would be outages that do not immediately cause on feeder data loss but subsequently could result into Severity-1 category outage, loss of an important subsystem that may affect the day-to-day works and loss of archived data. Failure of any redundant system component affecting the critical redundancy like loss of any one Application Processor, Router, CFE would also be included in this category. Non-availability of Man-power at control centre during working hours will also be covered under this category.

#### **c) Severity-3 (Standard support)**

The support services included under this category are when the outage or loss of functionality is neither an emergency nor a priority functionality as indicated in severity level 1 or 2 above. Problems like database reworking, failure of any one workstation, etc. would be covered under this Severity.

#### **d) Severity-4 (General Technical Help)**

Request for information, technical configuration assistance, “how to” guidance, and enhancement requests are included under this category.

### **2.4 Problem/Defect Reporting Procedure**

The Contractor shall propose an appropriate problem/defect reporting procedure to meet the requirement of all severity level cases along with the offer.

### **2.5 Response and Resolution Time**

This clause describes the target times within which the Contractor should respond to support requests for each category of severity. The *Initial Response Time* is defined

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as the period between the initial receipt of the support request (through approved communications channels) and the acknowledgment of the Contractor. The *Action Resolution Time* is the period between the initial response and the Contractor delivering a solution. This period includes investigation time and consideration of alternative courses of action to remedy the situation. The *Action* is defined as a direct solution or a workaround.

Except for Severity Level 1, all hours and days specified are working hours only.

#### **2.5.1 Emergency Support Response/Resolution Time**

Severity	Initial Response Time	Action Resolution Time	Action
1	30 minutes	2 hours	An urgent or emergency situation requiring continuous attention from necessary support staff until system operation is restored – may be by workaround.
2	1 day	2 days	Attempt to find a solution acceptable to Utility/ Employer as quickly as practical. Resolution time is dependent on reproducibility, ability to gather data, and Utility prioritisation. Resolution may be by workaround.
3	2 days	5 days	Evaluation and action plan. Resolution time is dependent on reproducibility, ability to gather data, and Utility prioritisation. Resolution may be by workaround.
4	2 days	10 days	Report on the problem/query is to be furnished.

**The Contractor shall submit the detailed format/procedure for all the activities such as Reporting time, Resolution time, Downtime etc. along with the offer.**

#### **2.6 Preventive Maintenance**

The Contractor shall undertake preventive maintenance of all equipment/modules (i.e. Hardware & Software supplied under the SCADA/DMS System), under the scope of this contract, in accordance with this section. The Contractor will prepare the report as per periodicity defined below and submit the same to the Engineer-in-charge.

**i) Activities shall include but not limited to:**

- (a) Patch Management for OS and Application Software
- (b) Automatic update of Antivirus and firewall signatures on daily basis.
- (c) Average and peak usage of CPU, LAN, Memory and Disk –once every month .
- (d) Monitoring of machine with reference to error reports and logs - once every week
- (e) Online diagnostics for servers and workstations - once every 3 months.
- (f) Connection test of LAN cables for identifying potential loose contacts in machines, hubs and routers - once every 3 months.
- (g) Physical hardware checks to ensure proper working of cooling fans etc.- once every 3 months.
- (h) Physical inspection to check the machines and the panels for rat droppings, lizards or other vermin - once every 3 months,
- (i) Cleaning and blowing for removal of dust from Servers , Workstations, CFE panels and RTUs/FRTUs etc.- once every 3 months.

**ii) Exclusions:**

- a) Maintaining dust free environment and protection from rodents and vermin is the responsibility of Utility.
- b) Regular cleaning of computer furniture and surroundings is the responsibility of Utility.

Equipment shutdown during preventive maintenance shall be deemed as available.

## **2.7 Availability and Payment charges Calculation**

It is the endeavour of both the Contractor and Utility to maximize system availability to the extent possible. The Contractor shall provide guaranteed availability for various types of Severity levels as specified in clause [2.3](#) above. The non-availability hours for availability calculation may be reckoned from the end of the allowed Action Resolution time. A standardized register shall be maintained at each site containing full details of each outages, actions taken by Utility to correct the problem, applicable

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Severity level, time of reporting to the Contractor support engineer/support centers pursuant to the appropriate methods in the Agreement, allowed Response time as per the Response times defined in clause [2.5](#), actual Resolution time, and signature of Engineer-in-charge as well as the Contractor's support engineer of the site. Duration of outages over and above the Action Resolution time in each of the Severity levels shall be counted for the non-availability computation and shall be clearly brought out in the register. The resolution may be accomplished by a work around, and such solution shall mark the end of non-availability. In the event of multiple failures at a site, due to a common cause, the first FPR (Field Problem, Report) logged shall be used for the purpose of availability calculation. However, simultaneous multiple outages due to unrelated cause would be counted separately

### **2.7.1 Availability computation for SCADA-DMS System**

Availability would be on per quarter basis. The formula to be used for availability computation would be as under:

$$\text{Availability per quarter (per site)} = \frac{\text{THQ} - (S1 \times 1 + S2 \times 0.4 + S3 \times 0.1)}{\text{THQ}} \times 100\%$$

Where THQ is total hours in the quarter

S1 is the total non-available hours in Severity Level-1

S2 is the total non-available hours in Severity Level-2

S3 is the total non-available hours in Severity Level -3

### **2.7.2 Payment of maintenance charges (based on SCADA-DMS System availability)**

In the event of availability below a certain level, the maintenance charges would be proportionately reduced as follows:

#### **For overall system availability**

Availability per quarter	Deduction as % of the apportioned price of total FMS for SCADA-DMS portion of the contract applicable for that site
≥ 99%	NIL
Less than 99%	Deduction of 2% of the apportioned price of the apportioned

	quarterly AMC for every 1% or part there of decrease in availability under 99%.
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**For individual hardware & non critical functions**

<b>Availability per quarter</b>	<b>Deduction as % of the apportioned price of total FMS for SCADA-DMS portion of the contract applicable for that site</b>
$\geq 98\%$	NIL
Less than 98%	Deduction of 2% of the apportioned price of the apportioned quarterly AMC for every 1% or part there of decrease in availability under 98%.

While calculating Availability following shall be considered :

The Overall SCADA/DMS System shall be considered as available if

- a) All SCADA applications are available
- b) All DMS applications are available
- c) All SCADA/DMS functions described in the specification are executed at periodicities specified in the specification. without degradation in the response times
- d) Requests from available Operator Consoles & VPS are processed
- e) Information Storage and Retrieval applications are available
- f) Data exchange with other system is available
- g) One of the redundant hardware is available so that all the SCADA/DMS applications are functional to ensure the design & performance requirement as envisaged in the MTS

Further, Non-Availability of RTU/Data Concentrators/FRTUs/FPI/R-APDRP-IT System shall not be considered for calculating Overall SCADA/DMS System Availability.

However each device, including RTU, FRTU & Servers etc. shall individually exhibit a minimum availability of 98%. Further, the non-availability of following Non-Critical functions shall not be considered for calculations of SCADA/DMS 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

**2.7.3** The computation of Availability / Non-availability would be rounded up to 2 decimal places at each Contract Co-ordination Site on quarterly basis and any deduction in the maintenance charges thereof would be calculated as stated above in Clause [2.7.2](#) on pro-rata basis.

## **2.8 The Contractor's Obligations**

- 2.8.1** In order to optimise and improve the response of the system, the Contractor may re-install the program modules after making the Utility engineer aware of the consequence (like data loss, database rebuild etc).
- 2.8.2** Any modification of software/Operating System required to restore functionality due to hardware upgrades, patches, or arising out of a necessity to fix FPRs, would be done by the Contractor at no extra cost to Utility . Also, any software updates/upgrades released till the completion of warranty period /AMC shall be provided and installed & commissioned free of cost as per instructions from Utility.
- 2.8.3** The Contractor shall ensure that all components (Hardware & Software) covered under five years comprehensive on-site warranty are maintained in good working condition and in case of any defect , timely replacement/repair shall be carried out so as to meet the availability requirements specified herein.
- 2.8.4** The Contractor will submit FSR (Field Service Report) and the steps taken to solve the problem, along with details of code changes.

## **2.9 Responsibilities of Utility**

- i) utility will ensure the availability of competent staff appropriately trained in the administration and use of existing SCADA/DMS systems for proper operation of the system.
- ii) Utility shall ensure that proper Environmental conditions are maintained for the system.
- iii) Utility shall ensure that the System is kept and operated in a proper and prudent manner and only trained Utility employees (or persons under their supervision) are allowed to operate the system.
- iv) Utility shall provide access to the sites of installation for purposes of providing Support Services.

- v) Utility shall provide the Contractor with Office and storage space for their maintenance staff and spares.

## 2.10 Responsibility Matrix

The table in this clause provides a summary definition of the roles and responsibilities of the Contractor and Utility.

- Legend: ● This indicates who has primary responsibility to perform this function.  
A This indicates who will provide assistance.

Item	Task	Utility / Employer	Contractor
0.0	PROBLEM IDENTIFICATION		
0.1	Root cause analysis to determine whether the fault is attributable to Hardware or Software.	A	●
0.2	Resolution of problems involving third party maintainer where there is uncertainty whether the root cause is hardware or software.	A	●
1.0	SOFTWARE PROBLEM RESOLUTION		
1.1	Report problem and assist with problem identification	A	●
1.2	Provide or recommend corrections, temporary patches, workarounds or other fixes to system problems		●
1.3	Install and test corrections, temporary patches, workarounds or other fixes to system problems	A	●
2.0	ROUTINE SOFTWARE SUPPORT		
2.1	Build and maintain database, displays and reports	●	A
2.2	Perform system back-ups	A	●
2.3	Restore or reinstall software from back-ups	A	●
2.4	Monitor system logs (part of remote monitoring service)	A	●
2.5	Maintain system logs	A	●
2.6	Maintain user accounts	●	A
3.0	HARDWARE PROBLEM RESOLUTION		
3.1	Report problem and assist with defining problem	●	A
3.2	Troubleshoot problem to diagnose if it is software-related or hardware-related	A	●
3.3	Identify failed component, Replace failed components in online system using parts from spares inventory	A	●
3.4	Restore operation of repaired/replaced equipment	A	●
4.0	HARDWARE SPARE PARTS		
4.1	Manage local spares inventory	A	●
4.2	Provide appropriate facility for local storage of spares	●	
4.3	Replenish local spares inventory	A	●
5.0	Integration and database work		

5.1	CFE Card addition/Expansion	A	●
5.2	Database resizing	A	●

The contractor shall be responsible for all the maintenance of the system till the operational acceptance. The consumables and spares wherever required for maintaining the system shall be provided by the contractor till operational acceptance of the system. The consumable items shall include but not be limited to (a) VPS lamps (b) printer paper (c) Printer toner, ink, ribbons and cartridges (d) Special cleaning material

## **SECTION - 7**

### **PROJECT MANAGEMENT, QUALITY ASSURANCE AND DOCUMENTATION**

This section describes the project management, schedule, quality assurance, and documentation requirements for the project.

#### **7.1 Project Management**

The Contractor shall assign a project manager with the authority to make commitments and decisions that are binding on the Contractor. Employer will designate a project manager to coordinate all employer project activities. All communications between employer and the Contractor shall be coordinated through the project managers. The project managers shall also be responsible for all communications between other members of the project staffs.

Bidder shall submit the manpower deployment plan along with the bids, describing the key roles of each persons.

#### **7.2 Project Schedule**

The project implementation schedule shall be not exceed 8 months from the date of award. Based upon this schedule the bidder shall submit a preliminary implementation plan along with the bid. The detail project implementation schedule shall be submitted by the contractor after award for employer's approval, which shall include at least the following activities:

- (a) Site Survey
- (b) Documents submission and approval schedule
- (c) Factory & Site Testing Schedule
- (d) Database development schedule
- (e) Hardware purchase & Manufacturing, Software development & integration schedule
- (f) Despatch Schedule
- (g) Installation / commissioning schedule
- (h) Training schedule

The project schedule shall include the estimated period for completion of and its linkage with other activities.

##### **7.2.1 Progress Report:**

A progress report shall be prepared by the Contractor each month against the activities listed in the project schedule. The report shall be made available to employer on a monthly basis, e.g., the 10th of each month. The progress report shall include all the completed, ongoing and scheduled activities.

#### **7.3 Transmittals**

Every document, letter, progress report, change order, and any other written transmissions exchanged between the Contractor and employer shall be assigned a unique transmittal number. The Contractor shall maintain a correspondence index and assign transmittal numbers



consecutively for all Contractor documents. Employer will maintain a similar correspondence numbering scheme identifying documents and correspondence that employer initiates.

## **7.4 Quality Assurance & Testing**

All materials and parts of the system / sub-system to be supplied under the project shall be of current manufacture from a supplier regularly engaged in the production of such equipment.

### **7.4.1 Quality Assurance and Quality Control Program**

The Contractor shall maintain a Quality Assurance/Quality Control (QA/QC) program that provides that equipment, materials and services under this specification whether manufactured, designed or performed within the Contractor's plant, in the field, or at any sub-contractor source shall be controlled at all points necessary to assure conformance to contractual requirements. The program shall provide for prevention and ready detection of discrepancies and for timely and positive corrective action. The Contractor shall make objective evidence of quality conformance readily available to the Owner. Instructions and records for quality assurance shall be controlled and maintained at the system levels. The Contractor shall describe his QA/QC program in the Technical Proposal, (along with samples from his QA/QC manual) and shall submit his QA/QC Manual for review and acceptance by the Owner.

Such QA/QC program shall be outlined by the Contractor and shall be finally accepted by Owner after discussions before the award of Contract. A Quality Assurance Program of the Contractor shall generally cover but not be limited to the following:

- a. The organization structure for the management and implementation of the proposed Quality Assurance Program.
- b. Documentation control system.
- c. Qualification data for key personnel.
- d. The procedure for purchase of materials, parts/components and selection of sub-contractor's services including vendor analysis, source inspection, incoming raw material inspection, verification of material purchases, etc.
- e. System for shop manufacturing including process controls.
- f. Control of non-conforming items and system for corrective action.
- g. Control of calibration and testing of measuring and testing equipments.
- h. Inspection and test procedure for manufacture.
- i. System for indication and appraisal of inspection status.
- j. System for quality audits.
- k. System for authorizing release of manufactured product to utility.

- l. System for maintenance of records.
- m. System for handling, storage and delivery.
- n. A Quality Plan detailing out the specific quality control procedure adopted for controlling the quality characteristics of the product.

The Quality Plan shall be mutually discussed and approved by the employer after incorporating necessary corrections by the Contractor as may be required.

Neither the enforcement of QA/QC procedures nor the correction of work mandated by those procedures shall be cause for an excusable delay. An effective Quality Assurance and Quality Control organization shall be maintained by the Contractor for at least the duration of this Contract. The personnel performing QA/QC functions shall have well-defined responsibility, authority, and organizational freedom to identify and evaluate quality problems and to initiate, recommend, or provide solutions during all phases of the Contract. The QA/QC organization of the Contractor shall be an independent administrative and functional structure reporting via its manager to the Contractor's top management. The QA/QC manager(s) shall have the authority within the delegated areas of responsibility to resolve all matters pertaining to quality to the satisfaction of employer when actual quality deviates from that stated in the Work Statement.

The Contractor shall be required to submit all the Quality Assurance Documents as stipulated in the Quality Plan at the time of employer's inspection of equipment/materials.

The employer or his duly authorized representative reserves the right to carry out Quality Audit and Quality Surveillance of the systems and procedures of the Contractor's/his vendor's Quality Management and Control Activities.

The scope of the duties of the employer, pursuant to the Contract, will include but not be limited to the following:

- (a) Review of all the Contractor's drawings, engineering data etc.
- (b) Witness or authorize his representative to witness tests at the manufacturer's works or at site, or at any place where work is performed under the Contract.
- (c) Inspect, accept or reject any equipment, material and work under the Contract in accordance with the specifications.
- (d) Issue certificate of acceptance and/or progressive payment and final payment certificate
- (e) Review and suggest modification and improvement in completion schedules from time to time; and
- (f) Monitor the Quality Assurance program implementation at all stages of the works.

#### **7.4.2 Inspection**

The Contractor shall give the employer/Inspector two weeks in case of domestic supplies and six weeks in case of foreign supplies written notice of any material being ready for testing. Such tests shall be to the Contractor's account except for the expenses of the Inspector. The employer/Inspector, unless witnessing of the tests is waived, will attend such tests on the scheduled date for which employer/Inspector has been so notified or on a mutually agreed alternative date. If employer/Inspector fails to attend the testing on the mutually agreed date, Contractor may proceed with the test which shall be deemed to have been made in the Inspector's presence and Contractor shall forthwith forward to the Inspector, duly certified copies of the test results in triplicate.

The employer/Inspector shall, within fourteen (14) days from the date of inspection as defined herein, give notice in writing to the Contractor of any objection to any drawings and all or any equipment and workmanship which in his opinion is not in accordance with the Contract. The Contractor shall give due consideration to such objections and shall make the modifications that may be necessary to meet said objections. When the factory tests have been completed at the Contractor's or Sub-contractor's works, the employer/Inspector shall issue a certificate to this effect within fourteen (14) days after completion of tests but if the tests are not witnessed by the employer/Inspector, the certificate shall be issued within fourteen (14) days of receipt of the Contractor's Test Certificate by the Employer/Inspector. The completion of these tests or the issue of the certificates shall not bind the employer to accept the equipment should it, on further tests after erection, be found not to comply with the Contract.

In cases where the Contract provides for tests, whether at the premises or works of the Contractor or of any Sub-contractor, the Contractor except where otherwise specified shall provide free of charge items such as labour, materials, electricity, fuel, water stores, apparatus and instruments, as may be reasonably demanded by the employer/Inspector or his authorized representative to carry out effectively such tests of the equipment in accordance with the Contract and shall provide facilities to the employer/Inspector or his authorized representative to accomplish testing.

The inspection by Employer and issue of Inspection Certificate thereon, shall in no way limit the liabilities and responsibilities of the Contractor in respect of the agreed Quality Assurance Program forming a part of the Contract.

The Contractor shall keep the Employer informed in advance of the time of starting of the progress of manufacture of material in its various stages so that arrangements can be made for inspection.

Record of routine test reports shall be maintained by the Contractor at his works for periodic inspection by the Employer's representative.

Certificates of manufacturing tests shall be maintained by the Contractor and produced for verification as and when desired by the Employer. No material shall be dispatched from its point of manufacture until it has been satisfactorily inspected and tested. Testing shall always be carried out while the inspection may be waived off by the Employer in writing only.

However, such inspection by the Employer's representative(s) shall not relieve the Contractor

from the responsibility for furnishing material, software, and equipment to conform to the requirements of the Contract; nor invalidate any claim which the Employer may make because of defective or unsatisfactory material, software or equipment.

Access to the Contractor's facilities while manufacturing and testing are taking place, and to any facility where hardware/software is being produced for Employer shall be available to Employer representatives. The Contractor shall provide to Employer representatives sufficient facilities, equipment, and documentation necessary to complete all inspections and to verify that the equipment is being fabricated and maintained in accordance with the Specification. Inspection rights shall apply to the Contractor's facilities and to subcontractor facilities where equipment is being manufactured.

Inspections will be performed by Employer, which will include visual examination of hardware, enclosure cable dressings, and equipment and cable labeling. Contractor documentation will also be examined to verify that it adequately identifies and describes all wiring, hardware and spare parts. Access to inspect the Contractor's hardware quality assurance standards, procedures, and records that are applicable to the facilities shall be provided to Employer.

#### **7.4.3 Inspection and Test**

All materials furnished and all work performed under this Specification shall be inspected and tested. Deliverables shall not be shipped until all required inspections and tests have been completed, all deficiencies have been corrected to Employer's satisfaction, and the equipment has been approved for shipment by Employer.

Should any inspections or tests indicate that specific hardware, software or documentation does not meet the Specification requirements, the appropriate items shall be replaced, upgraded, or added by the Contractor as necessary to correct the noted deficiencies. After correction of a deficiency, all necessary retests shall be performed to verify the effectiveness of the corrective action.

The test shall be considered complete when (a) when all variances have been resolved (b) all the test records have been submitted (c) Employer acknowledges in writing the successful completion of the test.

##### **7.4.3.1 Test Plans & Procedures**

Test plans for both factory and field tests shall be provided by the Contractor to ensure that each test is comprehensive and verifies all the features of the equipment are tested. The test plans for factory and field tests shall be submitted for Employer approval before the start of testing.

The contractor shall prepare detail testing procedure in line to specification and submit for employer's approval. The procedure shall be modular to the extent possible, which shall facilitate the completion of the testing in the least possible time.

##### **7.4.3.2 Test Records**

The complete record of all factory and field acceptance tests results shall be maintained by the Contractor. The records shall be maintained in a logical form and shall contain all the relevant

information. The test reports shall be signed by the testing engineer and the engineer witnessing the tests.

#### **7.4.3.3 Reporting of variances**

A variance report shall be prepared by either Employer or Contractor personnel each time a deviation from specification requirements is detected during inspection or testing. All such variances shall be closed in mutually agreed manner.

However, at any stage if employer feels that quality of variances calls for suspension of the testing the testing shall be halted till satisfactory resolution of variances, which may involve retesting also.

#### **7.4.3.4 Factory Test**

The factory tests shall be conducted on all the equipments and shall include, but not be limited to the following, appropriate to the equipment being tested:

- (a) Verification of all functional characteristics and requirements specified
- (b) Inspection and verification of all construction, wiring, labeling, documentation and completeness of the hardware

Before the start of factory testing, the Contractor shall verify that all changes applicable to the equipment have been implemented. As a part of the factory tests, unstructured testing shall be performed for SCADA/DMS system to allow Employer representatives to verify proper operation of the equipment under conditions not specifically tested in the above structured performance test. The Contractor's test representative shall be present and the Contractor's technical staff members shall be available for consultation with Employer personnel during unstructured test periods. All special test facilities used during the structured performance test shall be made available for Employer's use during unstructured testing.

Unless otherwise specified in the relevant sections of the specification & except for SCADA/DMS Hardware , Software, RTUs , the sampling size for FAT ( ) is 10% and incase any selected sample fails during the test, the failed samples shall be rejected and 20% of the samples from the balance quantity shall be tested. If any failures are observed, the entire lot shall be rejected.

#### **7.4.3.5 Field Performance Test**

After the equipment has been installed, the Contractor shall start up and check the performance of the equipment of field locations. All hardware shall be aligned and adjusted, interfaces to all inputs and outputs installed, operation verified, and all test readings recorded in accordance with the Contractor's recommended procedures. The field performance test shall exhibit generally all functions of the equipment and duplicate factory test. All variances must be corrected prior to the start of the field performance test. The list of final tests to be carried out in the field shall be listed in the site-testing document in line to the requirements specified in the relevant sections of this volume.

### **7.5 Type Testing**

The equipment being supplied shall conform to type tests as per technical specification and shall be subjected to routine tests in accordance with requirements stipulated under respective sections. The type test shall be conducted on the equipment if it is specifically mentioned in the relevant section, for other equipment the type test report shall be submitted. Employer reserves the right to witness any or all the type tests. The Contractor shall intimate the Employer the detailed program about the tests at least three (3) weeks in advance in case of domestic supplies & six (6) weeks in advance in case of foreign supplies.

The reports for all type tests as per technical specification shall be furnished by the Contractor along with equipment / material drawings. The type tests conducted earlier should have either been conducted in accredited laboratory (accredited based on ISO / IEC Guide 25 / 17025 or EN 45001 by the national accreditation body viz NABL / of the country where laboratory is located) or witnessed by the representative(s) of Utility. However, type test reports shall not more than 5 year old than the date of bid opening

In the event of any discrepancy in the test reports i.e. any test report not acceptable due to any design / manufacturing changes or due to non-compliance with the requirement stipulated in the Technical Specification or the type test(s) not carried out, same shall be carried out without any additional cost implication to the Employer.

In case of failure during any type test, the Supplier at his own expenses shall modify the equipment and repeat all type tests successfully at his own cost and within the project time schedule.

Wherever, the make of the items is indicated in the technical specification, the type test reports are not required to be submitted for the makes, indicated in the specification. For the new makes (other than those indicated in the technical specification), type test reports as per relevant standard shall be submitted for Employer's approval.

## **7.6 Documentation**

To ensure that the proposed systems conform to the specific provisions and general intent of the Specification, the Contractor shall submit documentation describing the systems to employer for review and approval. Further the contractor shall also submit the drawings/documents for all the hardware & software required for site installation, testing and commissioning and thereafter operation of the system. The contractor shall obtain approval of employer for the relevant document at each stage before proceeding for manufacturing, system development, factory testing, site testing, training etc. The schedule for submission/approval of each document shall be finalised during the discussions before placement of the contract, this schedule shall be in line to overall project schedule.

Each document shall be identified by a Contractor document number, the employer document number, and the employer purchase order number. Where a document is revised for any reason, each revision shall be indicated by a number, date, and description in a revision block along with an indication of official approval by the Contractor's project manager. Each revision of a document shall highlight all changes made since the previous revision.

The contractor shall submit two copies of each document/drawing for employer's review and approval. After approval five sets of all the documents shall be submitted as final documentation, however, for site specific documents two sets of documents shall be provided for each site. Any changes observed during field implementation shall be incorporated in the

as-build drawing and required sets of the same shall be submitted to employer/owner. In addition to paper copies all the documents shall also be provided on electronic media in two copies. In case any documentation requirement is specified in the relevant section the same shall apply for the equipment /system defined in that section. The contractor shall also supply five sets of User manuals/guides/O&M manuals/manufacture's catalogues for all the hardware & software supplied under the contract which shall be in addition to the one set each at all the locations where the System has been installed. The user manual shall at minimum include the principle of operation, block diagrams, troubleshooting and diagnostic and maintenance procedures. Considering all the components of the project briefly the following documents/drawings shall be required under the project.

- (a) System Description Documents (Overview)
- (b) Data Requirement sheets
- (c) Software Requirements Specification
- (d) Data base Documents
- (e) Drawings/Documents for manufacturing/Assembly of the equipment/system
- (f) Drawings/Documents for installation of the equipment/system at site
- (g) Software description/design documents for each software module
- (h) Testing Procedures and reports
- (i) Manuals for each equipment/hardware/test equipment
- (j) Bill of Quantities
- (k) Site Testing documents
- (l) Training documents
- (m) System Administrator Documents
- (n) User guide for Despatcher

However, all the above type of documents may not be required for each sub-system of the project e.g. item (n) above may not be required for auxiliary power supply system, therefore, the contractor shall submit a comprehensive list of the document as applicable for the offered system for employer's approval immediately after signing of the contract and the documents shall be finalised as per the approved list. In regard to Data requirement sheets (DRS) for these will be duly filled in by the bidder & submitted along with the bid. During detailed engineering, contractor will be required to submit detailed DRS to include all technical parameters of the equipment to ensure that the offered equipment meets all the technical specification requirements

## **SECTION 8**

### **A ) DESIGN PARAMETERS AND PERFORMANCE TABLES**

The SCADA/DMS system shall be designed as per the technical parameters defined in the specification and the tables specified here. The SCADA/DMS system (such as databases, network elements etc.) shall be sized to accommodate the requirement mentioned in table 7.

The system shall be tested with the doubled present power system size (ultimate capacity ) as defined in table 7 & measure the various performance of the system as defined in the tables and technical specification including peak and average load scenarios.

The auxiliary memory utilisation , average CPU, RAM & LAN utilisation parameters shall not exceed the limits as defined in table 8. This memory utilisation includes the memory used for storage of data for the defined duration as specified in the various sections of technical specification.

The SCADA/DMS system shall be suitable for addition of atleast double the operator workstations (in future) without requiring any up gradation of the servers.

The SCADA/DMS system design & performance parameters are defined in the following tables:

TABLE 1 - DESIGN PARAMETERS FOR SCADA FUNCTIONS

TABLE 2 - DESIGN PARAMETERS FOR ISR FUNCTIONS

TABLE 3 - DESIGN PARAMETERS FOR DMS FUNCTIONS

TABLE 4 - MAINTENANCE ACTIVITIES

TABLE 5- DESIGN PARAMETERS FOR USER INTERFACE

TABLE 6 - CONFIGURATION CHARACTERISTICS & AVAILABILITY FUNCTIONS

TABLE 7 - POWER SYSTEM SIZE

TABLE 8- OTHER PERFORMANCE REQUIREMENTS AND  
ACTIVITIES FOR NORMAL AND PEAK LEVEL OF LOADING



**TABLE 1 – DESIGN PARAMETERS FOR SCADA FUNCTIONS**

Note ; The parameters which are not indicated in the tables & only mentioned elsewhere in the specification shall also be considered as design parameters

Ref. Section	Function Description	Design capacity	Execution rate
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Ref. Section	Function Description	Design capacity	Execution rate
<b>1.2.2.1</b>	<b>Data Acquisition from RTU</b>	As per specification	
	a) Status data	All status points	<ul style="list-style-type: none"> <li>By exception, updated &amp; displayed within 4sec from data collection from RTU at S/s 6 sec from data collection from FRTU/ FPI</li> <li>Integrity check of all status at every 10 Minutes ( configurable )</li> <li>On demand</li> </ul>
	b) Analog data	All analog points	<ul style="list-style-type: none"> <li>By exception, updated &amp; displayed within 5 sec &amp; 10sec</li> <li>Integrity check for all analog at every 10 Minutes (configurable)</li> <li>provision for all analog update at periodicity of 10 sec configurable upto 1 hour.</li> <li>Energy values periodically configurable from 5 min to 24 hours</li> <li>On demand</li> </ul> <p>The time skew at SCADA/DMS control centre ,S/S , RMU,FPI shall not be more than 0.1sec at each location &amp; latency shall not be more than 0.5sec for status. For analog data the time skew shall not be more than 1sec &amp; latency shall not be more than 1sec for analog as per IEEE C37.1.</p> <p>Energy values of 15 minute blocks shall be collected periodically from the RTU, FRTU at scan rate of 15 minute/1 hour (configurable upto 24 hours). Alternatively, the energy values shall be calculated for each 15 minute/1 hour blocks at SCADA level from the acquired energy values of MFTs through RTU &amp; FRTU.</p>
<b>1.2.3</b>	<b>Time synchronisation of RTU</b>	All RTUs shall be synchronised from Master station	every 5 Minutes (Configurable from 5-60 minutes)

Ref. Section	Function Description	Design capacity	Execution rate
<b>1.2.4 ,1.3 sub section</b>	<b>SCADA/DMS Data Exchange with other system as specified (R-APDRP system)</b>	As per specification	A/R for ISR function & data exchange
<b>1.2.5</b>	<b>Data Processing</b>		
<b>1.2.5.1</b>	<b>Analog data processing:</b>		
	a) Conversion to engineering units	Per analog points	Each time the value is received in SCADA
	b) Zero dead band processing	Per analog points	Each time the value is received in SCADA
	c) Reasonability Limit checking	High and Low reasonability limits per analog point	Each time the value is received in SCADA
	d) Limit Monitoring (Operational, Alarm and Emergency limits)	High and Low for each of the limits per analog point	Each time the value is received in SCADA
	e) RATE OF CHANGE	per analog point	Each time the value is received in SCADA
	f) Sign conventions	per analog point	Each time the value is received in SCADA
	g) Accumulator processing	Accumulator points	Each time the value is received in SCADA
<b>1.2.5.3</b>	<b>Calculated Data Processing:</b>		
	- Arguments for analog calculations	32	Each time the value is received in SCADA
	- Arguments for status calculations	32	Each time the value is received in SCADA
	- No. of calculated data ( Min / Max with time stamp and Average)	3 X no. of analog point for max /min/avg and 1x no. of max/min/avg for other calculations	Min/Max /Average calculation for each 5 min duration
<b>1.2.5.2</b>	<b>Digital Input data processing</b>	<b>As per specification</b>	<b>As per specification</b>
<b>1.2.5.4</b>	<b>Substation Topology Processing</b>	For no. of status, refer RTU/FRTU/FPI point counts in the technical specification. within 1 sec response after updation in SCADA database	Triggered by status change.
<b>1.2.5.5</b>	<b>Alternate source of data</b>	For all status , analog telemetered parameters	Each time the value is received in SCADA
<b>1.2.5.6</b>	<b>Quality codes</b>	<b>As per specification</b>	Each time value is received by SCADA

Ref. Section	Function Description	Design capacity	Execution rate
1.2.6	<b>Continuous Real time data storage &amp; Playback</b>	a) Atleast 2 days storage for all tele-measurands	a) Each time the value is received from RTU in SCADA database
		b) Playback of stored data for selected time period of 1 to 10 minutes	b) playback sampling rate configurable in Second/ minutes
1.2.7	<b>Sequence-of-Events data</b>	1000 events circular buffer in the SCADA database	SOE retrieval Periodically (5 minutes) or by exception and On demand
1.2.9	<b>Supervisory Control</b>		
	a) Control Inhibit Tag Types	4	(a) (b) (c) On demand by Dispatcher/DMS function initiated
	b) Control inhibit Tags Per D	4	(d) Each time supervisory control is requested
	c) Control Action Monitor	10 timer periods (1 to 60 sec)	
	d) Control permissive	For all control points	
1.2.10	<b>Failsoft capability</b>	Critical functions	in the event of system crosses mark of peak loading requirements through graceful degradation of non - critical functions & also relaxing periodicity / update rate of display refresh & critical functions by 50%..

**TABLE 2 – DESIGN PARAMETERS FOR ISR FUNCTIONS**

<b>Reference section</b>	<b>Function Description</b>	<b>Design capacity</b>	<b>Execution rate</b>	<b>Response time</b>
<b>1.3.1</b>	<b>Circuit breaker status table</b>	Data as per spec for all CBs	Updation on change in CB status or any of the associated information	2 sec after updation in SCADA database
		b) data storage On Auxiliary memory	b) 2 months retention	
<b>1.3.2</b>	<b>Data Snapshot table</b>	a) Volume of data = Total telemetered status and analog points and max/min with time stamp and average for each analog point with quality codes	a) Snapshot - 5 minutes periodicity	
		b) data storage On Auxiliary memory	b) 2 months retention	
<b>1.3.3</b>	<b>Hourly data table</b>	a) Volume of data = Total telemetered points and max/min with time stamp and average for each analog point with quality code	a) Hourly	
		b) data storage On Auxiliary memory	b) 2 months retention	
<b>1.3.3</b>	<b>Hourly Energy data table/Missed hourly data table</b>	a) Volume of data = Export/Import KWh & Export/Import KVARh for all energy meters with quality code	a) Energy values of 15 minute blocks of each Hour	
		b) data storage On Auxiliary memory	b) 2 months retention	
<b>1.3.4</b>	<b>Daily Energy data table</b>	Volume of data = Export/Import KWh & Export/Import KVARh for all energy meters with quality code	a) Energy values of 15 minute blocks of each Hour	

Reference section	Function Description	Design capacity	Execution rate	Response time
		b) data storage On Auxiliary memory	b) 2 months retention	
1.3.5	Load priority table	Data as per spec for all CBs	On demand by Billing system Under R-APDRP IT implementation. Besides load priority shall be possible to assign locally in SCADA/DMS system .	
1.3.6	SOE data table	daily 4 changes per SOE point	Each time the SOE is received from RTU/FRTU/FPI in SCADA database	
1.3.7	Data exchange with Billing system Under R-APDRP IT implementation	a) Daily Energy values of specified hour b) Load priority table	a) Daily & on demand b) On demand by SCADA or change in priorities by Billing system Under R-APDRP IT implementation	a) 30 sec
1.38	Data Exchange with Customer Care System _under R-APDRP IT implementation	Circuit breaker status table	By exception & On demand by CCS	30 sec
1.3.9	Data Exchange with GIS System under R-APDRP IT implementation	Data of electrical network	On user request/validation	
1.3..10	Historical information data retrieval	Retrieval of all stored data	On demand	
1.3.11	System message Log Storage	a) 20,000 entries /month		
		b) data storage On Auxiliary memory	b) 2 months retention	
1.3.12	Mass storage of data file	As per spec		
1.4	DR function	As per spec	As per spec	
DATA EXCHANGE REQUIREMENTS WITH SLDC SHALL BE DEFINED BY UTILITY AS PER EXISTING SLDC SYSTEM CONDITIONS				

TABLE 3 - DESIGN PARAMETERS FOR DMS FUNCTIONS

Reference section	Name	Design capacity	Execution rate	Response time
2.2	<b>NETWORK MODEL</b>	One model with atleast 10 possible islands. Islands may be formed dynamically.. All electrical components mentioned in the spec		
2.3	<b>NETWORK CONNECTIVITY ANALYSIS (NCA)</b>	Complete network		
	2) Real time mode		- - Event driven	2sec
	b) Study mode		- On demand	2sec
2.4	State estimation	Complete network	On change	Complete network
2.5	<b>LOAD FLOW APPLICATION (LFA)</b>	Complete network		
	a) Real time mode		- periodic (10 minutes) - On demand by user/application - Event driven	5sec
	b) Study mode		On demand	5 sec
2.6	Voltage/VAR Control	All tap changers & cap bank	On change	5sec
2.7	<b>LOAD SHED APPLICATION (LSA)</b>	Complete network		
	a) Manual mode		a) On demand	a) 30sec (for analysis)

Reference section	Name	Design capacity	Execution rate	Response time
	b) Auto mode		b1) On scheduled time (Time of day) b2) Event driven (Frequency threshold)	b) 30 sec (for analysis)
2.8	<b>FAULT MANAGEMENT &amp; SYSTEM RESTORATION (FMSR)</b>	Atleast two simultaneous faults in the network shall be supported & Complete network		30 sec
	Manual mode		On demand	
	Auto mode Generation of switching plans		Event driven	
	Prefault configuration mode		On demand	
2.9	<b>LOSS MINIMISATION VIA FEEDER RECONFIGURATION</b> Generation of switching plans (Manual & Auto mode)	Complete network	-Periodic (15 minutes) -On demand	30 sec
2.10	<b>LOAD BALANCING VIA FEEDER RECONFIGURATION</b> Generation of switching plans Manual & Auto mode	Complete network	-Event driven -periodic (15 minutes)	30sec
2.11	Distribution Load Forecasting	Complete network	Periodic & on demand	30 sec
2.12	<b>Operations Monitor</b>	Complete network	change in devices status	5 sec
2.13	<b>DTS (Also refer specification clause 2.13)</b>	Complete Network	Replica of SCADA/DMS	Same response



**Table - 4**

**Maintenance activities**

Action	Performance
Complete database regeneration	2 hours
Complete system software build, including operating system, applications, and databases	6 hours
Software build of all applications and databases	3 hours
Software build of a single applications and databases	10 minutes
Installation of a single, new display including distribution to all consoles	60 seconds
Reinstallation of all displays	60 minutes
Perform an on-line update of a database parameter and propagation of the change to the source data	60 seconds

**TABLE 5 - DESIGN PARAMETERS FOR USER INTERFACE**

Reference section	Name	Design capacity	Execution rate
3.1&3.2	<b>SCADA/EMS SYSTEM ACCESS SECURITY</b>		
	Function and Data Access Security Operating jurisdictions	16	
3.3	<b>Windows Environment</b>		
	Rooms	32	
	Layers	8	
	Declutter Levels	16	
	Panning and Zooming	supported	
3.5.5	<b>TREND</b>		
	a) Trend files	10	
	b) Variables per trend file	4	

Reference section	Name	Design capacity	Execution rate
	c) Samples per trend variable	5,000	
	d) Sampling rate	Configurable from 5 sec to 15 minutes	
<b>3.6</b>	<b>ALARMS</b>		Triggered by event
	Alarm priority levels	16	
	Alarm Message Recording on auxiliary memory - alarms	2months	
<b>3.7</b>	<b>EVENTS</b>		
	Event Message Recording on Auxiliary memory - events	2months	

TABLE 6 - CONFIGURATION CHARACTERSTICS & AVAILABILITY FUNCTIONS

Reference Section	Name	Execution Rate	Maximum Response Time (With in )
<b>6.6</b>	CONFIGURATION CHARACTERISTICS AND AVAILABILITY		
	Backup Databases Data backup	60 seconds or event driven	5 seconds
<b>6.8</b>	Processor Errors Processor failure detection		10 seconds
	Device Errors Device failure detection		10 seconds
<b>6.10</b>	Processor Redundancy and Configuration Management		
	Function Restart Other functions except ISR ISR		30 seconds 120 seconds
<b>6.11</b>	Processor Start-Up <i>with applications functional</i> 1) Hot Start		1) Not more than failover time

Reference Section	Name	Execution Rate	Maximum Response Time (With in )
	2) Warm Start a) all applications  3) Cold Start a) Application except ISR operational b) ISR application		2) 10 minutes a) 15 minutes  3) 15 minutes a) 20 Minutes b) 60 Minutes
6.12	Device/Processor Failover		30 seconds from detection of failure

**TABLE 7- POWER SYSTEM SIZE**

#### **POWER DISTRIBUTION SYSTEM SIZING**

AS PER ATTACHED NETWORK DIAGRAMS -

Note Control system hardware & software shall be equipped & sized for for double the size of the above

1.

S.no	System	Present	Ultimate
1.	Primary S/S		
2.	RMU		
3.	FPI		
4.	Power transformer		
5.	Distribution transformer		
6.	Feeders		
7.	Bus bars		
8.	Capbanks		
9.	OLTCs		
10.	Switchable breakers		
11.	Switchable isolators/swirtches		
12.	sectionizer		
13.	MFTs		
14.	Meters		
15.	Any other network parameter		

**Table 8- PERFORMANCE REQUIREMENTS**

**(a) USER INTERFACE REQUIREMENTS**

At no time the SCADA/DMS system shall delay the acceptance of User request or lockout console operations due to the processing of application functions.

User interface requirements	Response time (Peak loading )
Requests for call-up of displays shall be acknowledged with an indication of request is being processed	Within 2 sec
Any real time display and application display (except RDBMS DB displays) on workstation console, Complete display & data values shall appear on screen	Within 3 sec after acknowledgement of request
Manual Data entry of the new value shall appear on screen	Within 2 sec
Display update rate	Every 2 sec for at least 4 displays together
Panning of a world display from one end of screen to other end of screen in a continuous manner	Within 2sec
Supervisory control action shall be completed with result displayed on the screen	Within (2sec + scan time + communication delay time +field device operation time)
Alarm and event response time	display within 1 sec of receipt in SCADA/DMS system
Alarm and event acknowledgement	With in 2 sec
Requests for printing of displays shall be acknowledged with an indication of request is being processed	Within 2 sec
Requests for generation of reports shall be acknowledged with an indication of request is being processed	Within 2 sec

**(b) UTILISATION**

**(Considering double the present power system size )**

Name	Average Utilization	Comments
PROCESSOR UTILIZATION		
Servers	30%	Normal loading
	50%	Peak loading
Communication Front end/ ICCP server	30%	Normal Loading
	67%	Peak loading
LOCAL AREA NETWORKS		
Uncontrolled Access	15%	Normal loading

Name	Average Utilization	Comments
(e.g., Ethernet)	20%	Peak loading
Controlled Access (e.g., token-ring)	40%	Normal loading
Memory	40%	Peak loading
Main memory utilisation (avg)	50%	Normal loading
	67%	Peak loading
Auxiliary memory utilisation	50%	

**Table 8c- ACTIVITIES FOR NORMAL AND PEAK LEVEL OF LOADING**

(Considering double the present power system size )

**(1) NORMAL LEVEL OF ACTIVITY**

The normal level of activity shall simulate system activities spread over one hour period. During the testing, the response times and the average utilizations shall not exceed the specified values. The following conditions define normal level of system activity to generate the normal loading scenario. Test simulation shall be done using software tool to generate this loading within 1 hr . Staggering of loads during the test duration of 1 hour is permitted.

- (a) All RTU/FRTU/FPI data shall be scanned and processed as specified in the Specification.
- (b) All data exchange with other systems shall occur as specified in the Specification.
- (c) All periodic functions shall be executed at the rates defined in tables
- (d) The following SCADA/DMS functions shall be executed on-demand:

Function	Number of demand executions
Substation topology processor	50 state changes
Sequence-of-Events data	50 SOE points reported
All DMS applications	4 on-demand per DMS application

- (e) Alarms (2 X no. of RTUs +FRTU+FPI ) per hour shall be generated. Each alarm shall be acknowledged individually within 5 seconds.
- (f) Events (2 X no. of RTUs +FRTU+FPI ) per hour shall be generated.

- (g) 1% analog of total analog/ 5sec measurements of total analog point count changes as per IEEE C37.1
- (h) One complete run of on-line diagnostics shall be performed on all computers
- (i) Communications channel monitoring shall be performed.
- (j) The following user interface actions shall be performed:

Display Selection	30 per operator workstation & VPS
Supervisory control actions	2 per RTU & 1 per 50 FRTUs
Display Updates	Each operator workstation shall display 3 updating and 1 non-updating display window per monitor. This also includes VPS. <b>Updating displays:</b> - alarm summary list - world display containing a S/S SLD - Network display <b>Non-updating displays:</b> - SCADA/DMS System Display
Data Entry	5 data entry actions from any single display
Display Trending	8 display trends, each trending 4 variables
Reports	Prepare and printing of 5 reports

- (k) The following maintenance activities shall be performed:

Function	Task
On-Line Database Editing	Modify 20 data points in each of the 5 RTUs
Display Generator and Management	Modify one single-line diagram one tabular display

## 2) PEAK LEVEL OF ACTIVITY

The peak level of activity is an addition to the average level of activity described in (A) NORMAL LEVEL OF ACTIVITY above. The peak level of activity shall be applied for a five minute period. During the next ten minutes, only the normal level of system activity shall be applied. This test shall be repeated for four consecutive fifteen minute periods, for a total peak level test time of one hour. The five-minute peak loading period shall coincide with SCADA/ DMS system period where all periodic software is scheduled for execution and at least one five minute period shall span an hour boundary to consider the scheduled hourly periodic activities. There shall be no restrictions on the period when the five-minute peak can occur.

The software execution rates and response times defined in tables of this section , shall not be degraded and the utilization defined in tables of this section shall not exceed during the peak loading conditions. The following conditions shall define the additional peak level of system activity:

- (a) As per IEEE C37.1
  - a. 15 % of status of total status points/ 5sec measurements
  - b. 40% analog of total analog measurements /5sec

50% of the alarms shall be acknowledged within the five-minute period (automatic acknowledgement is unacceptable).

- (c) Display Requests
  - 6 display requests per minute per console

- (d) Supervisory Control

Total 1 per RTU & 1 per 10/ FRTUs in four 5Minute period of peak loading cycles

- (e) DMS applications
  - 3 Network Connectivity Analysis

- (f) Reports
  - Prepare 5 reports.