

Section 3
Network Configuration and Equipment

Characteristics

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Section 3

Network Configuration and Equipment Characteristics

3.1 Introduction

This section describes the Fiber Optic Communication network configuration and the equipment characteristics for the communication system to be installed under the project. The sub-systems addressed within this section are:

- (1) Fiber Optic Transmission System (FOTS)
- (2) Termination Equipment Subsystems
- (3) Network Management System (NMS)
- (4) MDF, DDF and Cabling

The requirements described herein are applicable to and in support of network configurations depicted in Appendix and Network Management System (NMS) for monitoring and control of this communication network. TMN and NMS have been interchangeably used in this specification.

The security related requirements of the equipment shall be as per CEA (Cyber Security in Power Sector) Guidelines, 2021 and all similar security requirements as amended by CEA on time-to-time basis shall be followed/complied by the vendor at no additional cost to Employer till the implementation of the project.

The manufacturer shall allow the Employer and/or its designated agencies to inspect the hardware, software, design, development, manufacturing, facility and supply chain and subject all software to a security / threat check any time during the supplies of equipment.

The contractor shall ensure that the supplied equipments have been got tested as per relevant contemporary Indian or International Security Standards e.g. IT and IT related elements against ISO/IEC 15408 standards, for Information Security Management System against ISO 27001/2, Power Control Systems – Security Requirements against IS 16335, Cyber Security for Industrial Control Systems against IEC 62443-4 etc. from an authorized and certified agency/lab. These mentioned standards shall be current with all amendments, if any and in case any standard is superseded, the new standard shall be applicable.

The Contractor shall ensure that all the Communicable Intelligent Equipments are sourced from the list of the “Trusted Sources” as and when drawn by MoP/CEA. In case, for any Communicable Intelligent Devices, if no Trusted Source has been identified, the Contractor in compliance with the provisions made in MoP order dated 2.07.2020 and any other relevant MoP order shall get the product cyber tested for any

kind of embedded malware/Trojan/cyber threat and for adherence to Indian Standards at the designated lab.

The Contractor shall also ensure that the equipment supplied has all the contemporary security related features and features related to communication security as prescribed under relevant security standards. A list of features, equipments, software etc. supplied and implemented in the project shall be given for use by the Employer. The supplied Equipment/System shall be accompanied by a certificate from a certification body accredited to assess devices and process for conformance to IEC 62443-4 standards during design and manufacture.

The contractor shall get the Employer's network audited from a security point of view once in every year from a CERT-In Empanelled Cyber Security Auditor. The audit of the network shall be carried out once in a financial year till the maintenance service contract in the bid. Network forensics, Network hardening, Vulnerability Assessment, Network penetration test, Risk assessment, Actions to fix problems and to prevent such problems from reoccurring etc. shall be covered under network audit.

The Contractor shall ensure that all the documents, including software details are supplied to the Employer in English language. A record of all the software updating and changes shall be given to the Employer and any major updating and changes shall be done with the prior approval of the Employer.

During maintenance period the Contractor shall keep a record of all operation and maintenance procedure in the form of manual and shall also maintain a record of all command logs (actual command given, who gave the command, time & date and from where) for a period of 12 months. For the next 24 months the same information shall be stored/retained in a non-online mode. A list of all User ID linked with name and other details of the user duly certified by the Employer shall also be maintained.

A record of all supply chains of the products (hardware/software) shall be given to the Employer.

In case of any deliberate attempt for a security breach at the time of procurement or at a later stage after deployment/installation of the equipment or during maintenance, liability **may be dealt as per guidelines of CEA/Ministry of Power or any other Government department.**

3.2 General Network Characteristics

3.2.1 Description

The proposed fiber optic communication network shall support the voice & data communication requirements of RTUs, SCADA/EMS

system and other Power system operational requirements. The communication system shall provide data & voice connectivity across the various locations or connectivity of RTUs with Control Centers. The RTUs located at various locations will report to Control Center using IEC 60870-5-101 or IEC 60870-5-104 Protocol. The proposed communication system shall provide connectivity of RTUs over TCP/IP protocol using Ethernet interface and few other RTUs over serial interface. The offered communication System shall support the communication requirements of RTUs and the SCADA/DMS system described in point to multi point and/or multipoint to multipoint configurations using Ethernet over SDH

The fiber optic network shall be based on the Synchronous Digital Hierarchy (SDH) having bit rate of STM-4/ STM-16. The network shall consist of overhead fiber optic links with a minimum bit rate of Synchronous Transport Module-4/16. The tentative list of Fiber Optic links to be implemented under this package are given in Appendix-A of this volume. The Contractor can propose a system based on higher bit rate systems, if required, so as to meet the link budget requirements or any other specification requirement. The detailed BOQ is described in Price Schedules.

3.2.2 Functional Requirement

The primary function of the equipment is to provide a highly reliable voice and data communication system for grid operation in support of the SCADA/EMS, RTUs, Tele protection & PMUs and for new technological requirements of Power System Operation such as Special Protection Scheme, Grid Security Expert System, Load Management, Advanced Protection System & Substation Automation System. A brief summary of the communication system requirements is as follows:

- (a) High speed E1 channel support
- (b) 64kbps & nx64kbps data channel support
- (c) Low speed (300 -1200 bps) data channel support
- (d) Voice (2 wires, 4 wires) channel support and integration with Employer's/RLDC's EPABX system. The details of EPABX System shall be provided during detailed engineering.
- (e) Data transport supporting Network Management channels.
- (f) The connectivity envisaged between Substation and Control Centre over TCP-IP using Ethernet interface for various services of data and voice such as for PMUs, RTUs, VOIP etc..

3.2.3 General Systems Requirements

Required characteristics are defined and specified herein at the system level, subsystem level, and equipment level.

3.2.3.1 System Synchronization

The Contractor shall synchronize all the new equipments under the contract using GPS Clock. In addition to GPS input reference, the synchronization clock must have provision to take INPUT reference coming from other clock. All sync equipments proposed under this contract should meet ITU-T G.811 criterion. The holdover quality of slave clock, if any, shall meet ITU-T G.812 standard requirements.

The Contractor shall provide system wide synchronization fully distributed throughout the telecom network and connected to all equipments new & existing. The Contractor shall submit the synchronization plan for the entire network meeting the requirement of ITU-T G.803.

The system equipment requiring “clock” shall be connected to the master clock using external clocking. For this purpose, appropriate interfaces(s) in the transmission & termination equipment being supplied and all other associated hardware shall be provided by the Contractor.

3.2.3.2 System Maintainability

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 TMN control. Such testing shall not affect the functional operation of the system.

Preventive and problem-oriented maintenance of the communications system shall be performed using diagnostics tools such as TMN 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. The Contractor shall provide specialized training required to operate above mentioned diagnostic tools. For all redundant systems, disconnection and repair of any failed device shall not interrupt the operation of the system.

3.2.3.3 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 equipped subunits shall be terminated at appropriate patching facilities or termination blocks. Power supplies and TMN shall be sized for maximum equipped system capacity.

3.2.3.4 Equipment Availability

The Contractor shall ensure the availability for subscriber to subscriber where they are providing the new equipments (MUX/Drop-Insert) under this contract. The availability requirements are as follows, which shall be demonstrated at site for the equipments being provided under this contract:

- (1) The availability of each fiber optic link (E1 to E1) shall be at least 99.999%.
- (2) The availability of network end to end (E1 to E1) shall be at least 99.998%.
- (3) The average per link subscriber to subscriber availability shall be at least 99.97%. The per link subscriber to subscriber availability is defined as the availability between any two data or voice subscribers between RTU to reporting Control Centre and between control centres.
- (4) The network-wide subscriber to subscriber availability shall be at least 99.8% . The network-wide subscriber to subscriber availability is defined as the availability between any two data or voice subscribers on the wideband network.

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 down time of the fiber optic cable shall not be considered in the aforesaid availability calculations.

In order to ensure that the equipment & configuration proposed by the bidders shall be capable of demonstrating the specified availability figures it is required that the Bidders shall include in their proposal a calculated availability analysis for the proposed equipment/ sub system. The calculated failure rates of the units and the calculated availability of the equipment being offered shall be provided in the proposal. The analysis shall be based on an availability block diagram and shall include the mean-time- between failure (MTBF) and mean-time-to-repair (MTTR) of all of the components on the link. The Contractor shall indicate in the analysis the MTBF and MTTR and the resulting availability of each point-to-point link. For this analysis, an MTTR of at least 4 hours shall be assumed.

3.2.4 General Equipment Characteristics

All Contractor supplied equipment shall be new and of the finest production quality. The Employer 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 TMN equipment as specified in this Section.

3.2.4.1 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 the Employer, prior to the completion of the SAT.

All field modifications of the hardware, firmware and software that is required to meet installation and/or performance specifications, shall be fully documented as part of the deliverables, both as a separate field modification record and as corrected equipment/configuration documentation.

3.2.4.2 Equipment Capacities

Equipment supplied shall be sized and equipped with sufficient capacity to support BoQ and configuration requirements as identified in the appendices. Each subsystem supplied shall be sized (to be equipped as specified) to support full subsystem expansion.

Data communications channelization required to support the TMN subsystems specified in Technical Specifications (TS) are not identified in the appendices. Therefore, the Contractor is required to size and equip the system to include all channelization and channel cards required to support the TMN function.

3.2.4.3 Redundancy Requirements and Protection Schemes

Equipment redundancy and Automatic Protection Schemes (APS) are specified in the Table 3-1. The failure of one element shall not prevent the use of any other that has not failed.

Table 3-1
Equipment Redundancy Requirements
Summary

Fiber Optic transmission Equipment : SDH equipment Power Supply & Converters -----	 1:1 APS or distributed power
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**Table 3-1
Equipment Redundancy Requirements
Summary**

Common Control* Cards -----	supply 1:1 APS
DACS (Cross Connect) Power Supply -----	1:1 APS or distributed power supply
Common control* cards-----	1:1 APS
Drop/Insert Multiplexer Power Supply -----	1:1 APS or distributed power supply
* = Common control cards which are essentially required for operation of the equipment.	

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 Employer. The bidders shall provide details of protection schemes supported in the Bid document.

The offered equipment shall support automatic switchover function between the redundant modules and all required modules and hardware to support the automatic switchover shall be provided by the Contractor.

3.2.4.4 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 signal failure, shall be automatically cleared at the equipment, rack and monitoring levels and normal operation indications restored and reported if applicable.

3.2.4.5 Software Upgrades

The Contractor shall provide antivirus software along with all the computer hardware/software which shall be upgraded periodically till the maintenance services contract in the bid. Further, to meet all the specifications requirements during implementation and maintenance, if an upgrade in the hardware/software of supplied item is required, the same shall be done by the contractor without any additional cost to the Employer. All software and hardware shall support upgradation to MPLS-TP if required in future.

3.2.4.6 General Site Considerations

All fiber optic links upto 225 kms transmission line length for STM-16 and upto 250 kms transmission line length for STM-4 shall be implemented by the Contractor without repeaters. In order to meet the link budget requirement, the Contractor shall provide all the necessary equipments only in the end stations. The contractor may provide the optical amplifier, wavelength translator, optical cards or high capacity SDH equipment with suitable rack/subrack to meet the maximum distance limit. All the provided equipments shall be monitored by centralized NMS.

3.2.5 Fiber Optic Link Lengths

Tentative fiber optic link lengths are specified in appendices. The exact cable lengths shall be provided during detailed engineering. The same shall be used by the Contractor for final link design during the detailed engineering of the project as per the link budget criteria specified in the TS. In case of change in the specified BoQ, the contract price shall be adjusted accordingly.

3.3 Fiber Optic Transmission System

The Fiber Optic Transmission System (FOTS) is defined herein to include ETSI digital optical line termination equipment. The FOTS shall be based on SDH technology. The minimum aggregate bit rate shall be STM-4/16 equipped with E1 interface cards with minimum 16 interfaces (G.703) per card and Fast Ethernet interface card with minimum.

8 interface per card (IEEE 802.3/IEEE 802.3u) supporting layer 2 switching as tributaries. In addition, Gigabit Ethernet interface shall also be required as specified in the BPS. Ethernet shall support LCAS feature. It shall support full throughput upto 1000 Mbps on Ethernet port by virtual concatenation of requisite no. of VC-p12. There shall be the provision of "Auto Negotiation" and "Flow control" Enabling/disabling through NMS of the system. Also there shall be provision of configuring the equipment for unrestricted nxVC12 bandwidth (upto 1000Mbps). The Ethernet interfaces shall support VLAN (IEEE 802.1P/Q), spanning tree (IEEE 802.1D) quality of service. The protection scheme for Ethernet traffic should be ERPS based (Ethernet ring protection scheme) as per ITU-T G.8032.

All software and hardware shall support IPv4 and IPv6 simultaneously (dual stack).

The Contractor shall provide (supply and install) connectorised jumpers (patch cords) for FODP-to-equipment and equipment-to-equipment connection.

3.3.1 SDH Equipment

3.3.1.1 Functional Requirement

There is a requirement for different types of equipment under this project which are described in this section. The BOQ is provided in the Price Schedules. For the purpose of BOQ, the SDH Equipment is considered to be divided in three parts i.e. Optical interface/SFP, Tributary interfaces (Electrical tributaries such as E1, Fast Ethernet 10/100 Mbps, Gigabit Ethernet interface & Optical tributaries such as Gigabit Ethernet etc.) and Base Equipment (Consisting of Common Cards, Control Cards, Optical base card, Power supply cards, sub-rack, cabinet, other hardware and accessories required for installation of equipment i.e. everything besides optical interface/SFP and tributary cards).

If bidder is offering equipment with multifunction cards such as cross-connect or control card with optical interface/SFP or tributary interface, such type of multifunction card shall be considered as Common control card and shall be the part of base equipment. In case optical interface/SFP is embedded with control card, the adequate number of optical interface/SFPs shall be offered to meet the redundancy requirements of the specifications. Further, the main and protection channel shall be terminated on separate cards and there should be no single point of failure.

The equipment shall be configurable as Terminal Multiplexer (TM) as well as ADM with software settings only.

(i) STM-4 (MADM) with 3 MSP/5 MSP protected direction.

The aggregate interfaces shall be (at least) STM-4 towards at least three/five protected directions (Protected as specified in this specifications). At present the equipment shall be equipped with two (2) nos. E1 interface card with minimum 16 interfaces per card & two (2) nos. Fast Ethernet interface card with minimum 8 interfaces per card, as tributaries. The equipment shall provide non-blocking cross connect capability of 64 STM-1 (bi- directional) at high order VC-4 level and as well as at low order VC-12 level.

(ii) STM-16 (MADM) with 3 MSP/5 MSP protected direction.

The aggregate interfaces shall be (at least) STM-16 towards at least three/five protected directions (Protected as specified in this specifications). At present the equipment shall be equipped with two (2) nos. E1 interface card with minimum 16 interfaces per card & two (2) nos. Fast Ethernet interface card with minimum 8 interfaces per card, as tributaries. Gigabit Ethernet (optical/electrical) interface shall also be provided if specified in BPS. The equipment shall provide non blocking cross connect capability of 256 STM-1 (bi- directional) at high order VC-4 level and 128 STM-1 (bi-directional) at low order VC-12 level.

(iii) **Optical Interface/SFP to be implemented in the existing SDH equipment**

The bidder shall be required to provide only Optical Interface/SFP to be installed in the existing/third party SDH equipment at few locations. The bidder has to ensure compatibility of the supplied Optical Interface/SFP for the same.

3.3.1.2 Redundancy and Protection

Two fiber rings shall be implemented wherever the network permits. On linear sections of the network, protected links using 4 fibers shall be implemented.

3.3.1.3 Service Channel

Service channels shall be provided as a function of the SDH equipment and shall be equipped with Service Channel Muldem's that shall provide at a minimum: One voice channel (order wire) with analog interface (0.3 to 3.4 kHz)/VOIP and one data channel. There shall be a facility to extend the line system order-wire to any other system or exchange lines.

3.3.1.4 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, F2/Q2 interfaces for a local craftsperson terminal interface and remote equipment monitoring is required.

The Equipment shall support collection of at least four (4) external alarms for monitoring and control of station associated devices by the TMN.

3.3.1.5 Synchronisation

The equipment shall provide synchronization as per Table 3-2. One 2 MHz synchronization output from each equipment shall be provided.

3.3.1.6 Electrical and Optical I/O Characteristics and General Parameters

Table 3-2 provides the electrical and optical characteristics as well as other general parameters for SDH equipment.

Table 3-2 Electrical and Optical I/O Characteristics and General Parameters	
Optical Wavelength NOTE (1)	1310/1550nm
Optical Source NOTE (2)	Laser

Optical Source Lifespan	Better than 5 X10 ⁵ hours
Optical Fiber Type	G.652 D
Optical Connectors	Type FC-PC
Transmission Quality	Per ITU-T G.821, G.823, G.826
Source Primary Power	-48 Vdc
Equipment Specifications	Per ITU-T G.783
Tributary, Electrical Interface	Per ITU-T G.703, 75 Ω
Ethernet Interface	10/100 Mbps
SDH Bit Rates	Per ITU-T G.703
Optical Interfaces	Per ITU-T G.957, G.958
Frame and Multiplexing Structure for SDH	Per ITU-T G.707
Synchronization	Per ITU-T G.811, G.812, G.813, G.803
Management Functions	Per ITU-T G.774, G.784
Protection Architectures	Per ITU-T G.841
Built In Testing and Alarms	Per ITU-T G.774, G.783, G.784

- NOTE (1) Optical wavelength shall be selected considering the characteristics of the optical fiber 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) In case other than FC-PC connector is provided in the equipment, suitable patch cord with matching connector are to be provided to connect with FODP.

3.3.2 Optical Link Performance Requirements

The optical fiber link performance requirements are specified as follows:

3.3.2.1 Link Budget Calculations

The fiber optic link budget calculations shall be calculated based upon the following criteria:

- (1) Fiber attenuation: The fiber attenuation shall be taken to be the guaranteed maximum fiber attenuation i.e. 0.21 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 3 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 shall be considered and a similar margin shall be considered for optical amplifiers.

(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 2.5 dB/100Km 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 fiber dispersion shall be taken to be the guaranteed maximum dispersion i.e. 18 ps/nm.Km @1550 nm & 3.5 ps/nm.km @ 1310 nm for DWSM fibers.

(9) Bit Error Rate: The link budget calculations shall be done for a BER of 10^{-10} .

The bidders shall determine the total link loss based on the above parameters and shall submit the system design (including link budget calculations) for each category of fiber optic link during detailed engineering.

For finalising the FOTS system design & BOQ, the above methodology shall be adopted taking into account fiber attenuation, dispersion and splice loss determined during the detailed engineering. Accordingly, additions and deletions from the contract shall be carried out based on unit rates indicated in the contract.

3.3.2.2 Link Performance

The Link performance for ES, SES and BER for the fiber optic links shall correspond to the National Network as defined in ITU-T G.826.

3.3.2.3 FODP to SDH Equipment

The Contractor shall be responsible for connectivity between the FODP and the SDH equipment. The Contractor shall provide FC PC coupled patch cords. The location of FODP shall be finalized during detailed engineering.

The patch-cord length between the FODP & equipment rack shall be suitably protected from rodents, abrasion, crush or mechanical damage.

3.4 Termination Equipment Subsystem

The Termination Equipment Subsystem is defined to include the equipment that interfaces (adapts) the subscriber (user) to the Fiber Optic Transmission System (FOTS). The interfaces for Termination Equipment Subsystem may be supplied either in the same equipment as SDH or as independent PDH equipment. Functional descriptions of these equipments are as follows:

3.4.1 Functional Description

The transmission network node provides subscriber interface to the transmission network and/or switching/routing. For clarity, the basic functions accomplished at the network nodal points, are described briefly as follows:

Multiplexer shall be used to accomplish subscriber connectivity to the Digital Communication Network. Subscriber Line Units shall provide analog to digital and direct digital conversion to 64 Kbps digital channel. In the CEPT standard hierarchy, thirty (30) such 64 Kbps digital channels shall be Time Division Multiplexed (TDM) resulting in a single 2.048 Mbps (E-1) digital bit stream.

Digital Drop-Insert and Branching Equipment shall be used to digitally interface a small number of channels at spur locations without requiring successive D/A and A/D conversions of the throughput channels.

Digital Cross connect Equipment (DACS) shall be used to provide software controlled dynamic routing/rerouting of the primary (E-1) bit stream as well as the 30 channels of the E1 bit stream.

The equipment shall also have an interface for external 2048 kHz synchronisation signal according to ITU-T Recommendation G.703.

3.4.2 First Order Multiplexing

The Contractor shall be required to provide E-1 Drop & Insert Multiplexer and E-1 Channel Bank primary multiplexing in compliance with the electrical input-output characteristics provided in Table 3-3.

3.4.2.1 Drop & Insert Multiplexing

Drop & Insert multiplexing in conformance with CEPT E-1 characteristics shall be required at locations where the subscriber requirement is minimal. The drop and insertion of up to thirty 64 Kbps channels supporting subscriber line units (SLU) shall be required at intermediate locations. The Drop & Insert Muxes supplied shall be performance and card compatible with the Channel Bank Equipment provided so that all Subscriber Line Interface cards are interchangeable.

Table 3-3
CEPT E-1 Standard First Order Multiplexing Electrical Input/Output
Characteristics

Applicable Standards:	CEPT per CCITT Recommendation G.702, G.703, G.711 and G.712
Number of Tributaries:	30 X 64 Kbps
Alternative Sub-rate Tributaries:	n X 64 Kbps V.36 64Kb/s V.11/V.36
Output Aggregate Rate: Interface Code: Impedance: Peak Level @ 120 ohm: Peak Level @ 75 ohm: Maximum Insertion Loss:	2.048 Mb/s \pm 50 ppm HDB3 75 ohm unbalanced/120 ohm balanced 3.0 volts \pm 10% 2.37 volts \pm 10% 6 dB
Signal Waveform: Frame Structure: Jitter Performance:	Per CCITT G.703 Per CCITT G.742 Per CCITT G.823
Power Supply Voltage:	-48 Vdc

3.4.2.2 Channel Banks (Mux, Drop/Insert)

User voice and data equipment interfacing requirements are defined at the subscriber line level. Primary multiplexing in conformance with CEPT E-1 characteristics shall be used to provide first order multiplexing of up to thirty 64 Kbps channels supporting Subscriber Line Units (SLUs).

3.4.2.3 Subscriber Line Units\Subscriber Line Interface Cards

The terms Subscriber Line Interface Cards and Subscriber Line Units have been used interchangeably throughout the specification. Multiple configurations of SLUs shall be required to provide subscriber to primary multiplexer Bank interfacing for a variety of voice and data communications. In case there are changes in number or type of cards because of changes in channel requirements, the contract price shall be adjusted accordingly.

The SLU interface requirements are discussed in the following subparagraphs:

A. Voice Channels

The voice channel requirement is for (I) 4-Wire E&M trunking in support of PABX trunks & PLC VF and (II) 2-Wire telephonic interfaces. 2 wire SLUs shall be

DTMF/TP optioned for 2-wire loop start or 2-wire GND start. The voice cards shall utilize ITU.T A - law companded PCM G.711, 64 kbits/s encoding. The voice card requirements are indicated in the BoQ.

B. Sub-Channel Data Multiplexing

For this Project, the RTU data interface to the wideband telecommunications network node shall be defined at the DTE level at low-speed rates of 300, 600 and 1200 baud. The port shall be compatible with RS232C interface. The Contractor shall be required to furnish 64 Kbps SLU asynchronous dataplexing for at least 4 selectable low speed DTE interfaces whenever multiple asynchronous data circuits are required.

C. Nx64 kbps Synchronous Data

There is also a requirement for N x 64 kbps V.36, X.21 interfaces. The tentative quantities have been identified in the appendices. However the final BOQ shall be worked out during detailed design and contract price shall be adjusted accordingly.

3.4.3 Digital Access Cross connect System

The Contractor shall be required to provide Digital Access Cross connect Systems (DACS) capable of switching 16 or more E-1 lines in compliance with the electrical input-output characteristics provided in Table 3-4. DACS shall be fully compatible with CEPT E-1 tributary standards.

DACSs shall be provided at locations specified in the appendices and shall be used to establish and reconfigure cross-connections at the tributary level of up to 480 x 64Kb/s channels. DACS E-1 line interface shall be fully capable of accessing each E-1 line.

Within the context of this specification, sizing of DACS system is defined as 4 x n where n is the maximum size of the port switching matrix. Thus a DACS sized as 8 x 16 means that 8 E1 ports are interfaced over a 16 port (E1) matrix.

A DACS system shall consist of the switch matrix, all routing logic and timing circuitry for internally sourced, line derived or externally supplied network timing and full software support.

The DACSs to be provided under this contract shall consist of at least a 16 port switching matrix, with 16 ports equipped, i.e. 16 X 16 size. The DACS shall also be able to switch the signalling of the voice channels along with the voice channels. The DACS shall not use, decrease or block the specified capacity of the switching matrix while switching the signalling. The DACS shall support the Channel Associated Signalling (CAS) and Common Channel Signalling (CCS) both as per ITU-T G. 704.

The DACS shall provide user friendly control and management software. The user shall be able to operate the DACS locally through craft terminal, via an RS-232 interface or remotely under TMN supervisory control.

Table 3-4
CEPT E-1 Digital Access Cross Connect System
Required Operating Characteristics

E-1 Trunk Capacity:	Minimum 16-Port Switch Matrix Minimum 4-Port I/O per card
Tributary Capacity:	30 X 64 Kbps
Compatibility:	CEPT E-1, CEPT E-1 tributary channel
Frame Delay:	Minimum < 1 frame Maximum < 2 frames
E-1 Port Interface: Interface Code: Impedance: Peak Level @ 75 ohm: Maximum Insertion Loss:	2.048 Mb/s \pm 50 ppm HDB3 75 ohm unbalanced/120 ohm balanced 2.37 volts \pm 10% 6 db
Signal Waveform: Frame Structure: Jitter Performance:	Per CCITT G.703 Per CCITT G.742 Per CCITT G.823
Synchronisation:	Internal, external source and synchronized on incoming E-1
Routing: Routing Table Capacity:	Fully non-blocking tributary to/from E-1 channel Minimum of 9 routing tables for reconfiguration
Supervisory Ports: Supervisory Port Interface: Interface:	Serial Com Ports RS-232 Standard ASCII ANSI compatible terminal
Supervisory Channel:	Async data rates, software selectable: speed of 110-9600 bps, odd or even parity 7 or 8 bits.
Power Supply Voltage:	-48 VDC

3.4.3.1 Required DACS Applications

The DACS provided shall be fully capable of implementing standard applications such as "Groom and Fill", Drop & Insert/Bypass, Broadcast and Alternative Routing.

3.4.3.2 Menus and Reports

DACSs throughout the network shall be required to function as fully integrated subsystems of the Telecommunications Management Network (TMN).

The DACS software shall provide menu driven management of DACS and shall provide at least the following:

- (I) Active Configuration: The user shall be able to modify the current active configuration.
- (II) Configuration: The configurations other than the active one shall be listed, edited, viewed, renamed, deleted and activated. Actions shall be allowed manually, upon a carrier failure or specified alarm condition, remotely or on a scheduled basis.
- (III) Reports: The user shall have a selection of pre-formatted specific reports and "Report Options" to be used to select where the next reports will be sent.
- (IV) Administration: This shall provide the user, options to control, view and maintain various logs and the DACS software.
- (V) Alarms: This shall display Alarm Status on all active ports and shall have an alert mechanism that readily identifies an alarm event to the user through TMN (locally as well as remotely). The alarms will have different colours based on the importance of the alarm.

3.5 MDF, DDF and Cabling

For the purposes of the specification, the contractor shall provide cabling, wiring, DDF patching facilities and MDFs interfacing to the wideband telecommunications system. Equipment and material components for MDF, DDF and cabling are also part of this procurement. It shall be the Contractor's responsibility to provide all cable support required for full supplied equipment interconnection with the MDF and shall be in accordance with communications industry standard practices and the requirements mentioned in the technical specifications.

3.5.1 MDF and DDF Patching Facilities

The Contractor shall supply and install all cabling, wiring, connectors, cross connects, Digital Distribution Frames (DDF) and Main Distribution Frames (MDF) associated with the installation and interconnection of equipments procured under this package as follows:

- (i) DDF for termination of new SDH equipment E-1 ports
- (ii) Cabling (including connectors) for E1 level connections from DDF to existing SDH equipments, DDF to Existing & new PDH equipments. To the extent possible, existing cable at site shall be used.
- (iii) All Ethernet ports shall be terminated with RJ-45 connector. Provision for 100% expansion with connector for terminating additional Ethernet ports shall be provided.
- (iv) MDF for termination of all the subscriber channels at new PDH node
- (v) Cabling and connectors required to enable subscriber-to-subscriber circuits over the telecom network. The Line side of the MDF shall be cabled to the Primary Multiplex and the equipment side shall be cabled to the MDF of the assigned subscriber (PLCC, PABX, Telephone at wideband locations etc).
- (vi) Any other cables, connections etc required for a fully functional, integrated telecom system.

The connections amongst various equipments such as FOTS, termination equipment and subscriber MDFs etc shall always be routed through DDF and MDF to provide maintenance access.

3.5.2 Digital Distribution Frame Functional Requirements

The Contractor shall provide DDF for Digital Signal Cross connect (DSX) Broadband-quality (better than 20 MHz) patching facilities configured "normally-thru" with Equipment, Line and Monitor Patch Jacks. DDFs shall provide the following basic functions:

- (i) "Normally thru" circuit routing
- (ii) Circuit rerouting via patch cord assemblies
- (iii) Circuit disconnect and termination

All DDFs shall be sized and equipped to support the offered configuration of the provided equipment. Independent Transmit and Receive patch jack assemblies (line and equipment) shall provide for separate transmit and receive single-plug patching. Transmit and receive patch jack assemblies shall be located side-by-side such that dual-plug patch cord assemblies may be used to route both transmit and receive for the same circuit.

3.5.3 Main Distribution Frames

The Contractor shall make provision for cross connection of subscriber services to the subscribers utilizing Krone type or equivalent and shall provide full connectivity up to and terminated on the equipment side of the appropriate DDFs and line side of MDFs. The Contractor shall terminate on the equipment side of patching facilities provided by other contracts and shall provide DSX type patching facilities supporting aggregate bit streams (i.e. dataplexers and E-1 Channel Banks). Separate Patch panels or MDFs shall be provided for Data and Voice. All cross connects shall be accomplished utilizing one, two or three pair patch cords. Patch plugs are permissible for direct one-to-one circuit "cut-thru".

3.6 Patch Cords

The Contractor has to supply FC PC coupled Patch cords as described in BOQ. 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. Fiber jumpers shall be of sufficient lengths as to provide at least 0.5m of service loop when connected for their intended purpose.

3.7 Telecommunication Management Network / Network Management System

The Contractor shall provide a Telecommunications Management Network System (TMN), in main and backup configuration, for operational support to the FOTS and associated Termination equipment subsystems. This TMN shall provide the capability to monitor, reconfigure, and control elements of the telecommunications network from a centralized location and at each node of the network where equipment is located. This TMN system shall assist Employer/Owner in the operations and maintenance of the wideband communication resources of the including detection of degraded circuits, 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.

The contractor shall supply preferably a single TMN for all the NEs (Network Elements) such as SDH equipment, Mux, Drop-Insert, DACS etc. In case a single TMN cannot be provided for all the NEs, the contractor may supply separate TMNs. Each of the offered TMN shall meet the requirements indicated in this section. The bidder shall provide details of the offered TMN in the bid. TMN and NMS (Network Management System) have been interchangeably used in this specification.

3.7.1 Applicable Standards

The TMN design concept, functional and informational architecture and physical architecture, shall be in compliance with ITU-T Recommendation M.3010.

3.7.2 TMN Architecture

The TMN 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 equipment shall be as defined in this section.
- (b) Processing of above management data by using processor(s) located at Control Centre and additional intermediate station processor(s), wherever required.
- (c) Monitoring and control of the NEs as defined below:
 - i) The Control Centre for all the network elements being procured under this package (including local operator console) shall support management of all equipments supplied under this package. At minimum functions of Network management layer (NML) and Element management layer (EML) as defined in CCITT M3010. The detailed functions are listed in TS.
 - ii) Monitoring and control of NEs using Craft Terminals as defined in this Section.
- (d) Supervisory monitoring and control of the following station associated devices:
 - I) Intrusion Detection Alarms
 - II) Power Failure
 - III) Fire and Smoke Detection
 - IV) Environmental Control (Temperature, Humidity etc.)
- (e) Communication channel support for TMN System as specified in Technical Specifications (TS).

The supplied TMN system shall be capable of handling all management functions for at least 150% expansion of the final network elements. The NMS location indicated here are tentative and the same shall be finalized during detailed engineering. TMN system should not be dependent on each other for their working.

The TMN system hardware shall be so designed that failure of single processor/component (router, switch, converter etc.) shall not inhibit any of the functionality of the TMN system. The Contractor shall submit for Employer's approval the TMN architecture describing in detail the following subsystems/features:

- (a) Database used in TMN
- (b) Master Processor, server/workstation, LAN, Peripherals and hardware
- (c) Software and operating system
- (d) Local Consoles/remote consoles
- (e) Craft Terminals
- (f) Data communication between NEs, Remote/Local Consoles and TMN Processor(s)

- (g) Routers/Bridges
 - (h) Expansion Capabilities
- f) The offered TMN system shall be capable of integration with Centralized Network Management System (UNMS) upwardly through standard North bound interface (NBI) protocol such as SNMP/CORBA/XML/REST etc. as per standards TMF814/TMF 864/RFC standard/XML etc. The interface shall support all functionalities such as fault, inventory, configuration, performance and security of TMN system over the standard NBI protocol to facilitate integration with UNMS. Integration with U-NMS shall be in the scope of U-NMS provider. However, necessary support for integration of supplied NMS with U-NMS shall be provided by the contractor as required, which may be during implementation stage/AMC period.

Contractor shall be obliged to provide/share all necessary documentations to facilitate centralized supervision, centralized inventory management, centralized provisioning of bandwidth/services, availability computation, monitoring of events and alarm handling etc. of supplied TMN/NEs through UNMS.

3.7.3 Management Functions

The TMN shall support following Management functions:

3.7.3.1 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.

3.7.3.2 Fault Management

Fault management is concerned with detecting, diagnosing, bypassing, directing service restoration, and reporting on all the backbone network equipment, systems, 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.
- 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. The criteria for fail over shall be configurable as automatic fail over to redundant equipment wherever possible and through operator-initiated actions where automatic fail over is not possible. The status of fail over shall be reported to the NMS.
- f. Track network equipment failure history.

3.7.3.3 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 (atleast for SDH).
- b. Monitor point to point & end to end signal quality and history. Provide operator controls to monitor performance of specified events, measures, and resources (atleast for SDH). 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. Performance data provided is limited to what is available from the equipment Contractors.
8. Provide graphical displays of point to point and end to end current performance parameter values. Provide tabular displays of current, peak, and average values for performance parameters.
9. Generate reports on a daily, weekly, monthly, and yearly basis containing system statistics.

3.7.3.4 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 two levels of operator access shall be provided - read (view) only and write (configure). The system administrator shall be able to create, define and modify operators with different access levels, network domains and perform all kinds 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. It shall be possible to define multiple domains for purposes of monitoring and control.

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.

3.8 Communication Channel Requirement and Integration

Communication requirements for TMN system have not been considered in Appendices and the Contractor shall provide these as a part of TMN system. The Contractor shall provide all required interface cards / devices, LAN, routers/bridges, channel routing, cabling, wiring etc. and interfacing required for full TMN data transport.

The TMN data transport shall utilize the wideband communications transmission system service channel in the overhead whenever possible. This will provide

inherent critical path protection.

Should the configuration requirements dictate multiple TMN station processors, the TMN Master Station shall require bidirectional data transport with its station processor(s). This communications interfacing shall be via critically protected data channels. It shall be the Contractor's responsibility to provide for and equip all necessary critically protected TMN data channel support.

In case supervisory channels are not available, the Contractor shall provide suitable interfaces in their supplied equipment for transport of TMN data. The Contractor shall also be responsible for providing suitable channels with appropriate interfaces to transport the TMN data.

The NMS information of the new PDH & SDH system shall be transported through the existing communication network, wherever required, up to the NMS location. The NMS information of the new SDH & PDH system being procured under the package shall be transported through the existing communication network using 64 kbps/2Mbps (G.703) interfaces. Any hardware required for the above interfacing shall be provided by the Contractor.

The bidders shall describe in the proposal the TMN data transport proposed to be used by the bidder in detail including capacity requirements and various components/equipment proposed to be used.

3.9 Craft Terminal

Each equipment(SDH equipment, Mux, Drop/Insert and DACS etc.) on the fiber optic communication network shall include provision for connecting a portable personal computer (PC) to be known as craft terminal to support local commissioning and maintenance activities. 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 craft terminal shall be connected to the interface available in the communication equipment. Portable (laptop) computers (Craft terminals), each complete with the necessary system and application software to support the functions listed above, shall be supplied to the employer as per BOQ.

3.10 Hardware Requirements

3.10.1 Master Processor, Server/Workstation and Craft Terminal

The server/workstation and craft terminal shall have suitable processor(s) which shall be sufficient to meet all the functional requirements and expansion capabilities stipulated in this specification. Only reputed makers like Dell, IBM, HP, Compaq make shall be supplied.

The server shall have minimum configuration of 2.4 GHz Quad-Core processor (same will be acceptable with turbo boost option also), 8 GB RAM, DVD-RW drive, redundant 320 GB internal Hard Disk Drive, 101-Enhanced style keyboards, mouse, serial, USB(2.0) ports and hot swap redundant power supply. VDUs shall be 19" TFT active matrix color LCD with a minimum resolution of 1024 X 768. Appropriate network drive card shall also be provided wherever required. However, the internal hard disk drive for the server shall be redundant and all the data shall be mirrored. Further, the TMN software shall support data mirroring on redundant disk drives.

The workstation shall have minimum configuration of 3 GHz Core 2 Duo (same will be acceptable with turbo boost option also), 8 GB RAM, DVD-RW drive, 500 GB Hard Disk Drive, 101-Enhanced style keyboards, mouse, serial and USB (2.0) ports. VDUs shall be 19" TFT active matrix color LCD with a minimum resolution of 1024 X 768. Appropriate network drive card shall also be provided wherever required.

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

2.4 GHz (same will be acceptable with turbo boost option also), 8 GB RAM, 256 MB Video Graphics Memory, , 320 GB Hard Disk Drive, keyboard, mouse/trackball etc., serial/USB (2.0) ports to accommodate printers, and a battery back-up of at least 3 hours. VDUs shall be 15" TFT active matrix color LED with a minimum resolution of 1024 X 768.

The configurations mentioned for server, workstation & craft terminal are minimum and the same shall be finalized during detailed engineering as per latest industrial standards.

3.10.2 Peripherals and hardware

TMN system shall be provided with laser printer. The laser printer shall have a minimum print speed of 17 pages per minute and a minimum resolution of 1200 x 1200 dpi. The laser printer shall have LAN ports for connecting to TMN system.

The laser printer under this specification shall be black & white and include print enhanced buffering to prevent loss of print data in the event of a print failure.

3.10.3 Local Operator Consoles

The Contractor shall provide operator consoles sized and equipped to support the subsystem(s) furnished and in compliance with the specification. The console shall provide alongwith the TMN Server interfacing for the TMN users to the software operating support systems. At a minimum, a console shall include the hardware similar to a workstation. The Local Operator Console & Server Hardware & Software is part of the set for Network Manager & Element Manager System as specified in BoQ in Price Schedules.

3.10.4 Power Supplies

The TMN system shall use 220 volts 50 Hz A.C or -48 volt D.C as available at site for its operation as available at site.

3.11 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.

3.11.1 Operating System Software

Operating system software shall be provided to control the execution of system programs, application programs, 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.

3.11.2 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.

3.11.3 Software Utilities

A utility shall be provided to convert all reports into standard PC application formats such as excel.

3.11.4 Revisions, Upgrades, Maintainability

All firmware and software delivered under this specification shall be the latest field proven version available at the time of contract approval. Installed demonstration for acceptance shall be required. All firmware provided shall support its fully equipped intended functional requirements without additional rewrite or programming.

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.

Software provided shall be compliant with national and international industry standards.

3.11.5 Database(s)

The contractor shall develop all the databases for final wideband 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.

3.11.6 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.

-----End of the Section-----