वर्गीय आवश्यकताओं के लिए मानक

टीईसी ८६०७०:२०२१

(टीईसी/जीआर/टीएक्स/डब्लूडीएम्-००९/०१/मार्च16 को अधिक्रमित करता है)

STANDARD FOR GENERIC REQUIREMENTS

TEC 86070:2021

(Supersedes No. TEC/GR/TX/WDM-009/01/Mar16)

४०/८० चैनल डेन्स वेवलेंथ डिविसन मल्टीप्लेक्सिंग (DWDM) सिस्टम, चैनल बिट रेट १००/२०० जीबीपीएस कोर/मेट्रो नेटवर्क केलिए

40/80 Channel Dense Wavelength Division Multiplexing (DWDM) System with Channel bit-rate of 100/200 Gbps for Core/Metro Network Applications

ISO 9001:2015

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FOREWORD

Telecommunication Engineering Centre(TEC) functions under Department of Telecommunications (DOT), Government of India. Its activities include:

- Framing of TEC Standards for Generic Requirements for a Product/Equipment, Standards for Interface Requirements for a Product/Equipment, Standards for Service Requirements & Standard document of TEC for Telecom Products and Services
- Formulation of Essential Requirements (ERs) under Mandatory Testing and Certification of Telecom Equipment (MTCTE)
- Field evaluation of Telecom Products and Systems
- Designation of Conformity Assessment Bodies (CABs)/Testing facilities
- Testing & Certification of Telecom products
- Adoption of Standards
- Support to DoT on technical/technology issues

For the purpose of testing, four Regional Telecom Engineering Centres (RTECs) have been established which are located at New Delhi, Bangalore, Mumbai, and Kolkata.

ABSTRACT

The present document describes the standard for Generic Requirements for DWDM system, comprising of DCM-Free Coherent system,40/80 channels with a channel bit rate of 100Gps/200Gbps. The document has been revised to include 200G per channel capacity. Using a 200G coherent mQAM uplink attains 200G capacity over a single DWDM wavelength within the C-band spectrum, reaching spectral efficiency of up to 40/80 x 200G DWDM channels sharing the same fiber providing solution to the most challenging traffic demands of today's enterprise DCI markets.

The ability of 200G optics to operate within the existing 50 GHz wavelength grid is crucial for allowing the simple upgrade of existing DWDM networks. However, the spacing required generally goes up as the bandwidth being transmitted goes up. Advanced modulation techniques like QAM and QPSK reduce the spacing required to transmit higher bandwidth, but eventually, higher speeds will need more than

50GHz to operate. The standard has been revised to include flexi-grid concept as a solution to this problem. The more recently defined Flexi-grid standard allows groups of 12.5GHz spacing to be combined into whatever size is required for transmission. The document defines various client interfaces such as STM-64, 10GE, Fiber Channel and OTN interface such as OTU2, OTU2e, OTU3 and OTU4. The specifications of these client interfaces have been defined in the standard. The standard is aimed to cater for Metro, long haul and Very long haul DWDM networks.

The standard describes the Colourless and Directionless features of ROADM, which enables the remote Administrative, Operative and Monitoring capabilities of the network. A brief description about the contention less capability of ROADM is given at purchaser guidelines and this feature is considered to be optional. The 100Gbps DWDM systems will have ASON (Automatic Switched Optical Networks) capability for Metro Networks.

The standard envisages EMS of multi-user system and shall be based on Graphical User Interface. It shall be possible to generate customised reports for various types of faults, performance history, security management etc. It shall also be possible to generate reports at various client's levels to facilitate monitoring of performance statistics in predefined/customised format

CONTENTS

HISTORY SHEET

Sl. No.	*Standard/ Document No.*	*Title*	*Remarks*
1.	TEC/GR/TX/WDW-009/01/Mar16	Generic Requirements for DCM-Free Coherent system 40/80 Channel Dense Wavelength Division Multiplexing (DWDM) Equipment with channel bit-rates of 100Gbps for Metro/Core Network Applications.	Release-1
2.	TEC 86070:2020	Standard for 40/80 Channel Dense Wavelength Division Multiplexing (DWDM) Equipment with channel bit-rates of 100Gbps/200Gbps for Metro/Core Network Applications.	Release-2 • The document was taken up for revision based on the request of CDOT. • Revised to include 200Gbps per channel rate. • The environmental category has been changed from “B1” to “A”. • The minimum equipment for type approval

			has been modified to 16 channels instead of 40/80 channels. • Flexi-grid concept introduced in the standard.

REFERENCES

S.No	*Document No.*	*Title/Document Name*
1.	ITU-T Rec.G.652	Characteristics of a single-mode optical fibre and cable
2.	ITU-T Rec.G.655	Characteristics of a non-zero dispersion-shifted single-mode optical fibre and cable
3.	ITU-T Rec.G.664	Optical safety procedures and requirements for optical transport systems
4.	ITU-T Rec.G.691	Optical Interfaces for single channel STM-64, STM- 256 systems and other SDH systems with optical amplifiers.
5.	ITU-T Rec.G.692	Optical interfaces for multichannel systems with optical amplifiers
6.	ITU-T Rec.G.694.1	Spectral grids for WDM applications: DWDM frequency grid
7.	ITU-T Rec.G.697	Optical monitoring for DWDM systems
8.	ITU-T Rec.G.707	Network node interface for the synchronous digital hierarchy (SDH).
9.	ITU-T Rec.G.709	Network node interface for the Optical Transport Network hierarchy (OTH).
10.	ITU-T Rec.G.712	Transmission performance characteristics of pulse code modulation channels.
11.	ITU-T Rec.G.783	Characteristics of SDH equipment functional blocks.
12.	ITU-T Rec.G.798	Characteristics of optical transport network hierarchy equipment functional blocks
13.	ITU-T Rec.G.806	Characteristics of transport equipment – Description methodology and generic functionality

14.	ITU-T Rec.G.812	Timing requirements of slave clocks suitable for use as node clocks in synchronization.
15.	ITU-T Rec.G.813	Timing characteristics of SDH equipment slave clocks (SEC)
16.	ITU-T Rec.G.825	The control of jitter and wander within digital networks which are based on the synchronous digital Hierarchy (SDH)
17.	ITU-T Rec.G.828	Error performance events for SDH paths
18.	ITU-T Rec.G.829	Error performance events for SDH multiplex section and regenerator section
19.	ITU-T Rec.G.957	Optical interfaces for equipment's and systems relating to the synchronous digital hierarchy.
20.	ITU-T Rec.G.959.1	Optical transport network physical layer interfaces
21.	ITU-T Rec.G.975.1	Forward error correction for high bit-rate DWDM submarine systems
22.	ITU-T Rec.G.7041	Generic Framing Procedure
23.	ITU-T Rec.G.7710	Common equipment management function requirements
24.	ITU-T Rec.G.8201	Error performance parameters and objectives for multi-operator international paths within the Optical Transport Network (OTN)
25.	ITU-T Rec. G.8251	Control of jitter and wander within digital networks which are based on OTN hierarchy.
26.	ITU-T Rec.M.3010	TMN conformance and TMN compliance.
27.	ITU-T Rec.M.3100	Generic network information model
28.	IEEE 802.3	IEEE Ethernet standards series
29.	IEEE 802.3ae	Media Access Control (MAC)Parameters, Physical Layers, and Management Parameters for 10 Gb/s Operation
30.	IEEE 802.3ah	Ethernet link aggregation standard

31.	IETF RFC 2544	Benchmarking for IP/Ethernet devices
32.	TMF-513	Multi-Technology Network Management Business Agreement
33.	TMF-608	Multi-Technology Network Management Information Agreement
34.	TMF-814	TM Forum MTNM Implementation Statement (IS) Template and Guidelines
35.	IS 8437 {1993}	Guide on the effects of current passing through the human body
36.	IS 13252 {1993}	Safety of information technology equipment including electrical business equipment
37.	CISPR 22 {2006}-	Limits and methods of measurement of radio disturbance characteristics of Information Technology Equipment
38.	IEC-60825-1	Optical safety requirements
39.	IEC Publication 61000-4-2	Testing and measurement techniques of Electrostatic discharge immunity test
40.	IEC Publication 61000-4-3	Testing and measurement techniques-Radiated RF Electromagnetic Field Immunity test
41.	IEC Publication 61000-4-4	Testing and measurement techniques of electrical fast transients/burst immunity test
42.	IEC Publication 61000-4-5	Testing and Measurement techniques for Surge immunity test
43.	IEC Publication 61000-4-6	Immunity to conducted disturbances

CHAPTER-1

1.0 Introduction:

1.1 This document describes the standard for Dispersion Compensation Module Free Coherent system with a capacity of 40/80 channel Dense Wavelength Division Multiplexing (DWDM) Optical Line System (OLS) operating at discrete wavelengths in the C-band centred around 193.1 THz frequency as per ITU-T Rec. G.694.1 grid, at 100/50GHz channel spacing.

1.2 Per channel transmission rate of this DWDM system shall be 100Gps/200Gbpsin the C-band. 100G DWDM system shall use coherent Polarization Multiplexed - Quadrature Phase Shift Keying (QPSK) digital modulation technique. For 200 Gbps, DWDM system at 50 GHz Channel spacing shall use coherent Polarisation Multiplexed - mQAM digital modulation technique. Specifications for 100Gbps /200Gbps DWDM systems and associated client's interfaces have been given in this standard.

1.3 The document stipulates DWDM systems for Metro & Longhaul and Very Longhaul applications in the Telecom Networks. Apart from the SDH and Ethernet interfaces, OTN client interfaces have also been introduced in the document. The system shall also support Reconfigurable Optical Add Drop Multiplexer (ROADM) which shall provide lot of flexibility in the network.

1.4 A newer flexible DWDM grid shall allow a mixed bit rate or mixed modulation format transmission system to allocate frequency slots with different widths so that they can be optimized for the bandwidth requirements of the particular bit rate and modulation scheme of the individual channels. For the flexible DWDM grid, the allowed frequency slots have a nominal central frequency (in THz) defined by: 193.1 + n × 0.00625 where n is a positive or negative integer including 0 and 0.00625 is the nominal central frequency granularity in THz and a slot width defined

by: 12.5 × m where m is a positive integer and 12.5 is the slot width granularity in GHz. Any combination of frequency slots is allowed as long as no two frequency slots overlap.

2.0 Description of DWDM equipment: Following shall be the functional blocks of the DWDM system.

2.1 Terminal blocks:

Shall provide the following functionalities:

(a) Interface from/to100Gbps/200Gbps line equipment

(b) Pre-emphasis of gain

(c) Booster/pre-amplification

(d) OSC termination

(e) Performance Monitoring etc.

(f) Multiplexing/De-multiplexing element:

The Multiplexer of the DWDM equipment shall combine a maximum of 40/80 coloured DWDM channels from the Transponders/Muxponders into a multi-channel signal. Similarly, the Demux shall provide the reverse function.

Notes-I:

(a) Various DWDM Mux/Demux characteristics for 'Add-out insertion loss (max.) per channel for Mux', 'Drop-in insertion loss (max.) per channel for De-Mux', are left open for implementation to manufacturer subject to conformance to parametric limits as imposed by Table 1a, 1b, 2a, 2b, 3 & 4/ Annexure-I at all relevant reference points 'RMn/SDn' and 'MPI-S/MPI-R'.

(b) If desired by the purchaser, Optical Terminal Multiplexer and ILA equipment can also be upgraded to high capacity Optical Add/Drop Multiplex equipment with additional cards/chassis. The traffic disruption in this activity can be avoided using the appropriate protection mechanism.

(c) The details of technology and characteristics (other than defined in this document) of Multiplexer/Demultiplexer are to be specified by the manufacturer.

Upgrades to additional add/drop channels is required to be hitless and to be supported in field.

Note-II:

Cross-talk values - 'Maximum adjacent channel cross-talk for De-Mux', 'Minimum Isolation (for adjacent as well as non-adjacent channels) for Mux & De-Mux' shall be complied at relevant 'SDn' reference point (for the disturbed channel) at De-Mux, S' reference point on ILA/OADM and MPI-S reference point at MUX output under the following conditions:

- The channel power for the disturbed channel at 'RMn' reference point at MUX is at a minimum.
- The powers at other channels at respective 'RMn' reference points are at a maximum.
- The optical filter characteristics in Mux/De-Mux to be such as to compensate for channel-power disparities to adhere to cross-talk specifications.

2.2 **In Line Amplifiers:**

Provide optical line amplification and Optical Supervisory Channel termination. The DWDM system shall provide EDFA Booster Amplifiers (at Mux end), Pre-Amplifiers (at Demux end) and ILA's at enroute stations to compensate fibre-attenuation etc. The Optical In-Line Amplifier amplifies the optical signals received at the input and has the characteristics as given in the Table 1a, 1b, 2a, 2b, 3 & 4/Annexure-I. The Coherent Channel systems shall be required to compensate the dispersion occurred in the link.

2.3 **OADM module:**

Optical Add/Drop Module, as the name specifies has the capability to ADD or Drop one or more channels at specified nodes, as per the need. It multiplexes/De-multiplexes for channel Add/Drop functionality. The OADM design is such that it allows unrestricted continued re-use of same channel/channels in the subsequent cascaded spans for the dropped channels. Upgrades to additional add/drop channels is hitless and is supported in field. It also provides Gain, Pre-emphasis and OSC

termination. The standard envisages a common platform for Optical Add/Drop Mux and optical line amplification. OADM node provides an integrated two-stage EDFA/Raman optical amplifier to offset various losses i.e. insertion loss channel add/drop and fiber-attenuation etc. Two variants of Optical Add/Drop Multiplexers shall be supported – Fixed OADM (static) and Reconfigurable OADM (ROADM).

2.3.1 **Fixed OADM (Static) (Optional):**

Optical Add/Drop Multiplexer supports a minimum of 2 nos. of bidirectional optical wavelengths for add/drop traffic with the remaining optical wavelengths passed through to outgoing path without 3R regeneration. However, purchaser may indicate the exact number of add/drop channels.

2.3.1.2 **Dual-fibre OADM node:**

Such type of OADM allows add/drop for minimum 2 channels/wavelengths from each fibre direction of a two-fibre DWDM linear-chain or ring. The other channels/wavelengths are passed through the OADM as 'express traffic'. If the purchaser wants to realize the multi direction node (more than 2 directions) without the use of ROADM same can be realized using separate Mux – Demux for each direction. Pass through connections in this case will be done manually by interconnecting the ports of required Mux Demux using optical patch chords. Dual-fibre are used for both network and transponder/Muxponders connections. The OADM option can be for both – long haul as well as very long haul with Sn/Rn and S'/R' parametric compliance to Table 1a, 1b, 2a, 2b, 3 & 4/ Annexure-I for respective application codes.

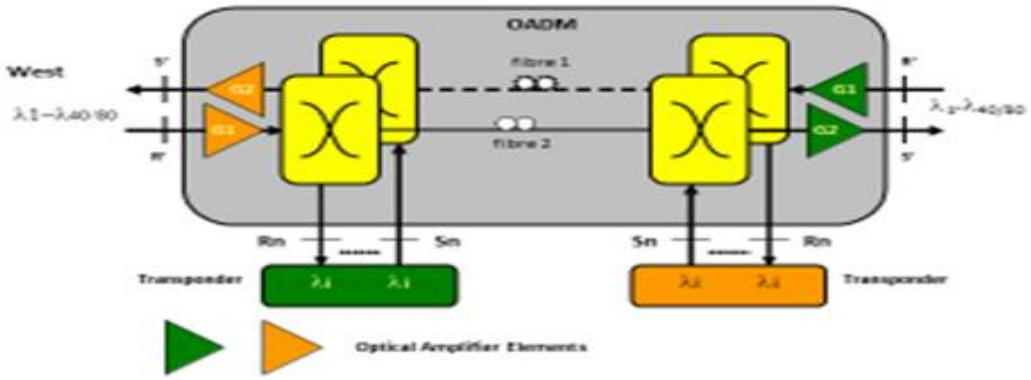


Fig.1 OADM schematic

Note 1: Both directions of traffic may also be implemented on two unidirectional units. Transponders for add/drop tributaries may be internal or external part of the OADM node.

Note 2: The 'Sn' & 'Rn' and S' & R' reference points on OADM shall comply for parametric values as outlined in Table 1a, 1b, 2a, 2b, 3 & 4/Annexure-I of the standard. The parametric values refer to above are the worst-case values for all channels.

2.3.2 Multi-Degree Reconfigurable OADM (MD-ROADM):

A Reconfigurable Optical Add-Drop Multiplexer (ROADM) is a form of optical add-drop multiplexer that adds the ability to remotely configure wavelength in OADM system. This allows individual wavelengths carrying traffic channels to be added and dropped from a transport fibre without the need to convert the signals on all of the WDM channels to electronic signals and back to optical signals. Planning of entire bandwidth assignment need not be carried during initial deployment of a system. The configuration can be done as and when required. A model diagram for ROADM supporting 5 directions, using 1XN WSS is given at fig-2. ROADM is a wavelength selective switch (WSS) based on LCOS/LC or Micro-Electro-Mechanical Systems (MEMS) technology. Presently two features viz. Colourless and Directionless are considered for this standard. Various combination of colorless & directionless configuration is

upto the discretion of purchaser based on his network requirements. Purchaser can fulfil his requirements in any of the following combinations, however for realizing the optical layer ASON, directionless feature is must requirement.

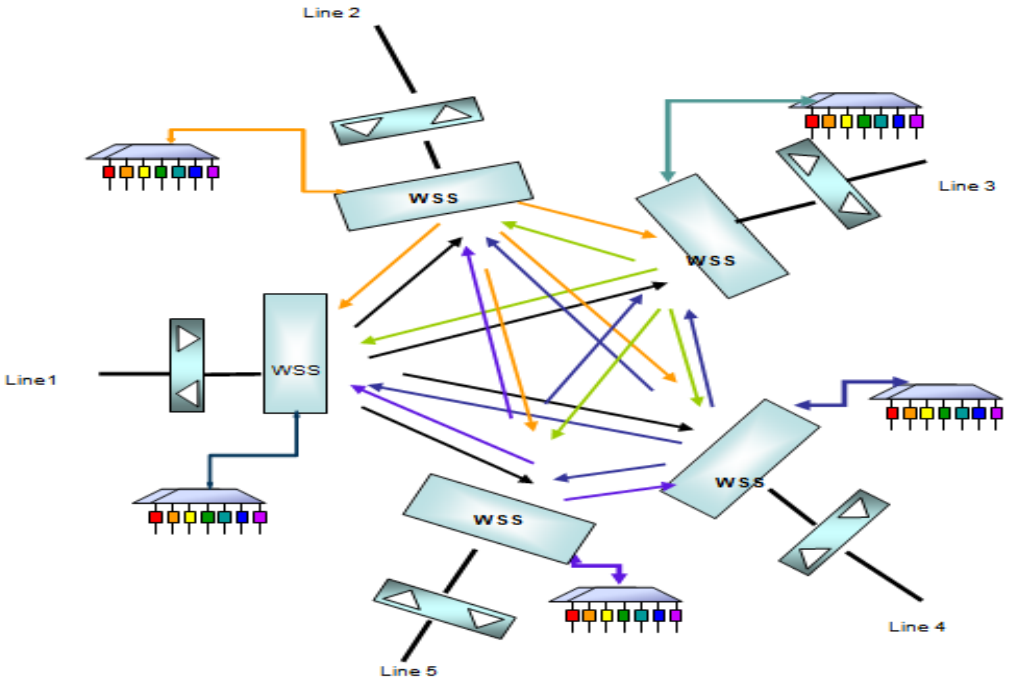


Figure 2: Pictorial View of 5 Degree ROADM

2.3.2.1 Colored & Directional ROADM

ROADM sites which are Coloured & Directional, only pass-through wave direction can change on these ROADM nodes. The add/drop wave is connected to a specific direction MUX DEMUX. The add wave direction can't change without changing physical connections to other direction MUX DEMUX. The add/drop wave is connected to a specific wavelength (specific colour) port of MUX DEMUX. The add drop wavelength can't change even if the OTU is Tunable, because each port of MUX DEMUX frequency (wavelength) is fixed. Pictorial view of Coloured and Directional ROADM is shown at Fig. 3 below.

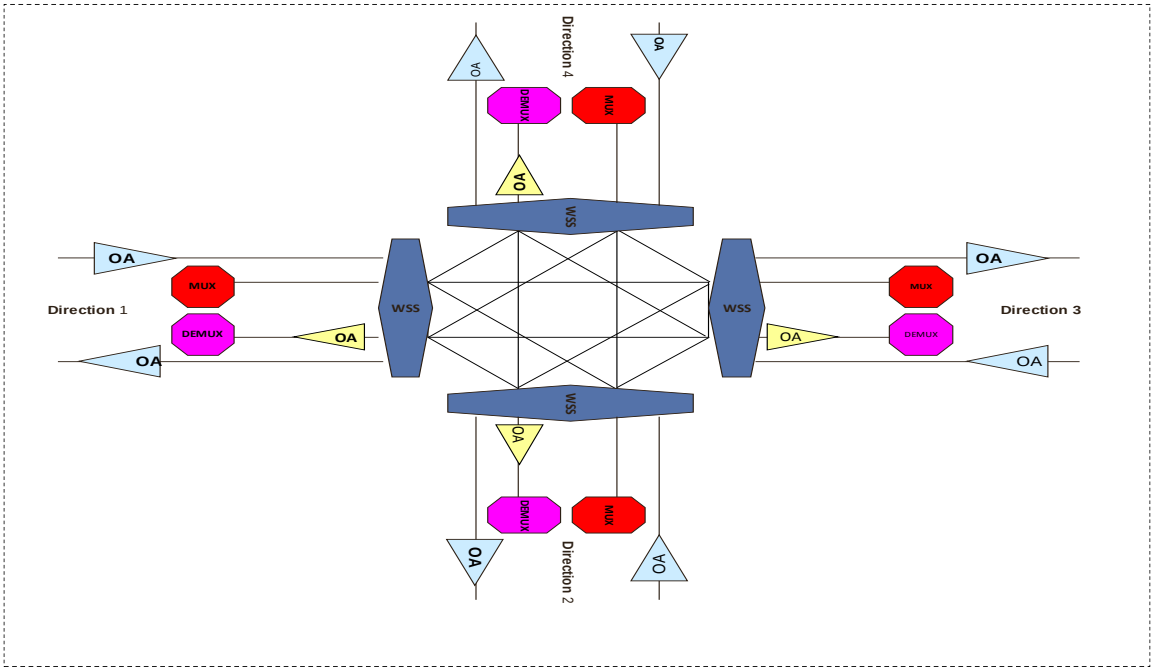


Figure 3: Pictorial View of Coloured and Directional ROADM

2.3.2.2 Colored & Directionless ROADM

ROADM sites which are Colored & directionless, not only pass-through wavelength on these ROADM nodes but also add/drop the wavelength, so it can realize optical layer reroute. Optical layer ASON must use Directionless model. WSS is connected to the add/drop OTU board & makes the direction of any wavelength changeable. The add drop wavelength can't change (even the OTU is Tunable) without changing physical connections at MUX & DEMUX, because each port of Mux/Demux frequency (wavelength) is fixed. Pictorial view of Colored and Directionless ROADM is shown at Fig. 4 below

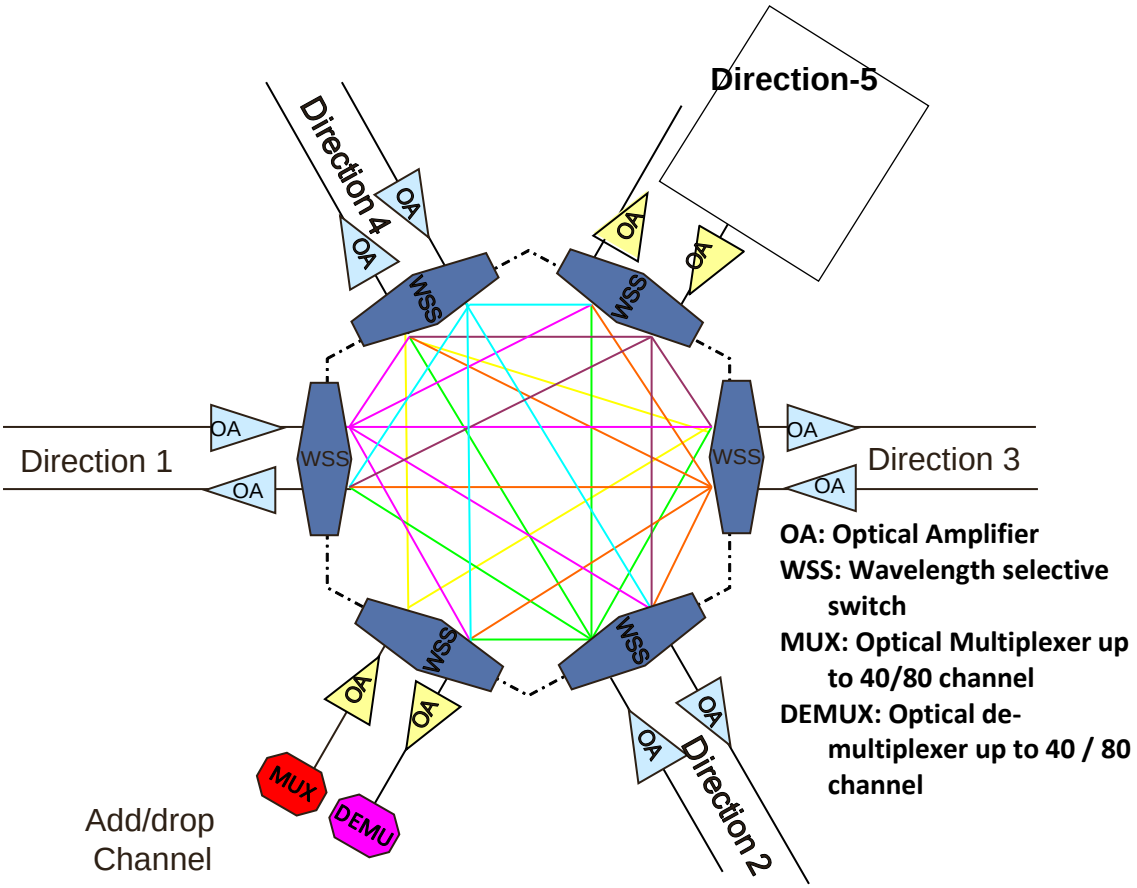


Figure 4: Pictorial View of Coloured and Directionless ROADM

2.3.2.3 Colorless Directionless ROADMs:

To re-route around a local, nearest span failure, the direction of an add/drop port must be switchable, Directionless switching is therefore needed for automatic restoration with a GMPLS/ASON control plane, or remote provisioning using pre-installed transponders. In colourless ROADMs ports can be tuned to arbitrary wavelengths by software command. This allows to tune the wavelengths of the transponders and the add/drop port remotely.

The Colourless/Directionless-Add/Drop allows that each port of the add/drop structure access any wavelength from any direction of any degree within a node. It is therefore ideally suited for highly flexible traffic patterns. The number of local directions in directionless configuration can be in set of 1+1 for hardware redundancy purposes. The number of 1+1 sets can be more than one in case number of wavelength drop are not accommodated in one set. However, the discretion of opting for 1+1

hardware redundancy may be decided by the purchaser. Pictorial view of Colourless and Directionless ROADM is shown at Fig. 5 below.

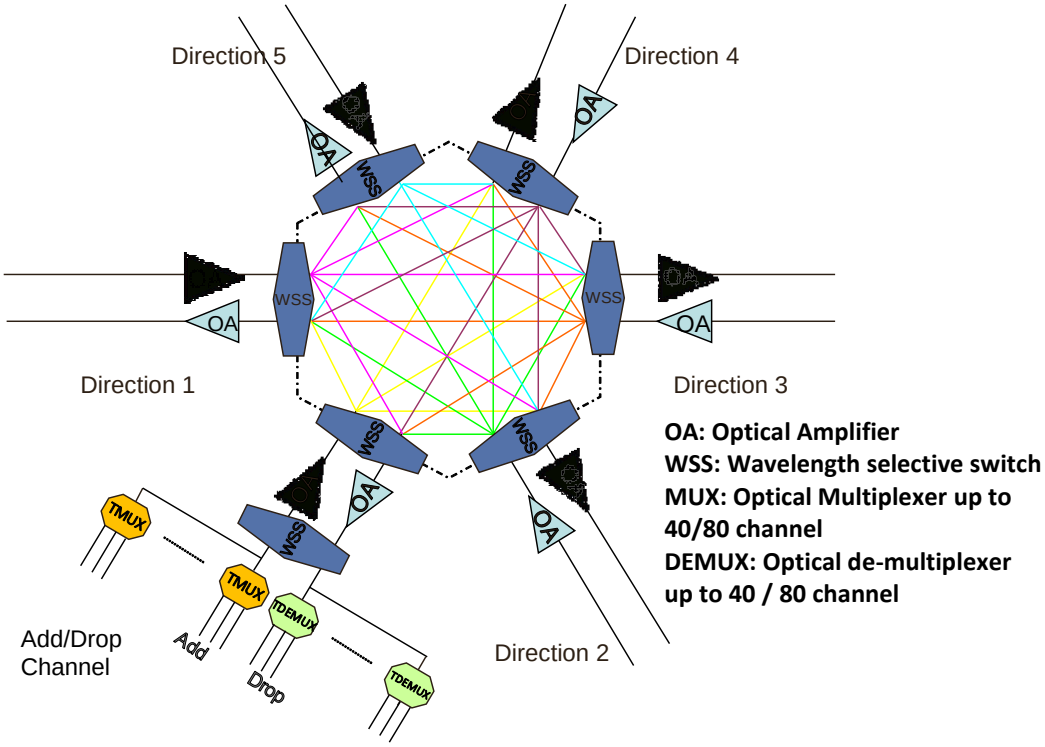


Figure 5: Pictorial View of Colourless and Directionless ROADM

Note: All above features of the ROADMs are optional features and may be decided by the purchaser as per the requirement.

2.4 Network Topologies:

2.4.1 Point-to-point topology:

The standard envisages a transverse compatible approach for point-to-point DWDM links, the reference model is outlined below in Figure-6:

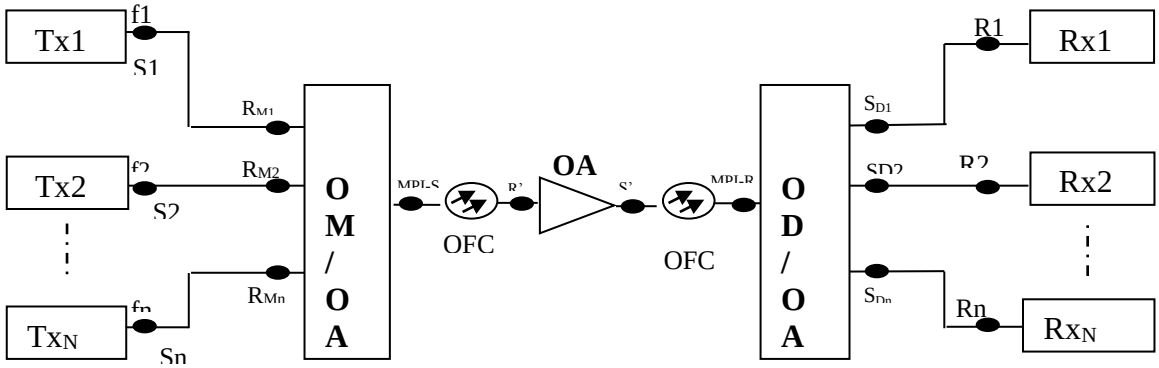


Figure 6- Point-to-point DWDM system

The DWDM system shall fully comply with parametric values & limits as per Table 1a, 1b, 2a, 2b, 3 & 4/Annexure-I of the standard, at reference points 'Sn/Rn', 'R_{Mn}/S_{Dn}' & 'MPI-S/MPI-R. The system shall also comply with the span-budget, dispersion, cross-talk limits from adjacent as well as non-adjacent channels and other specifications in all the spans as per Table 1a, 1b, 2a, 2b, 3 & 4/Annexure-I for even worst-case channel.

2.4.1.1 In the point-to-point DWDM link, the equipment shall be able to carry the maximum traffic of 40/80 channels on a single fibre-pair. The equipment shall be seamless in providing service migration path to linear add-drop or two-fibre DWDM ring structures, provided intention is expressed at the time of procurement by purchaser. Traffic shall be protected through client-layer protection mechanism which shall be unidirectional and single-ended.

2.4.2 **Linear add-drop topology:**

The reference model for linear add-drop topology is outlined in Figure-7 below:

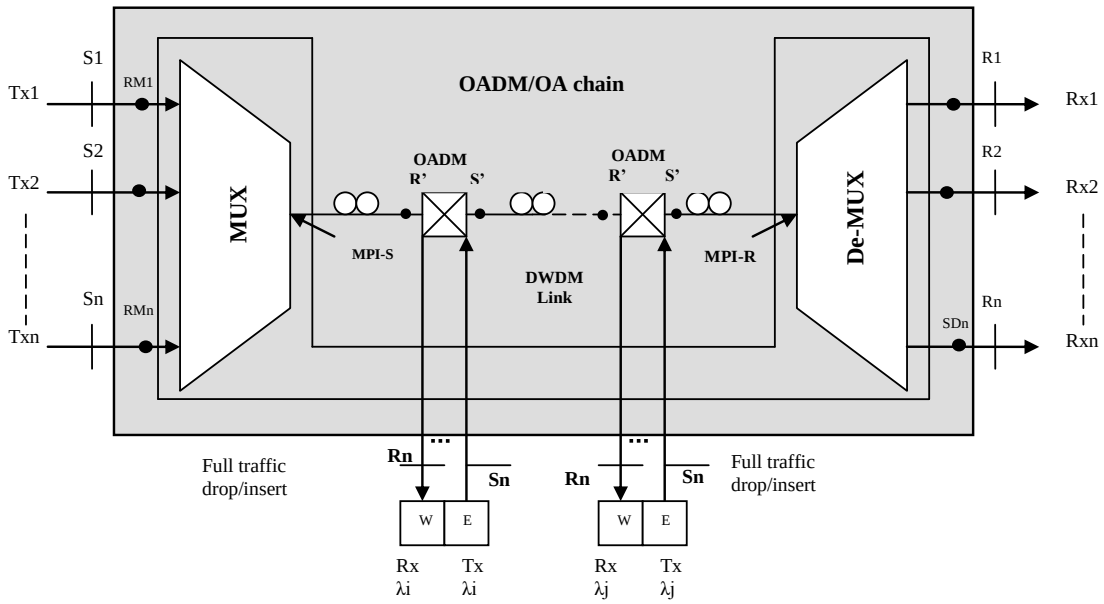


Figure 7- Reference Diagram for DWDM Linear-chain link

2.4.2.1 The DWDM equipment in linear-chain is to be able to carry a maximum traffic of 40/80 channels, on a fibre-pair with one fibre each for 'East-bound' and 'West-bound' direction. As required by the purchaser, a pre-configured drop & insert facility from both fibre directions at any intermediate OADM node shall be possible. The DWDM system shall provide channel re-use in subsequent spans, after termination of a wavelength at an intermediate OADM node.

2.4.2.2 The system is capable of implementation of proper mechanism to combat OSNR penalties incurred due to continued channel add/drops of same wavelengths in subsequent spans at enroute OADMs.

2.4.2.3 The add/drop channel transponders are supplied as an integrated part of the OADM in the same chassis.

2.4.3 **Two-fibre Ring DWDM ring:**

The two-fibre ring network may find two kinds of application topologies in a DWDM network:

I. Two-fibre ring with a single 'Hub Node' (called 'Head-end') and;

II. Closed two-fibre ring.

I. **Two-fibre DWDM ring with a Hub:**

In the two-fibre DWDM ring characterized by a Hub node, all the traffic shall be hubbed towards a 'Head-end'. The 'Head-end' shall consist of a back to back DWDM terminal for termination of 40/80 bi-directional channels from both fibres in both ('W'&'E') directions. The network shall support fibre termination or add/drop of a total of up to 40/ 80 bi-directional channels i.e. full traffic coming/going from East and West directions of the 'hub traffic' at any intermediate OADM node.

The reference model for a hubbed ring is outlined in Figure-8.

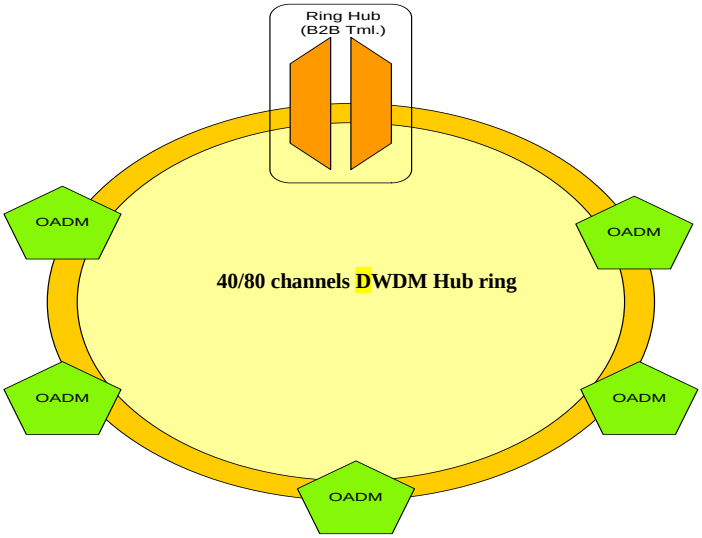


Figure 8-Reference diagram for a DWDM hubbed ring.

In DWDM ring configuration, the system shall fully comply with parametric values & limits as per Table 1a, 1b, 2a, 2b, 3 & 4/Annexure-I of the standard, at reference points 'Sn/Rn', 'R'/S' & 'MPI-S/MPI-R'. The system shall also comply with the span-budget, dispersion, cross-talk limits from adjacent as well as non-adjacent channels and other specifications in all the spans as per Table 1a, 1b, 2a, 2b, 3 & 4/Annexure-I for even the worst-case channel.

In the ring network, the '**working**' and '**protection**' paths for bi-directional traffic shall take different fibre routes around the ring ('East' and 'West') and the selection of the Rx signal shall be carried out at Rx-end.

II. **Closed two-fibre ring:**

The schematic of a closed two-fibre DWDM ring architecture with distributed traffic patterns between nodes is given in Figure-9. The protection mechanism shall operate at the client level. The network shall support termination of node to node traffic providing channel reuse feature.

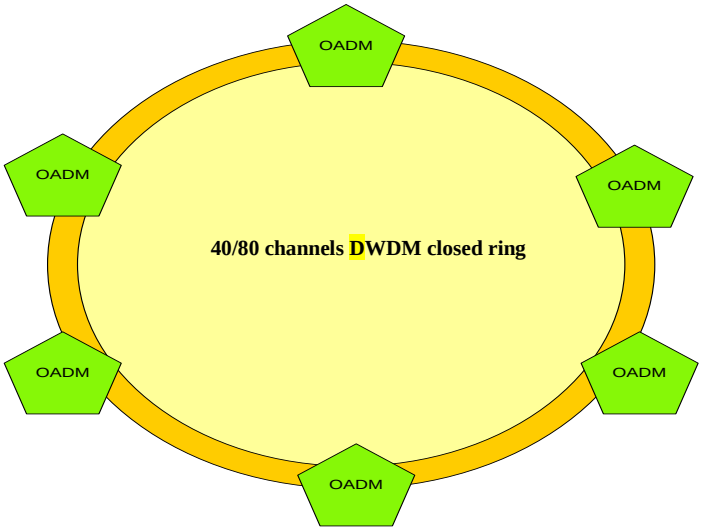


Figure 9-Reference diagram for an Internode DWDM ring.

2.4.4 Meshed Network:

The schematic of a closed two-fibre DWDM Mesh Network architecture with distributed traffic patterns between nodes is given in Figure-10. The protection mechanism shall operate at the client as well as at line side.

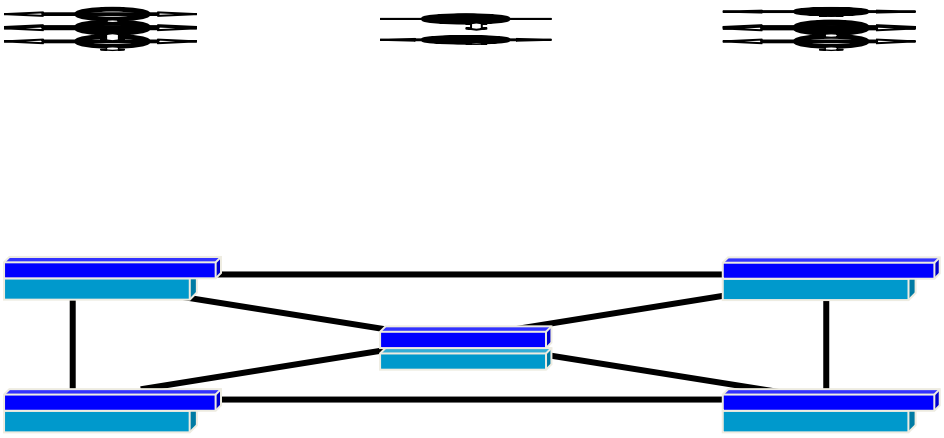


Figure 10- Reference diagram for a Mesh DWDM Network

3.0 Functional requirements:

3.1 The system shall support a combination of client interfaces - STM-64, 10G Ethernet LAN and WAN PHY as per IEEE 802.3ae,40GEand 100GE (As per IEEE 802.3ba). The DWDM system shall also be capable of interfacing G.709 based OTN client signals such asOTU2, OTU2e, OTU3 & OTU4.For

these client interfaces, various sets of Transponders and Muxponders have been defined and described later in the standard. A Transponder shall map grey STM-64, 10GigE and OTU2, OTU3 or OTU4 optical clients to a coloured DWDM wavelength towards Mux/Demux block and vice-versa. A Transponder shall be defined for Line Rate of OTU4. A Transponder shall interface with a client signal of 100GE and will give a OTU4 Line signal wavelength as output. A Muxponder shall multiplex up to ten grey channels of STM-64 or ten nos. of OTU-2 or upto10 nos. of 10GE interfaces, depending on the Muxponder 'type' and will give a 100G wavelength to Mux/Demux. A Muxponder shall multiplex 10 nos. of 10G rate of any Traffic over a Single OTU4 line signal wavelength. For 200G Muxponder, it shall multiplex up to ten grey channels of STM-64 or ten nos. of OTU-2 or up to 10 nos. of 10GE interfaces and one 100G client and will give 200G wavelength to Mux/Demux. It shall also multiplex up to twenty grey channels of STM-64 or twenty nos. of OTU-2 or upto20 nos. of 10GE interfaces and will give 200G wavelength to Mux/Demux. The block schematics of 100G/200G muxponders is shown at Fig.14 later in this standard. However, a muxponder with 40G client interfaces is optional and may be decided by the purchaser.

3.2 The system shall support a set of optical cards that when equipped in a specific configuration shall allow the system to function as an Optical Terminal Multiplexer (OTM), Optical Add/Drop Multiplexer (OADM) or In-Line Amplifier (ILA). The system shall also support Reconfigurable Optical Add Drop Multiplexer (ROADM) in a specific manner as per the requirements of the purchaser. However, for ILA sites, size of the chassis may be decided by the purchaser.

3.3 The OADM shall have East West separation resulting in traversing the East direction traffic not sharing the common cards with add/drop channels in the West direction. A separate booster and preamplifier cards, as shown in the Fig-11 shall be a precondition for EWS.

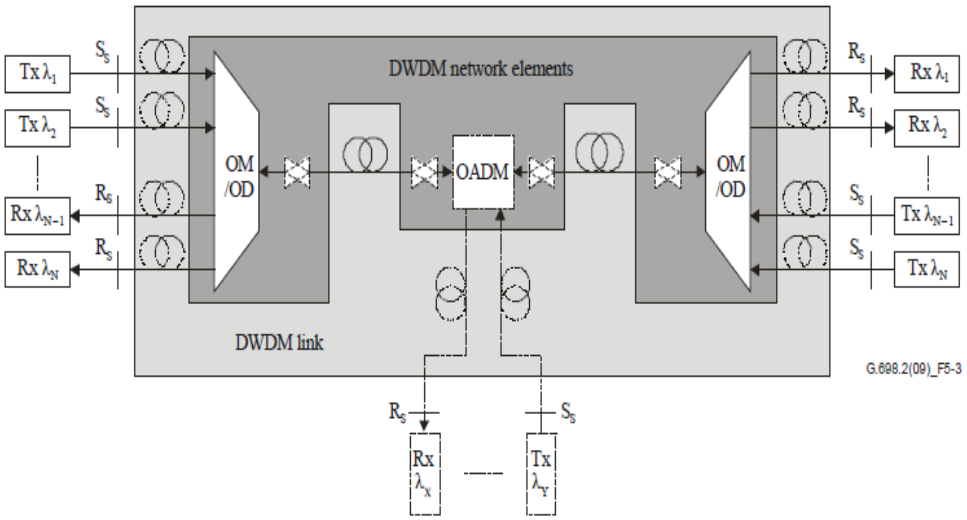


Fig-11: OADM architecture with East West separation

3.3.1 Upgrades to additional add/drop channels upto the limits proposed shall be supported and hitless. OADM shall facilitate unrestricted channel reuse in subsequent spans i.e. at all ILAs in chain/ring after a particular wavelength is dropped at very previous OADM node.

3.3.2 OADM shall support the add/drop of any channel in resolution of single channel of bi-directional optical wavelengths up to the maximum of 40/80 no. of bidirectional optical wavelengths, with the remaining optical wavelengths passed through to any other location without 3R regeneration. There shall be no restrictions on wavelength assignment to the add/drop channels, allowing any or all unique optical wavelengths to be added/dropped at any location. Both symmetric add/drop (whereby no. of dropped channels is equal to no. of inserted channels) and asymmetric add/drop (whereby no. of dropped channels is not equal to no. of inserted channels) shall be supported.

3.3.3 The system design shall be such that it implements wavelength reuse at Optical Add/Drop Multiplexers, allowing any particular wavelength that has been dropped from a previous optical multiplex section to be reinserted

into any subsequent optical multiplex section to carry new traffic. Any insertion losses incurred in the add/drop process is compensated within the system. The system shall support the physical ports for all the add/drop channels. No additional hardware except, Muxponders/transponders shall be required for the future upgradation of the equipment. In case existing slots cannot accommodate the transponder/muxponder, new chassis may be required while upgrading the capacity.

3.3.4 The technical requirements for static OADM shall be governed by the following specifications:

a. Minimum no of OADM's that can be supported in a linear add/drop or ring topology before 3R shall be required as per link distances/losses in spans.
b. In case of ring topology, true ring closure are supported without 3R depending upon link parameters.

3.4 The system shall support various topologies such as point-to-point, linear add/drop, closed ring and Mesh topologies (with or without 3R regeneration). The document specifies multiple protection at the DWDM Optical.

3.5 The DWDM system shall work in unidirectional mode of operation for all network topologies using dedicated separate fibres for 'TX' and 'RX' directions in terrestrial Metro, Longhaul and Very Longhaul networks with or without In-Line Amplifiers (ILA) as per network requirements. The maximum no. of spans deploying In Line Amplifiers (ILAs)& OADMs/ROADMs or a combination thereof, shall vary from 3 to 8 or more for different applications/line rate for various span-budget specifications as mentioned later in the standard.

3.5.1 The Booster Amplifier and Pre-Amplifier (optical amplifiers) shall be an integral part of DWDM Terminals, as well as ILAs and OADMs/ROADMs.

3.5.2 The Optical Amplifiers shall amplify the aggregate DWDM optical signal received at the input using EDFA and RAMAN (Optional) technology and shall have the characteristics as given in the Table 1a, 1b, 2a, 2b, 3 & 4/Annexure-I. At least two types of Line Amplifiers shall be supported viz. Longhaul Amplifier and Very Longhaul Amplifiers based on the amplification capabilities which are specified in the Table 1a, 1b, 2a, 2b, 3 & 4/Annexure-I. The equalization and other parameters shall be the same for both types unless these are specified.

3.5.3 The Optical Amplifiers can be single stage/Mid Access type for booster amplifier with due implementation for gain-flatness, feed-back gain-control & channel-power balancing etc. and shall provide parametric compliance with Table 1a, 1b, 2a, 2b, 3 & 4/Annexure-I.

3.5.4 There shall be active control and instantaneous adaptation of express traffic due to any degradation arising out from rapid reconfigurations. Sudden addition/removal of channels at intermediate site must not affect whole transmission of DWDM signals.

3.5.5 The optical amplifiers shall respond automatically to changes in the number of channels without the need for manual intervention or realignment. Integrated VOA shall allow the amplifier units to automatically compensate for variations in span-attenuation due to ageing and splicing etc.

3.5.6 The adaptation response for restoration after ILA fault, fibre-plant restoration or change in power levels etc., shall be immediate. The Booster Amplifier, In Line Amplifier and Pre Amplifier shall support in built optical monitoring device, which will not apply the correction to channels to keep the spectrum flat, but also shall be used for the monitoring of optical monitoring as per ITU-T G.697. The parameters to be monitored are listed in this standard.

3.5.7 The system shall restore autonomously on the restoration of link after fibre plant breakdown or a faulty amplifier.

3.5.8 The optical amplifiers must implement the following mechanisms to maintain error free system operation under dynamic conditions:

a) **Fast gain control loop:** to protect against short term transient conditions such sudden loss of channels.

b) **Slow output power control loop:** to protect against long term conditions such as fibre aging.

The optical amplifiers shall be double-stage or triple-stage amplifiers that can accommodate the optical gain and power requirements up to a full channel capacity per node.

Note: The above requirements shall hold for the optical amplifiers that are part of OADM, Mux & Demux also.

3.6 ROADM nodes shall support following functionality:

3.6.1 ROADM shall allow for full remote configuration to add/drop or pass-through any wavelength. It shall provide End-to-end service commissioning without visiting the intermediate sites.

3.6.2 In ROADM, since it is not clear beforehand as where a signal can be potentially routed, therefore there shall be a necessity of power balancing of these signals. ROADMs therefore shall also allow the automatic power balancing.

3.6.3 The ROADM shall be compact in size and shall require low power consumption and low insertion loss. It shall provide Express channel equalization. ROADM shall provide add/drop scalability from 0 to 40/80 channels.

3.6.4 The ROADMs considered in this standard can be (a) Coloured-Directional, (b) Coloured-Directionless and (c) Colourless-Directionlessadd/drop for all fiber directions and shall be enabled by ASON control plane in case of Directionless ROADM for optical service provisioning and restoration support for preplanned restoration.

3.6.5 The ROADMs shall be provisioned with integrated VOAs (Variable Optical Attenuators) for automation and shall be in-service upgradable by a terminal from 2Degree-ROADM to Multi Degree-ROADM as per the requirement.

3.7 The DWDM line transponders/interfaces shall implement the Forward Error Correction (FEC) algorithm as per ITU-T Rec. G.709, G.975 or G.975.1. The System shall support Hard Decision and Soft decision (SD) FEC mechanism for 100G. Accordingly, Long Haul and Very Long Haul 100G systems shall support either of following FEC coding gain:

- OTN standard requires 7% Overheads FEC bytes with Hard-Decision (HD) decoding for a minimum Net Coding Gain (NCG) of 7.0 dB.
- Soft-Decision (SD) decoder with 15% to 25% Overheads FEC bytes can improve NCG to 11 to 12.0 dB.

3.8 The fibre-media as stipulated in this document shall be compliant to ITU-T Rec. G.652D/ITU-T Rec. G.657A single-mode optical fibre and ITU-T Rec. G.655 NZ-DSF fibre.

3.9 At the junction point, where the traffic from the terminating hop is to be patched onto the new originating hop, no RX-Transponder shall be required unless 3-R Regeneration of the channels is required or is specifically ordered by the purchaser.

3.10 The equipment shall support Coherent Channel Systems to compensate the dispersion occurring in the link, equipped for the final capacity at the interface rate of 100G/200G.

3.11 The manufacturer shall supply entire common hardware including ROADM, Mux/Demux, Coherent Channel System and embedded control & management software etc. for 40/80channels @ 100G/200G DWDM system on day one. The system shall hitlessly upgrade in field to 40/80 channels @100G/200G through insertion of Transponders/Muxponders cards and associated chassis only, to reach its full capacity.

3.12 The removal/insertion of any Transponder/Muxponder card shall not disturb the working or deteriorate the BER of the other working channels in the system.

3.13 To accurately simulate the performance of the offered equipment under end of life conditions (i.e. equipment with aged components operating at maximum channels over aged fibre) and ensure successful transmission at 100Gbps/200Gbps per channel over high loss optical fibre, a comprehensive network planning tool shall be supported. The tool may be standalone or may be integrated in to EMS. The tool shall, among others, perform the following analysis and recommend the suitable hardware components as well as settings (i.e. optical power, gain) to mitigate the limiting effects:

i) Attenuation (including optical fibre loss, system component loss and margins),
ii) Chromatic dispersion (including required residual dispersion and dispersion compensation),
iii) Polarization mode dispersion (including contribution from both optical fiber and system components),
iv) Optical signal to noise ratio (OSNR) and
v) Non-linear effects (inc. XPM, SPM, FWM and SRS) (optional)

Note: Opting for the Planning Tool shall be optional.

3.14 As an option to the purchaser, 100G/200G DWDM system shall allow direct interface with 100G/200G Alien wavelength from 3rd party system to Mux input and the same signal shall be available directly from the De-multiplexer at the other end. In such cases, it may not be useful to use Transponders at either of the end points. That means the equipment shall support direct interworking with narrow wavelength coloured interface (as per ITU-T Rec. G.694.1 DWDM grid) from MSPP equipment for interfacing 100G/200G optical signals without Transponders.

3.15 The terminations for the unused channels shall be provided by the manufacturer as a part of the system. It shall be possible to equip the unused channel at a later date without affecting the existing traffic.

3.16 The system shall support one Optical Supervisory Channel (OSC) as specified by ITU-T Rec. G.692 for the monitoring and configuration of OTM, ILA, OADM and ROADM on the route and shall be manageable from one location for the entire route via the EMS and LCT of the local equipment. All OSC related functions including transmission, termination and processing shall be integrated within a single card. The Optical supervisory channel is compliant to G.692 and uses the 1510 nm wavelength in both transmission directions. Optical shelf offers up to 16 OSC per NE, each providing 12.5 Mbit/s or 150 Mbit/s bit rate OSC with a bandwidth of 10 Mbit/s or 75 Mbit/s respectively. This OSC design provides monitoring and configuration of OTM, ILA, F/ROADM on the entire route, manageable from one location via the EMS or LCT of the equipment.

3.16.1 Supervisory parameters:

The supervisory system of the equipment shall be capable of local & remote monitoring the following:

1. Input power of the Booster Amplifier
2. Output power of the Booster Amplifier

3. Laser temperature of the Booster Amplifier (optional)
4. Input power of the pre-amplifier
5. Output power of the pre-amplifier
6. Laser temperature of pre-amplifier(Optional)
7. Input power of the Optical Line Amplifier
8. Output power of the Optical Line Amplifier
9. Laser temperature of the Optical Line Amplifier(Optional)
10. Input power of the Insert Channel
11. Output power of the Dropped Channel
12. Input power of the Transponder
13. Output power of the Transponder
14. Laser temperature of the Transponder(Optional)
15. Input power of the individual optical channel
16. Input power of the Optical Supervisory Channel (optional)
17. Output power of the Optical Supervisory Channel (optional)
18. Laser temperature or Laser-Bias current of the Optical Supervisory Channel(Optional)
19. B-1 Errors of individual Transponders/Mux-ponder.
20. Total power at the input of Booster amplifier
21. Total power at the output of Booster amplifier.
22. Total power at the input of Line amplifier
23. Total power at the output of Line amplifier
24. Total power at the input of Pre- amplifier
25. Total power at the output of Pre- amplifier
26. Bit error ratio (BER) before FEC at OTU-2/OTU-3 AND OTU-4 line interface of the Transponders/Muxponders
27. Fan failure at OADM/ILA/OTM.
28. 100G Transponder and 10X10G Muxponder, as per Annexure-III

3.16.2 The supervisory parameters shall be monitored and on crossing the specified limits an alarm shall be activated against each parameter listed as above. On the basis of nature of alarm, it shall be possible to mark it as Critical, Major and Minor.

3.16.3 The measurement accuracy of input/output power of the Booster/In-Line Amplifier/ Pre-Amplifier/ Transponders from the EMS of the system shall be within ± 1.0dB from the actual measured value on a wide-band Optical Power Meter.

3.16.4 The supervisory system shall provide necessary audio/visual alarm on equipment for indicating the alarms. Also from the EMS of the system it shall be possible to locate the faulty-section in the case the fibre is cut.

3.16.5 To maintain transparency and supervision capability of client services in accordance with ITU-T Rec. G.709, all client services shall be supervised by processing the ODU/OTU overhead bytes. At least path monitoring (PM) and section monitoring (SM) shall be supported.

3.17 The system shall provide software controlled Optical Pre-emphasis via Variable Optical Attenuators (VOA) in case of Fixed OADM's else use inbuilt mechanism when using WSS based ROADM's. The optical power per channel must be adjusted automatically, without using external measurement equipment. The adjustment arising out of adding/removing channels has to be done without manual adjustment.

3.18 The equipment shall have the provision for monitoring the performance of individual client through B1 byte of SDH. Also, in the case Ethernet support, there shall be the provision of analysis of Ethernet frames at GigE, 10 GE and 100 GE Transponders on the client side.

3.19 The equipment shall provide support for a comprehensive Element Management System (EMS). The managed-object database access protocol shall be either:

TL-1, SNMPver.2c (or later) interface or any other communication mode based on any standard protocol stack shall be provided for South Bound Interface. In case of total loss of EMS connectivity, the sub-network shall continue to provide the services without any deterioration.

3.20 The upgradeability of the equipment including Optical In-Line Amplifiers shall be possible without discarding the existing hardware.

3.21 The equipment shall provide built-in 'plug and play' type of Optical Equalization/ Pre-emphasis, if any, to meet individual channel power difference (channel-power balancing) and individual channel OSNR requirements etc. No field adjustments such as use of external attenuators etc., at the output of Mux/Transponders shall be permitted for the purpose of equalization/gain adjustments etc.

3.22 The equipment shall support built in soft selectable electronic optical attenuator or shall support built-in mechanism or shall support automatic gain control mechanism on the Booster amplifiers, ILAs and Pre Amplifiers to adjust the span loss as per the actual requirements of field. The optical attenuator shall be variable supporting up to 20 dB loss in steps of 0.5 dB. The manufacturer shall strictly comply with span-loss range for the ILAs & OADMs as per the standard to cope with parametric specifications of Table 1a, 1b, 2a, 2b, 3 & 4/Annexure I. The standard expects the ILAs and OADMs to be designed to cope with the span-loss range from 17-22db for Longhaul & 23-28dB for Very Long haul application codes, at a minimum.

3.23 From evaluation testing perspective, the client optical interfaces of the transponders at STM-64 bit rates shall be S 64.2a or S 64.2b optical interfaces@1550nm window as specified in ITU-T Rec. G.691 or 10GE interfaces at 10GBASE-ER/EW, 10GBASE-LR/LW. The client optical interfaces for 40G and 100G have been defined in this standard. Other application codes may be demanded by the purchaser. The interfaces offered for testing shall be clearly marked out on the certificate.

3.24 The equipment shall provide end to end performance at the BER of 1x10⁻15 at end of the life. To ensure end-of-life margins, the span lengths shall be tested for 3dB higher values than that values specified during testing

3.25 The equipment shall adopt standard mapping techniques for GFP/GMP/AMP mapping. Forward Error Correction coding and multiplexing techniques as per ITU-T Rec. G.7041, G.975.1 and G.692 standards respectively. The output of Muxponder/Transponder shall be in a standard ITU-T format.

3.26 There shall be sufficient sideways space for the running of the fibres/cables for inter- rack cabling etc. It shall be possible to handle the cabling from the front or rear side.

3.27 There shall be provision of in-service monitoring points for the optical power, channel wavelength and OSNR measurement (Optional) at output points of Optical Amplifiers (including ILA's), OADM's, Mux & input point of Demux.

3.28 Online Optical Performance Monitoring

The optical monitoring of the DWDM system shall provide the facility of locally and remotely monitoring of some important parameters as specified in the ITU-T Rec. G.697. The system shall support centralized configuration for optical-layer parameters. Specifically, it shall perform monitoring and analysis of 100G/200G system performance and in-service performance optimization, support visualized analysis of optical-layer performance data (such as multiplexed-wavelength optical power, single-wavelength optical power/OSNR(Optional), BER, gain, attenuation, fiber loss, and flatness) and comparison with historical performance data. The system shall monitor and report network optical-layer performance in real time to EMS. The system shall monitor main optical path performance,

flatness, and input optical power of the receive-end OTU board. After receiving the error information reported by equipment, the system shall uniformly process the error information and starts optimizing abnormal trails. The system shall perform the following optical-layer performance optimization: line loss compensation optimization, optical power optimization, and optical signal-to-noise ratio (OSNR) equalization.

The system will support following measurements:

I. **Channel power:**

a. Channel power at the DWDM transmitter output before the multiplexer.

b. Channel power at the DWDM receiver input after the demultiplexer.

c. Channel power at the output of various stages of optical amplification(optional).

II. **Total power**: The equipment shall support the total channel power measurements at the following points:

a. Total power at input of various stages of optical amplification.

b. Total power at output of various stages of optical amplification.

III. The BER before FEC shall also be monitored by analyzing of the number of corrected bits by FEC as specified in ITU-T Rec. G.798.

IV. **Fiber performance Monitoring (Optional)**

The DWDM system or a separate system shall support to monitor and manage line fibers in a network. By precisely detecting the fiber connection status, the system shall help maintenance personnel to analyze the quality of fiber connectors and splicing points, which facilitates quick fiber issue diagnosis. In a WDM system, fiber issues, such as fiber aging, fiber damages, fiber coiling, large-radius bending, and large pulling stress, may cause large fiber attenuation and high BERs that will consequently impair network operating.

3.29 **Jitter & wander:**

The output jitter and input jitter tolerance specifications (considering the worst-case channel) for transponders, at all DWDM channels, shall be as per relevant ITU-T Recs. G.825 and G.783 for SDH and as per IEEE 802.3 standards for Ethernet client signals. The jitter and wander for the ODU (OTN) shall be as per ITU-T Rec. G.8251.

3.30 **Monitoring points:**

There shall be the provisioning of monitoring points for monitoring of channel power, OSNR and wavelengths at the output points of Booster Amplifier, In Line Amplifier and Pre-amplifier using external OSA/DWDM analyzer etc. These points shall be suitably connectorised and on connection of a measurement device, the main transmission path shall not be affected at all.

3.31 **Type of connectors:**

The connectors used at the OTM, Optical Amplifiers and OADMs shall be SC/LC/E2000 type with automatic shutters having spring-action or provision of closing them manually. When out-of-use, they shall remain closed or otherwise the optical connectors shall be so positioned as to be leaning down towards ground to avoid direct laser-beam incidence on the user. The Return Loss of the optical connectors shall be ≥40dB. At the ODF/FDF-end, the connectors used shall be Angle Polished FC/APC type.

3.32 **Error Performance:**

The equipment shall support the following performance parameters relating to the ODU-k as specified in ITU-T Recs.G.8201 and G.7710.

1. Optical Channel Transport Unit Background Block Error (OTU_ BBE).
2. Optical Channel Transport Unit Errored Second (OTU_ ES).
3. Optical Channel Transport Unit Severely Errored Second (OTU_ SES).
4. Optical Channel Transport Unit Unavailable Second (OTU_ UAS).

5. Optical Channel Transport Unit Far End Error Background Block Error (ODU_FEBBE).
6. Optical Channel Transport Unit Far End Errored Second (ODU_FEES).
7. Optical Channel Transport Unit Far End Severely Errored Second (ODU_FESES)
8. Optical Channel Transport Unit Far End Unavailable Second (OTU_ FEUAS).
9. Optical Channel Data Unit Path Monitoring Background Block Error (ODU_PM_BBE).
10. Optical Channel Data Unit Path Monitoring Errored Second (ODU_PM_ES)
11. Optical Channel Data Unit Path Monitoring Severely Errored Second (ODU_PM_SES).
12. Optical Channel Data Unit Path Monitoring Unavailable Second (ODU_PM_UAS).
13. Optical Channel Data Unit Path Monitoring Far End Error Background Block Error (ODU_PM_FEBBE).
14. Optical Channel Data Unit Path Monitoring Far End Errored Second (ODU_PM_FEES).
15. Optical Channel Data Unit Path Monitoring Far End Severely Errored Second (ODU_PM_FESES)
16. Optical Channel Data Unit Path Monitoring Far End Unavailable Second (ODU_PM_FEUAS)

3.33 **Alarms requirement:**

The equipment shall support the generation of following alarm conditions and it shall also be able to report alarms when integrated with the EMS:

1. Input power failure of the Transponder/Mux-ponder interface (including Ethernet interfaces).
2. Input power failure of the Amplifiers
3. Output power failure of the Amplifiers
4. Fan/s failure

5. Output power out of range for OA, ROADMs
6. Input power out of range for OA, ROADMs
7. Loss of input at Optical Add/Drop Multiplex equipment
8. Input channel failure at Optical Add/Drop Multiplex equipment
9. Hardware mismatch alarm
10. Low input power at Transponder
11. Low input power at OA, Optical Add/Drop multiplex equipment
12. Degraded input at OA, Optical Add/Drop multiplex equipment
13. Degraded output of OA, Optical Add/Drop multiplex equipment
14. Degraded output of the dropped channel.
15. GMP related alarm for GE clients. (Optional, may be decided by the purchaser)

3.33.1 The equipment shall support following ODU-k related alarms, as listed in ITU-T G.798 and it shall also be able to report these alarms when integrated with the EMS:

1. OTU-k Loss of Frame alarm (OTU -LOF).
2. OTU-k Loss of Multiframe alarm (OTU -LOM).
3. Loss of Payload alarm (LOS-P).
4. Open Connection Indication alarm (OCI).
5. OTU-k Degrade Defect alarm.
6. OTU-k Trace Identifier Mismatch alarm (OTU-k TIM).
7. OTU-k-AIS alarm
8. OTU-k Backward Defect Indication alarm (OTU-BDI).
9. OTU-k Payload Mismatch alarm.
10. ODU-k AIS alarm at path layers
11. ODU-k Backward Defect Indication alarm (ODU-kpBDI) at path.
12. ODU-k Locked Defect alarm at path layers.
13. ODU-k signal degrade alarm (ODU-kpDEG)
14. ODU-k loss of frame and multi frame. ODU-LOFLOM)

15. ODU-k Trace Identifier Mismatch alarm (ODU-k TIM) at path level.
16. ODU-k Payload mismatch alarm at path level (ODU-kp PLM).

Note: These alarms shall be categorized as Urgent, Non-urgent and Deferred alarms, with threshold programming by software, wherever applicable.

3.34 **Laboratory and Field testing of DWDM equipment:** The equipment shall be subjected to laboratory and field testing as per below schedule:

a) In Laboratory:

BER performance over a simulated-section shall be tested for 48 hours and BER performance shall be equal to or better than 10^{-12} (with FEC enable). For Ethernet clients, end to end IETF RFC 2544 compliance and ITU-T G.7041 – GFP mapping compliance shall be tested.

b) In field:

BER performance for 48 hours shall conform to ITU-T Rec. G.828 for SDH payloads. For Ethernet clients, end to end IETF RFC 2544 compliance and ITU-T G.7041 – GFP/GMP/AMP mapping compliance shall be tested.

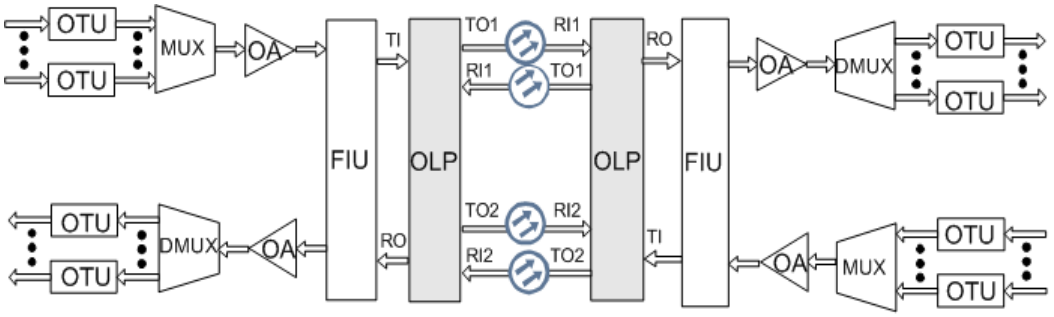
3.35 **Network Protection:**

The standard document specifies multiple protection at the DWDM Optical level.

Protection	Description
Optical Line Protection(50 ms Protection)	It uses the dual fed and selective receiving function of the *Optical Line Protection Switching device* board to protect line fibers between adjacent stations by using diverse routing. Refer Fig.12 below.
Client 1+1	It uses the dual fed and selective receiving function of

Protection	Description
Protection (50 ms protection)	the *Optical Line Protection Switching device* board to protect the OTU and the OCh fibers. Refer Fig.12 below.

Optical line protection



Client 1+1 protection

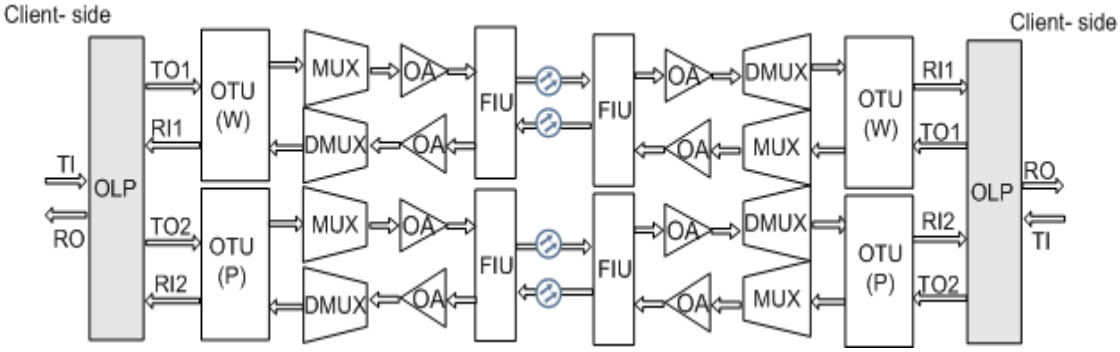


Fig 12: Diagram of OLP protection for 1+1 line & 1+1 client protection

Notations in the diagrams

OTU: Optical transponder unit

OTU(W): Optical transponder unit – Work path

OTU(P): Optical transponder unit – Protection path

MUX: Optical multiplexer

DMUX: Optical de multiplexer

OA: Optical amplifier

FIU: Fiber interface unit (For multiplexing & de multiplexing OSC)

TO1: Transmit output 1

RI1: Receive input 1

TO2: Transmit output 2

RI2: Receive input2

3.36 In case of total loss of EMS connectivity, the performance data of the NE shall be stored in the controller card of the equipment, and shall be sent to central EMS server upon restoration of EMS connectivity. Minimum 6400 performance and fault data messages containing a minimum of 100 alarms shall be stored by the system.

3.37 **ASON Feature**

3.37.1 The Automatically Switched Optical Network (ASON) is a new generation of the optical transmission network and has been defined in ITU-T Recommendation G.8081. The architecture of ASON is defined in ITU-T Recommendation G.8080. The ASON software provided by vendor shall be applied to the offered Metro DWDM equipment only to support the evolution from a traditional network to an ASON network. Such evolution complies with the ITU ASON related standards, such as G.7712 for call and connection management, G.7714 for auto-discovery technology, G.7712 for DCN, G.7715 for routing and G.7716 for link management.

3.37.2 ASON technology involves signalling, switching and a control plane to enhance its network connection management and recovery capability. ASON technology shall provide wavelength-level ASON services at the optical layer for Metro DWDM system. It shall also support end-to-end service configuration and the service level agreement (SLA). A typical ASON network is shown in the Figure.13.

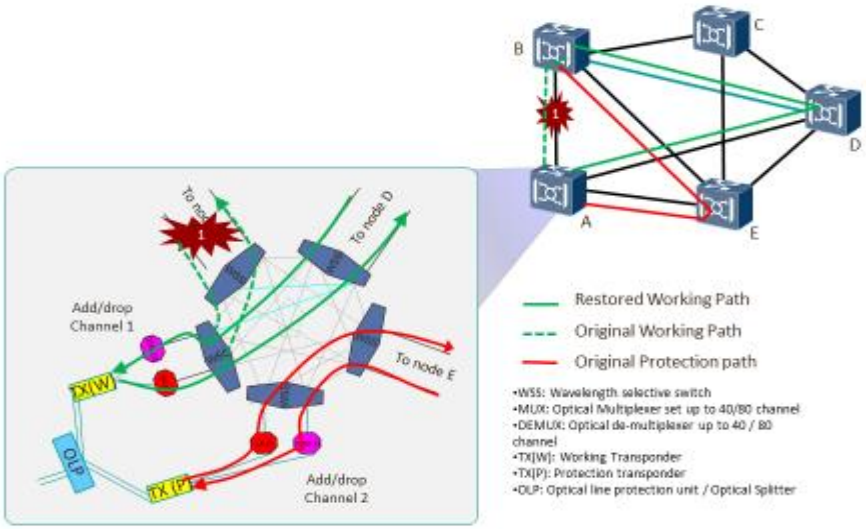


Figure 13-ASON protection and Management schematic

3.37.3 The ASON shall support following features:

a. It shall support automatic wavelength restoration on available path based on optical viability using Layer-0 Control Plane (WSON).

b. Wavelengths can be automatically allocated for newly created services.

c. Automatic configuration of end-to-end services.

d. Automatic discovery of topology.

e. Provides mesh networking that enhances the survivability of the network.

f. Supports different services which are provided with different levels of protection.

g. Provide traffic engineering in such a way that user shall be able to do constraint based routing of the services.

h. User shall specify the functionality of Layer-0 (WSON) Control which he intend to use in the network which can be implemented by the vendors by using different protocols to ensure the intended functionality as desired by the user.

3.38 **Diversified SLA (Service Level Agreement)**

ASON supports services with different protection levels, that is, diamond, silver, and copper services. Services with different protection levels are charged differently. Such diversified service schemes are more flexible in meeting customer requirements.

Table 1 Service levels available by ASON

Attribute Service	Protection and Restoration Scheme	Implementation Means	Performance
Diamond service	1+1 Protection with restoration.	1. Client 1+1 protection 2. Rerouting	1. Switching time < 50ms 2. Protect multi failures
Silver service	Restoration	1. Dynamic Restoration or pre plan restoration 2. Pre or post Calculation Restoration with proper 3R planning (Optional)	Protect multi failures
Copper service	No protection	-	-

3.39 The equipment shall support the generic requirements of fault, configuration, security, software, inventory and performance management when interfaced with EMS/NMS. The details of these management

functions is mentioned under Element Managements System later in this standard.

3.40 **LCT interface of NE:**

The system shall provide at least one Local and remote Management Interface at each NE - a Terminal, an ILA, an OADM or 3-R DWDM Regenerator. The equipment shall provide an Ethernet port for Work Station connectivity with standard RJ-45 connector.

4.0 **Operational requirements:**

4.1 The manufacturer shall guarantee satisfactory performance of the equipment without any degradation up to an altitude of 3,000 metres. A certificate to this effect shall be admissible.

4.2 The equipment shall be able to work without any degradation in saline atmosphere near coastal areas and should be protected against corrosion. A certificate to this effect shall be admissible.

4.3 Visual indication to show power ON/OFF status shall be provided.

4.4 Suitable visual indications shall be provided. (It is suggested that ‘green’ colour for healthy and ‘red’ colour for unhealthy conditions may be provided. Some other colour, preferably ‘Amber’, may be used for non-urgent alarms.)

4.5 The software/hardware in equipment shall not pose any problem due to changes in date and time caused by events such as changeover of millennium/ century, leap year etc., in the normal functioning of the equipment.

4.6 **Redundancy requirements:**

If the Controller/Processor unit/module failure does not affect the working traffic, no redundancy of Control/Processor unit shall be required. There shall be no disruption to the healthy operation of the equipment upon failure of controller/processor card. However, if the Controller/Processor unit failure does result in traffic failure, then (1+1) hot-standby mode redundancy of Controller/Processor shall be provided in the equipment. Further, there shall not be any disruption to system-working when the faulty card is taken out and the healthy one is inserted back. Immediately upon insertion of a healthy card, the system shall revert back to its pre-failure EMS configuration. There shall be support for dual-homing for EMS connectivity for no loss of EMS connectivity, through two Gateway NEs (GNE's) on a DWDM link. In case of total loss of EMS connectivity to the system/network, the system design shall provide local storage of all performance & fault data, as specified in Appendix-I of the standard, for all connections pertaining to all NEs, in the sub-network. Such connectivity loss might happen due to control-card failure at both GNE's and/or failure of DCN link to EMS. In-built intelligence shall be there in EMS for selection of appropriate GNE at distant end of a DCN link upon failure of control card at one of the GNE's, for EMS connectivity.

5.0 **Muxponders and Transponders**

The DWDM equipment shall support various types of Fixed/Tunable Muxponders and Transponders. As per purchaser requirement, the Muxponders and Transponders can also be two port types and shall be provided with tuneable lasers for the DWDM line interface covering the complete C-Band i.e., 40/80 discrete wavelengths at 100/50 GHz spacing with 3R functionality. If desired by the purchaser, the same can be of single port type. It is envisaged that all the client optics shall be of pluggable type (through SFPs) for easy in-service upgrades & maintenance ease.

Respective DWDM line interface of the Transponder/Muxponder shall be automatically verified by the system controller for correctly provisioned wavelength. The tuning shall happen automatically without using LCT/ EMS as soon as the card is inserted in the equipment

Following is the details of Muxponders and Transponders, which shall be supported by the DWDM equipment.

5.1 Fixed/Tuneable Muxponder

Single port or multiport Muxponder can be used to multiplex multiple STM-64/STM256 bit rates SDH payloads or multiple 10GigE interfaces to form 100Gbps/200Gbps coloured wavelength to Mux/Demux, after carrying out Forward Error Correction (FEC) encoding such as super-FEC specified in ITU-T G.975.1. The Muxponders shall be used at TX as well as RX end and shall be interfacing the Mux/Demux component of DWDM equipment.

5.1.1 100G Tunable Muxponder

(a) The client side of this type of Muxponder shall accommodate 10XSTM-64/10GE-WANPhy/10GE-LANPhy/ interfaces. This type of Muxponder shall map up to 10 nos. of optical client STM-64/10GE-WANPhy/10GE-LANPhy streams individually into OPU-2/2e>>ODU2/2e frame format, which shall subsequently be multiplexed into OTU-4 frame format and transported via a 100G optical wavelength in the DWDM grid as per ITU-T Rec. G.694.1. Hence, the DWDM line signal shall be an OTU-4 IaDI (Intra-domain Interface) including Super-FEC as per ITU-T Rec. G.975.1. Schematic diagrams for Typical 100G Muxponders is given at Fig.14.

(b) In the receive side, OTU-4 data carrying STM-64//10GE-WANPhy/10GE-LANPhy interfaces payloads shall be converted to electrical signal, after processing for error correction as per algorithms of FEC state machine specified in ITU-T Rec. G.975.1 and de-mapping

the overheads and other data of OTU-4, the payload data shall be de-multiplexed into 10 streams of OPU-2/2e and then to SDH payloads @ STM-64 bit-rate with optical interfaces as per ITU-T Rec. G.957 and shall be presented back to the client interfaces. It shall be a 3R muxponder.

(c) The equipment shall also support client services such as OTU-2IrDI (Inter-domain Interface) over the same hardware by simply performing a software upgrade and if required, introducing new SFP optics. Enabling and disabling of FEC of the OTU-2 shall be software configurable.

(d) The architecture of OTU-k (k=2 or 4) shall be as per ITU-T Rec. G. 806. The structure of OTU-k shall be strictly as per ITU-T Rec. G.709. The mapping of SDH data on to an OTU-k shall strictly follow the requirements specified in ITU-T Recs. G.709 and G.806 and shall support the generation of all the relevant alarms and monitoring and supervision of performance parameters specified in ITU-T G.707, G.709, G.798 and also in ITU-T Rec. G.872. The equipment shall support the management aspect of optical network as specified in ITU-T Rec. G.874.

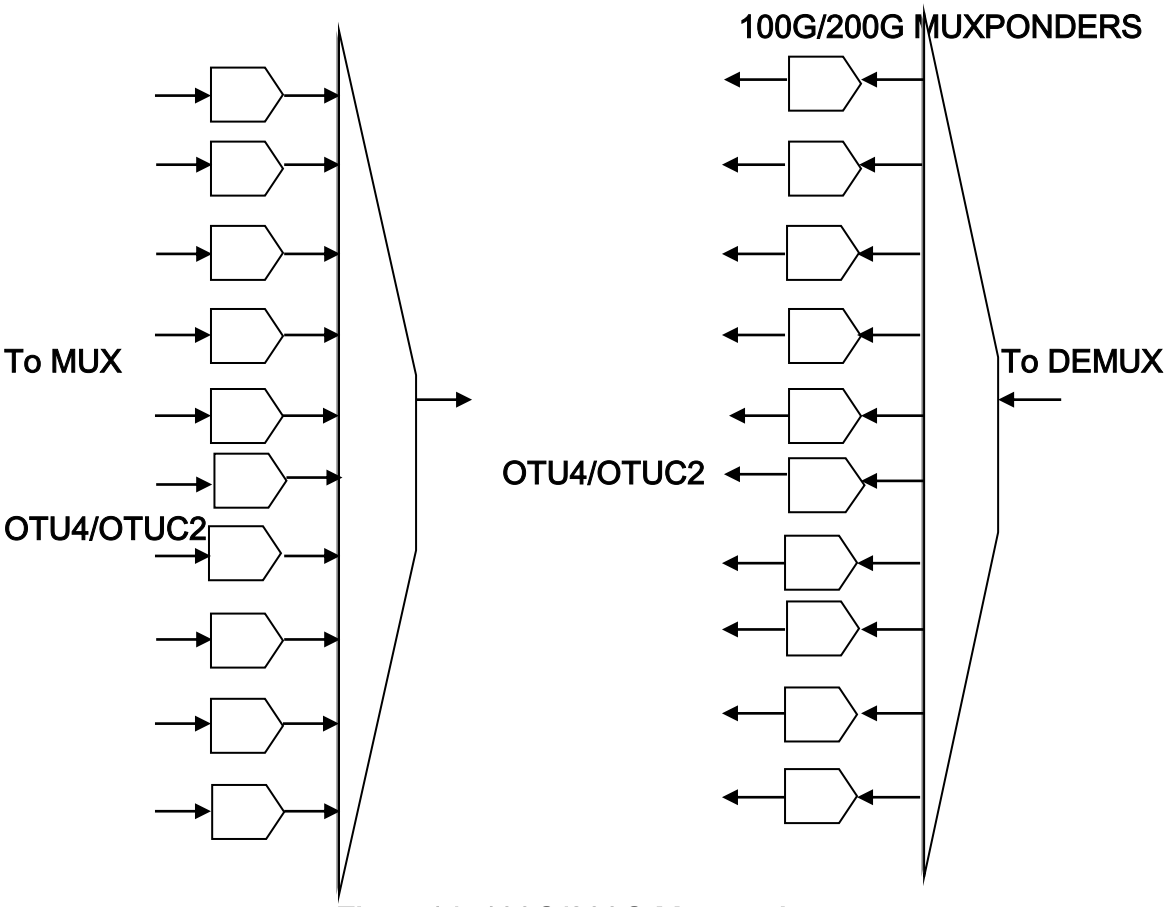


Figure14: 100G/200G Muxponder.

5.1.2 200G Tunable Muxponder

a) The client side of this type of Muxponder shall accommodate 10XSTM-64/10GE-WANPhy/10GE-LANPhy/ interfaces and 1x100 G Client. This type of Muxponder shall map up to 10 nos. of optical client STM-64/10GE-WANPhy/10GE-LANPhy streams individually into OPU-2/2e>>ODU2/2e frame format and 1 no. of Optical Client 100 G, which shall subsequently be multiplexed into OTUC2 frame format and transported via a 200 G optical wavelength in the DWDM grid as per ITU-T Rec. G.694.1. Hence, the DWDM line signal shall be an OTUC2 including Super-FEC as per ITU-T standard.

b) The client side of this type of Muxponder shall accommodate 20XSTM-64/10GE-WANPhy/10GE-LANPhy interfaces. This type of Muxponder shall map up to 20 nos. of optical client STM-64/10GE-WANPhy/10GE-LANPhy streams individually into OPU-2/2e>>ODU2/2e frame format

which shall subsequently be multiplexed into OTUC2 frame format and transported via a 200G optical wavelength in the DWDM grid as per ITU-T Rec. G.694.1. Hence, the DWDM line signal shall be an OTUC2 including Super-FEC as per ITU-T standard.

c) The client side of this type of Muxponder shall accommodate 2x100 GE/2xOTU4/ (mix of 1x100 GE and 1xOTU4) interfaces. This type of Muxponder shall map up to 2 nos. of optical client into OPU-4/4e>>ODU4/2e frame format which shall subsequently be multiplexed into OTUC2 frame format and transported via a 200 G optical wavelength in the DWDM grid as per ITU-T Rec. G.694.1. Hence, the DWDM line signal shall be an OTUC2 including Super-FEC as per ITU-T standard.

5.2 Transponder:

Following types of Transponders are envisaged in the standard:

Type-I: OTU4 Transponder

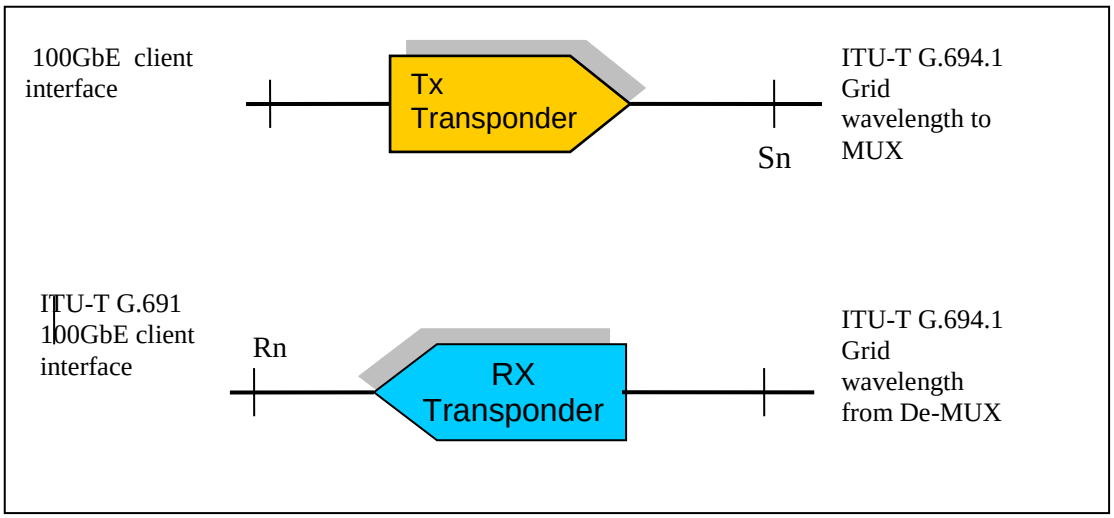
Type-II: 100GE Ethernet Transponder

5.2.1 Type-I: OTU4 Transponder

(a) One OTU4 client shall be mapped directly on DWDM coloured wavelength after regeneration and implementation of FEC algorithm. The Transponder shall interface OTU4 client from LAN and convert to electrical signal to carry out 3R functionality, subsequently to make it a data module of OTU-4 format as per ITU-T Rec. G.709. The Forward Error Correction (FEC) encoding shall be performed on the OTU-4 and computed redundant symbols of FEC shall be added as overheads to the OTU-4 data as per the algorithms of ITU-T Rec. G.975.1 for super FEC. The electrical data of OTU-4 with FEC data computed on it shall be assigned a discrete wavelength of ITU-T DWDM-Grid as specified in G.694.1. Such OTU-4 client then subsequently shall interface Mux part of DWDM equipment.

(b) In the receive side, optical data received at the input of transponder having OTU4 and super FEC contents shall be brought to electrical stratum, the super FEC decoder shall perform error correction and shall be extracting the redundant symbols and shall regenerate that data that was encoded by the FEC coder. The OTU4 pay load shall go for electrical to optical conversion, as per the interface requirements.

(c) The client optical interface at 'Receive Transponder' output towards 'Terminal Receiving Equipment' (TRE) for client interfaces shall be 1550nm single-mode interface. For OTU4 client's optical interfaces also, the equipment shall comply with the parametric requirements of Tables 1a,1b, 2a, 2b, 3 &4/Annexure-I, at 'Sn' & 'Rn' reference points.



Figue15-TX & RX Transponder interface.

Note: The transponders described above shall provide 3-R functionality.

5.2.2 Type-II: 100GE Ethernet Transponder

(a) One 100GbE client shall be mapped directly on DWDM coloured wavelength after regeneration and mapping necessary overheads for ODU and FEC. The Transponder shall interface 100GbE data from LAN and convert to electrical signal to carry out 3R functionality, thereafter, the necessary processing of payload shall be done to add overheads of OPU/ ODU to make it a data module of OTU-4 format as per ITU-T Rec. G.709. The Forward Error Correction (FEC) encoding

shall be performed on the OTU-4 and computed redundant symbols of FEC shall be added as overheads to the OTU-4 data as per the algorithms of ITU-T Rec. G.975.1 for super FEC. The electrical data of OTU-4 with FEC data computed on it shall be assigned a discrete wavelength of ITU-T DWDM-Grid as specified in G.694.1. The100GbE Ethernet data formatted in OTU-4 format with added FEC, in optical domain shall interface Mux part of DWDM equipment. The optical interface of 100Gigabit Ethernet shall be 100GBASE-LR4 or 100GBASE-ER4 as per IEEE 802.3ba at 1550 nm window on single-mode fibre. Figure 15 above, show a block schematic of a typical 100GbE transponder.

(b) In the receive side, optical data received at the input of transponder having OTU4 and super FEC contents shall be brought to electrical stratum, the super FEC decoder shall perform error correction and shall be extracting the redundant symbols and shall regenerate that data that was encoded by the FEC coder. The payload data in OTU4 format shall be demapped and overheads shall be removed and 100GbE payload shall be reconstructed. The 100GbE pay load shall go for electrical to optical conversion, as per the interface requirements. 100GbE payload shall be assigned a grey wavelength, meeting the interface specifications of 100GBASE-LR4 or 10GBASE-ER4 as per IEEE 802.3ba.

(c) The client optical interface at 'Receive Transponder' output towards 'Terminal Receiving Equipment' (TRE) for client interfaces shall be 1550nm single-mode interface. For 100GbE client's optical interfaces also, the equipment shall comply with the parametric requirements of Tables 1 & 2/Annexure-I, at 'Sn' & 'Rn' reference points - like SDH client optical interfaces.

Note: The architecture of OTU-4 shall be as per ITU-T Rec. G.806. The constituents and structure of OTU-4 shall be strictly as per ITU-T Rec.

G.709. The mapping of Ethernet data on to an OTU-2 shall strictly follow the requirements specified in ITU-T Recs. G.709 and G.806 and shall support the generation of all the relevant alarms and monitoring and supervision of performance parameters specified in ITU-T G.709, G.707, G.798 and also in ITU-T Rec. G.872. The equipment shall support the management aspect of optical network as specified in ITU-T Rec. G.874.

6.0 **DWDM System Technical specifications:**

6.1 **DWDM window of operation** -The optical window of operation of the DWDM system shall be in the range from 1529nm to 1565nm (C-band) as per ITU-T Rec. G.694.1.

6.2 **Channel spacing-**The nominal central wavelength spacing shall be 100/50GHz and the source wavelength variation shall be as per Tables 1a, 1b, 2a, 2b, 3 &4/Annexure-I. Any consecutive 40/80 wavelengths may be chosen by purchaser from DWDM-grid as specified in ITU-T Rec. G.694.1.

6.3 **Central frequency-**The allowed channel frequencies are based on a grid with reference frequency at 193.1 THz.

6.4 **Client interface specifications and channel bit rates for 100G/200G DWDM Equipment:**

The client interface channel bit-rates at DWDM transponders/muxponders shall be as detailed below:

a) **SDH interfaces**

STM-64 (9953.280Mb/s): This client interface shall support @ PIII-2D1/Table-3 application code of ITU-T G.959.1, P1S1-2D2b/Table 8.4 of ITU-T G.959.1 on single mode optical fibre and S-64.2a/b interfaces as per ITU-T G.691. The client interface shall also support OTU-2 IrDI interface as per ITU-T Recs. G.959.1 and G.709. The jitter

and wander specifications shall be as per ITU-T Recs. G.825, G.783 and G.8251. The selection of interfaces shall be as per purchaser's requirements.

b) **Ethernet interfaces:**

Optical 10 Gigabit Ethernet (10GbE): 10G BASE-LR & ER as per IEEE 802.3ae standard optical interfaces for LAN applications(10.3125Gb/s), 10GBASE-LW and 10GBASE-EW as per IEEE 802.3ae standard optical interface for WAN applications (9.95328Gb/s-PHY) over single mode fibre shall be supported. The selection of interfaces shall be as per the purchaser's requirements. Interface specifications of 10GE interfaces shall be as per Table-6 (Table 52-7/IEEE 802.3ae), Table-7 (Table 52-9/IEEE 802.3ae), Table-8 (Table52-12/IEEE 802.3), Table-9(Table 52-13/IEEE 802.3), Table-10(Table 52-16/IEEE 802.3) and Table-11(Table 52-17/IEEE 802.3) as given in Annexure-I. The dispersion requirements and jitter & wander characteristics shall be as per IEEE 802.3ae.

Optical 100 Gigabit Ethernet (100GbE): This interface is defined by the IEEE 802.3ba-2010 standard. Two interfaces, 100GBase-ER4 (Extended range) and 100GBase-LR4 (Long range) are port type for single-mode fiber and uses four lasers using four wavelengths around 1300nm. Physical CodingSublayer64b/66b PCS for these interfaces is defined in IEEE 802.3 under clause-82 and Physical Medium Dependent PMD in Clause-88. Each wavelength carries data at a rate of 25.78125Gbit/s.

(c) **OTU4**

OTU4 on the client side shall support G.709 compliant forward error correction, PRBS function. It shall also support PM & TCM non-intrusive monitoring function.

(d) **Optical 40 Gigabit Ethernet Interface(Optional):**40GBASE-LR4 (Long Range) is a port type for single-mode fiber and uses 1300 nm lasers. Its Physical Coding Sublayer 64b/66b PCS is defined in IEEE 802.3 Clause 82 and its Physical Medium Dependent PMD in Clause 87. It uses four wavelengths delivering serialized data at a rate of 10.3125 Gbit/s per wavelength.

6.4.1 The equipment shall support following client-side pluggable modules:

I. 40GBase-LR4-10Km-CFP
II. 40GBase-ELR4-40Km-CFP
III. 100GBase-LR4-10Km-QSFP28
IV. 100GBase-ER4-40Km- QSFP28
V. 100GBase-10*10G-10km- QSFP28
VI. (100GBase-4*25G)/(OUT4-4*28G)-10Km QSFP28

6.5 100G and 200G Technical Specifications:

6.5.1 100G DWDM equipment shall support following DWDM- side fixed modules:

I. 40000 ps/nm-C Band-Tunable Wavelength-Single Carrier Coherent-QPSK(HFEC) with HD FEC
II. 55000 ps/nm-C Band-Tunable Wavelength-Single Carrier Coherent-QPSK(SDFEC) with SD FEC(SDFEC) (Optional)

6.5.2 200 G DWDM equipment shall support following DWDM- side fixed modules:

I. 20,000 ps/nm-C Band-Tunable Wavelength-Single Carrier Coherent-mQAM (m = 8) with HD FEC as well as/or SDFEC
II. 16,000 ps/nm-C Band-Tunable Wavelength-Single Carrier Coherent-mQAM (m = 16) with HD FEC as well as/or SDFEC

The specifications of DWDM- side fixed modules are given in Table-15, Table-16, Table-17 and Table 18 whereas specifications for client – side pluggable modules are given in Table-19, Table -20, Table- 21and Table - 22 at Annexure-I.

6.6 **100G Tech specs QSFP28 Standard**

(a) The 100G QSFP28 LR4 is a 100Gb/s transceiver module designed for optical communication applications compliant to 100GBASE-LR4 of the IEEE P802.3ba standard. The module converts 4 input channels of 25Gb/s electrical data to 4 channels of LAN WDM optical signals and then multiplexes them into a single channel for 100Gb/s optical transmission. Its 100Gb/s high sensitivity PIN receivers provide superior performance for 100Gigabit Ethernet and OTU 4 applications up to 10km links and compliant to optical interface with IEEE802.3ba 88 100GBASE-LR4 requirements.

(b) The 100G QSFP28 SR4 is a four-channel, pluggable, parallel, fiber-optic QSFP+ SR4 optical transceiver module for 100/40 Gigabit Ethernet, Infiniband DDR/EDR and 32GFC applications. This transceiver is a high performance module for short-range multi-lane data communication and interconnects applications. It integrates 4 data lanes in each direction with 112.2 Gbps bandwidth. Each lane can operate at 8.055Gbps up to 70M using OM3 fiber or 100M using OM4 fiber. The module is designed to operate over multimode fiber system using a nominal wavelength of 850nm.

Note-1: The purchaser may also specify requirements for IEEE 1000BaseSX, 10GBASE-SR and 10GBASE-SW at multi-mode optical interfaces.

Note-2: The optical power budgets for the Ethernet interfaces are as given in Annexure-1.

7.0 **Engineering requirements:**

a. The equipment shall be fully solid-state and adopt state-of-the-art technology. There shall be common shelf for all possible configurations e.g., Terminal, OADM and ILA. Only a main universal shelf and extension universal shelves shall be allowed for any configuration. But the entire OADM, OTM and ILA shall be controlled by a single control card in the respective nodes.

b. The equipment shall be compact and composite in construction and shall be light-weight. The actual dimensions and weight of the equipment shall be furnished by the manufacturer.

c. All connectors shall be reliable and of standard type to ensure failure-free operation over long periods under specified environmental conditions. All cables & components shall be CACT approved.

d. All connectors and cables used shall be of low-loss type and suitably shielded. The type of connectors used at the application interfaces & the user- interfaces shall be of wire-wrapping type or as per any other international industry standard. No soldering shall be allowed for the connectors. The positioning of the connectors shall be on the front end of the relevant Transponder/Muxponder cards so as to facilitate the ease of handling during operation.

e. The equipment shall be housed in standard 19" or ETSI standard rack and shall provide front access as well as rear access in standard 300mm, 60mm or 750mm depth rack.

f. The equipment shall provide natural cooling arrangement which shall not involve any forced cooling by using fans etc., either inside or outside the equipment. In case, the natural cooling arrangement is not sufficient, the manufacturer may use fans for cooling purposes provided:

- The fan failure is reported through LCT/EMS.

- Multiple fans are there in one tray with hot-standby redundancy.
- Fans are located at convenient place in the equipment not disturbing the internal equipment layout.
- Fans are DC operated.
- MTBF is better than 1,00,000 hours.
- Inclusion of fans for cooling purposes does not deteriorate the MTBF values of the equipment.
- There shall be fan failure alarm for each of the installed fan.
- The power consumption of all the fans provided with equipment shall not exceed the 20% of the total power consumption of that particular sub-rack under the fully equipped conditions.

g. The supervisory indications, built-in test equipment (BITE) and other control/ switches shall be provided at convenient locations for ease of maintenance.

h. The plug-in units shall be hot-swappable to allow easy removal/ insertion while the equipment is in energized condition.

i. The mechanical design and construction of each card/ unit shall be inherently robust and rigid under all conditions of operation, adjustment, replacement, storage & transport and shall conform to the latest quality manuals of the purchaser.

j. Each sub-assembly shall be clearly marked with schematic references to show its function, so as to be easily identifiable from the layout diagram in the handbook.

k. Each terminal block and individual tag shall be numbered suitably with clear identifying code and shall correspond to the associated wiring drawings.

l. All controls, switches & indicators etc., shall be clearly marked to show

their circuit designation and functions.

m. Important Do's and Don'ts about the operation of the equipment shall be clearly indicated at a convenient place on the equipment.

n. The optical safety shall be as defined in ITU-T Rec. G.664 & IEC 60825-1 (latest edition). The optical access ports shall be designed to protect themselves against the entry of dust when they are not occupied by an external fibre-optic connection. To prevent the failures in the optical line devices due to ingress of dust, the connectors provided at all high output devices shall be provisioned with the auto-shutter or shall be so positioned as facing downwards to avoid direct incidence of laser-beam on the user. The optical access port shall be easy to clean by the user.

o. All the optical connections shall have front access only. No access from the rear or from the sideways shall be permitted. There shall be elevated fibre guide with clip & wire saddles to guide the fibre to/from each module. There shall be separate channel in the rack to run the electrical cables and fibres. It shall be preferable that there shall be separate fibre slot for routing the client side fibres and line side fibres. All the leading–in cable shall have the proper arrangements to avoid accidental failures.

8.0 **Quality requirements:**

8.1 The manufacturer shall furnish the MTBF/MTTR values. MTBF values wherever specified in the standard, shall be met. The calculations shall be based on the latest operator's quality manual on "Reliability Methods and Predictions" or any other international standard.

8.2 The equipment shall be manufactured in accordance with international quality management system ISO-9001:2000 for which the manufacturer shall be duly accredited. A quality plan describing the quality assurance system followed by the manufacturer, shall be required to be submitted.

The equipment shall also meet the latest quality manual of the operator on

a. Quality and reliability in product design,
b. Guidelines for standard of workmanship for printed boards and assemblies,
c. Guidelines for standard of workmanship for surface mounted devices,

The supplier shall furnish a certificate from the manufacturer to this effect which shall be verified at the time of technical evaluation of the system.

8.3 The equipment shall conform to the requirement for the latest operator's quality manual for specification for environmental testing of electronic equipment for transmission and switching use for operation, transportation and storage, including vibration test.

8.4 The equipment shall conform to the requirements for environment as specified in the DoT-QA document QM-333 (Issue March 2010) - "Specification for environmental testing of electronic equipment for transmission and switching use". The applicable tests shall be taken for environmental category A including vibration test.

9.0 **Electromagnetic Compatibility (EMC) Requirements**

The instrument shall conform to the EMC requirements as per the following standards and limits indicated therein. A test certificate and test report shall be furnished from a test agency.

9.1 **Conducted and radiated emission:**

Name of EMC Standard: "CISPR 32 {2015}-Limits and methods of measurement of radio disturbance characteristics of Information Technology Equipment".

Limits:-

i) To comply with Class A of CISPR 32 {2015}

ii) The values of limits shall be as per TEC Standard No. TEC/SD/RD/EMC-002/02Oct.2016 with Amendment No. 1 dated 01.01.2008.

iii) For radiated Emission tests, limits below 1Ghz shall be as per Table 4(a) or 5(a) for measuring distance of 10m or Table 4(a1) or 5(a1) for measuring distance of 3m

9.2 **Immunity to Electrostatic discharge**

Name of EMC Standard: IEC 61000-4-2 {2008) "Testing and measurement techniques of Electrostatic discharge immunity test".

Limits:

i) Contact discharge level 2 {± 4 kV} or higher voltage;

ii) Air discharge level 3 {± 8 kV} or higher voltage;

9.3 **Immunity to radiated RF**

Name of EMC Standard: IEC 61000-4-3 (2010) "Testing and measurement Techniques-Radiated RF Electromagnetic Field Immunity test"

Limits:-

For Telecom Equipment and Telecom Terminal Equipment with Voice interfaces (s)

i) Under Test level 2 {Test field strength of 3 V/m} for general purposes in frequency range 80 MHz to 1000 MHz and

ii) Under test level 3 (10 V/m) for protection against digital radio telephones and other RF devices in frequency ranges 800 MHz to 960 MHz and 1.4 GHz to 6.0 GHz.

For Telecom Terminal Equipment without Voice interfaces (s)

Under Test level 2 {Test field strength of 3 V/m} for general purposes in frequency range 80 MHz to 1000 MHz and for protection against digital radio telephones and other RF devices in frequency range 800 MHz to 960 MHz and 1.4 GHz and 6.0 GHz.

9.4 **Immunity to fast transients (burst)**

Name of EMC Standard: IEC 61000- 4- 4 {2012) "Testing and measurement techniques of electrical fast transient's/burst immunity test"

Limits: -Test Level 2 i.e. a) 1 kV for AC/DC power lines; b) 0. 5 kV for signal / control / data / telecom lines;

9.5 **Immunity to surges**

Name of EMC Standard: IEC 61000-4-5 (2014) "Testing & Measurement techniques for Surge immunity test"

Limits: -

i) For mains power input ports: (a)2 kV peak open circuit voltage for line to ground coupling (b) 1 kV peak open circuit voltage for line to line coupling

ii) For telecom ports: (a) 2 kV peak open circuit voltage for line to ground (b) 2 kV peak open circuit voltage for line to line coupling

9.6 **Immunity to conducted disturbance induced by Radio frequency fields:**

Name of EMC Standard: IEC 61000-4-6 (2013) "Testing & measurement Techniques-Immunity to conducted disturbances induced by radio-frequency fields"

Limits: -

Under the test level 2 {3V r.m.s.} in the frequency range 150 kHz-80 MHz for AC / DC lines and Signal /Control/telecom lines.

9.7 **Immunity to voltage dips & short interruptions (applicable to only ac mains power input ports, if any):**

Name of EMC Standard: Name of EMC Standard: IEC 6100-4-11 (2004) "Testing & measurement techniques- voltage dips, short interruptions and voltage variation immunity tests"

Limits:

i. A voltage dip corresponding to reduction of the supply voltage of 30% for 500 ms (i.e 70 % supply voltage for 500 ms)

ii. A voltage dip corresponding to reduction of the supply voltage of 60%

for 200 ms (i.e 40 % supply voltage for 200 ms)

iii. A voltage dip corresponding to reduction of the supply voltage of > 95% for 5 s

iv. A voltage dip corresponding to reduction of the supply voltage of > 95% for 10 ms

9.8 **Immunity to voltage dips & short interruptions (applicable to only DC power input ports, if any):**

Name of EMC Standard: IEC 61000-4-29:2000: Electromagnetic compatibility (EMC) - Part 4-29: Testing and measurement techniques - Voltage dips, short interruptions and voltage variations on d.c. input power port immunity tests

Limits:

i. Voltage Interruption with 0% of supply for 10ms. Applicable Performance Criteria shall be B.

ii. Voltage Interruption with 0% of supply for 30ms, 100ms, 300ms and 1000ms. Applicable Performance Criteria shall be C.

iii. Voltage dip corresponding to 40% & 70% of supply for 10ms, 30 ms. Applicable Performance Criteria shall be B.

iv. Voltage dip corresponding to 40% & 70% of supply for 100ms, 300 ms and 1000 ms. Applicable Performance Criteria shall be C.

v. Voltage variations corresponding to 80% and 120%of supply for 100 ms to 10s as per Table 1c of IEC 61000-4-29. Applicable Performance Criteria shall be B.

Note 1: The test agency for EMC tests shall be an accredited agency and details of accreditation shall be submitted.

Note 2: For checking compliance with the above EMC requirements, the method of measurements shall be in accordance with TEC Standard No. TEC 11016:2016 (earlier No. TEC/SD/DD/EMC-221/05/OCT-16) and the references mentioned therein unless otherwise specified specifically. Alternatively, corresponding relevant Euro Norms of the above IEC/CISPR standards are also acceptable subject to the condition that frequency range and test

level are met as per above mentioned sub clauses (a) to (g) and TEC Standard No. TEC 11016:2016 (earlier No. TEC/SD/DD/EMC-221/05/OCT-16). The details of IEC/CISPR and their corresponding Euro Norms are as follows:

IEC/CISPR	Euro Norm
CISPR 32	EN 55032
IEC 61000-4-2	EN 61000-4-2
IEC 61000-4-3	EN 61000-4-3
IEC 61000-4-4	EN 61000-4-4
IEC 61000-4-5	EN 61000-4-5
IEC 61000-4-6	EN 61000-4-6
IEC 61000-4-11	EN 61000-4-11
IEC 61000-4-29	EN 61000-4-29

10.0 **Safety requirements:**

10.1 The equipment shall conform to IS 13252 part 1: 2010 “Information Technology Equipment Safety Part 1: General Requirements” [equivalent to IEC 60950-1 {2005} “Information Technology Equipment –Safety- Part 1: General Requirements”].

10.2 If the fibre is broken or an optical connector is opened, the laser shall be automatically shut down or the optical power to be decreased to a value less than -10 dBm. Optical connectors, if used in the system, shall be self-protective against entry of dust when not occupied by external patch cord.

10.3 The equipment shall have the provision of Automatic Laser Shut-Down (ALSD) in the case of fibre-plant breakdown and automatic re-start on restoration of fault in accordance with ITU-T Recs. G.664. The system shall restore within 0 – 10 second (programmable) after restoration of fibre-plant breakdown or a faulty amplifier.

11.0 **Protection requirements:**

11.1 The equipment shall have a terminal for grounding the rack.

11.2 Protection against short circuit/ open circuit in the accessible points shall be provided.

11.3 All switches/controls on front panel shall have suitable safeguards against accidental operation.

11.4 The equipment shall be adequately covered to safe-guarded against entry of even dust, insects etc.

12.0 **Mechanical standards:**

a. The equipment shall be housed in the standard 19" width sub-racks or ETSI standard racks. The sub-racks shall be fitted with mother-board duly masked to avoid short-circuiting. The height of the main rack shall be 2750 mm maximum or as per ETSI standards. No mini rack shall be accepted. The PCB's back and forth movement shall be very smooth without any significant sideway play.

b. Optional Note: If required the equipment can also be housed in the standard 21"/23" width sub-racks or ETSI standard racks. The same can be decided by the purchaser.

c. The connectors used on the PCB and their mating-connectors on the mother-board shall have tight grip to avoid jacking problems.

d. No damage shall take place to PCBs when loaded in the wrong slot except in power supply units. The PCBs shall have the provision of locking/ screwing to the sub-rack.

e. There shall be proper covers on the sub-racks/ main-racks or similar arrangements to avoid the ingress of dust.

f. The permanent wiring such as distribution of power supply and ground etc. shall be pre-wired. During Type Approval and supply of the equipment, the racks and sub-racks quality supplied by the manufacturer shall be ensured.

g. The front opening of the sub-rack/main rack is envisaged. No side-way opening shall be permitted. The access to data terminations shall be from the front or rear side.

13.0 **Power supply:**

The power supply to the equipment shall be fed from the station power-plant. The equipment shall meet the following requirements in respect of the power supply:

a) Nominal power supply is -48V DC with a variation over the range -40V to -60V. The equipment shall operate over this range without any degradation in performance.

b) The equipment shall be protected in case of voltage variation beyond the range specified in sub-clause (a) above and also against reverse input polarity. The manufacturer shall furnish the value of guaranteed input voltage up to which no irreversible damage to the equipment shall occur.

c) The derived DC voltages in the equipment shall have protection against over- voltage, short-circuit and overload.

d) If the power-supply is provided through a centralized power-supply unit at chassis level, a hot-standby power-supply shall be provided at chassis level, to ensure smooth working of the equipment during

failures.

e) Further, there shall be provision for dual-feed arrangement to the chassis power-supply, such that in case of failure of one feed, the system shall be able to function in a healthy manner without traffic interruption. The changeover of all redundancy actions shall be completed within 50ms.

f) The equipment requiring AC mains shall operate from single phase AC power supply without any degradation in the performance. The nominal AC voltage shall be 230V with variation of –15 % to +10 % at 50 Hz ± 2 Hz. The actual power consumption shall be furnished by the manufacturer.

14.0 Element Management System

14.1 Functional Requirements:

(1) The EMS shall be multi-user system and based on Graphical User Interface.

(2) It shall provide the graphical layout of the network elements with modules drawn using different colours to indicate their status. This color codes should be different from the color codes used in Alarm.

(3) It shall be possible to execute any schedulable administrative command i.e.- NE backup, software download, performance, operator log-in/log-out etc., at any time by attaching a time tag to the command and it shall be executed when the Network real time matches the time tag. It shall be possible to define both time and date. If no date is mentioned, the command shall be executed daily at the time indicated.

(4) The EMS shall have a messaging system which will generate and send alert messages on e-mail or SMS to the designated personnel depending upon the location of NE, on generation of alarms.

(5) Response time for query/command on any operator terminal, local or remote shall be 10 seconds or better. For updation on topological

information on the terminals, the response time shall be better than 20 seconds under normal conditions. The response time of any terminal shall however, be reviewed depending upon total NE load and topology by purchaser during testing of EMS.

(6) It shall be possible to manage complete DWDM link involving distant-end terminal, Optical Line Amplifiers and Optical Add/Drop Multiplexers en-route. For passive elements like Optical Add/Drop multiplexers, only viewing will be possible.

(7) It shall be possible to have a view of selected sub-networks/rings controlled by the Element Management System as per requirement. By zooming-in, it shall be possible to drill down up to module-level in each NE for configuration and fault management. It shall also provide the ability to drill down to the individual element, then to subsystem, then to card and then to port level configuration template from the domain-map by clicking on the icon of the network element. The same shall be provided through user-friendly GUI commands.

(8) The Element Manager shall provide the complete view of the network elements and the interconnecting links. The EMS shall have the ability to include the network elements and the links in the visual/graphical map of the domain. The visual maps shall display the elements and the links in different colour depending upon the status of the links. It is preferable that green colour for healthy and amber/yellow colour for degraded condition and red for unhealthy condition is used.

(9) It shall be possible to produce different type of reports based on the data available in the database.

(10) It shall be possible through a single Man-Machine Command or through GUI to obtain a list and the total number of equipment of a particular domain in various states (e.g. managed, Loss of Association, in-service, blocked etc.).

14.2 **Configuration Management:**

(1) It shall be possible to configure the DWDM equipment for various capabilities and features like enabling/disabling of optical

wavelengths, transponders configuration, optical channels addition/deletion, restricting client-speed at GigE interfaces, protection enabling/disabling at all wavelengths & inventory details of the local station as well as remote station at card level etc. The GUI shall provide efficient mechanisms to edit, re-groom, or decommission the service when necessary.

(2) Users shall be able to identify explicit routing through the network, or just define the end-points and service characteristics and select from a list of automatically generated viable recommended paths through the network.

(3) The system shall support 'Point & Click' provisioning in the DWDM sub-network, in respect of following:

i. Network Element creation in the NE Management domain.

ii. Programming of a multiple interface unit.

iii. Create, update, delete and retrieve the managed network topology data.

iv. Assigning the equipment protection to a unit/interface/wavelength/channel.

v. Selection of protection switching within the managed network and protection switching granularity enable/disable at individual channel level.

vi. Error detection thresholds.

vii. Network Element configuration.

viii. Software download (local & remote).

ix. It should be possible to provide an end-to-end wavelength service from an EMS Client system.

x. Power values overlaid on the topology map/drop down menus for selected Lambda by User

- Per Lambda Power
- Total AMP Power
- OSC (Optical Supervisory Channel) Power

xi. It should be possible to define the threshold (High/Low) for Power levels and EMS should be able to display if Power level is crossing the threshold.

xii. The configuration of the various network elements like creating, viewing, and editing shall be possible from the EMS. The configurations of the network elements shall also be stored in EMS which can be retrieved in case of failure.

14.3 **Fault Management:**

(1) The EMS shall support 'Fault Management Functions'. The 'Equipment Management Function' within the NE shall perform a persistency check on the fault-cause, before it declares an alarm which is causing failure in the DWDM network. Each alarm/failure and clearance, thereof, shall be time-stamped.

(2) The equipment shall carry out surveillance of alarms & their detection, reporting of relevant events and conditions that lead to the generation of alarm after filtering. The system shall produce, store and display the alarm history on demand. Further, the element management system shall have the following capabilities:

i. Path alarm notification to be generated and recorded, the alarm notification shall include: type, occurrence, severity, probable cause and clearing.

ii. Path alarm shall be graphically shown by the EMS/LCT.

iii. Alarm and status display.

iv. Fault localization.

v. Fault correlation control.

vi. Storing and processing of current alarm information, up to module/unit level.

vii. Storing and processing of historical alarm information for 30 days minimum. The EMS/LCT shall provide on-line logging capability for historical alarms and events with sufficient information such as managed resources, alarm/event type, alarm severity, day and time

of occurrence etc. The retrieving functions with filtering capabilities for historical alarms and events shall be provided as well.

viii. FCS errors for Ethernet clients.

ix. Assigning alarm severity i.e., Urgent, Non-urgent and Deferred.

x. The EMS shall be able to diagnose its own faults by running diagnostic software.

xi. The information model shall be as per specified standards. The EMS shall support correlation (filtering and suppression) to avoid multiple alarms from a single source of failure within the sub-network. Single Alarm shall be provided for the events that are correlated and are due to a common cause. However, it may be possible for the user to see other related alarms.

xii. The EMS shall provide the visual presentation of the Network Element's status and the alarms. It shall also present the complete map of the network domain with suitable icons and in suitable colour like green for healthy, red for non-operational, yellow for degraded mode of operation etc. Colour codes used for elements status and alarm should be different.

xiii. From the EMS, it shall be possible to view the status of any Network Element whether it is out-of-service or in-service.

xiv. The EMS shall carry out the systematic Health Monitoring of the elements of the Network. Check on the health of the card of any element of the Network shall be possible through reports with settable periodicity - @ 24 Hrs, 1 week, 1 month.

xv. It shall be possible to log recent operations which be re-displayed on request through GUI.

xvi. From a service assurance perspective, service to fault alarm correlation shall be supported. For each service there shall be an alarms tab visible on the service Display tab which displays the alarms impacting that specific service.

xvii. The DWDM related alarm conditions, as mentioned under Clause 3.43 and 3.43.1 in this GR shall be displayed by the EMS.

14.4 **Performance Management:**

(1) The EMS shall support the 'Performance Management' functions which shall consist of a set of functions that define, evaluate and report on the behaviour of the Network Elements and their effectiveness relating to the overall functions carried out by the network.

(2) EMS shall provide the information regarding degradation of the optical paths. It shall have the capability to monitor and display certain important parameters like optical power, λ &Pre FEC BER measurements of channels and of DWDM Central Office equipment, Line System and Remote Terminal. The EMS shall provide non-intrusive B-1 byte monitoring of individual channel of DWDM system and shall provide error-ratio/error-count along with other ITU-T Rec. G.826 parameters provisioning. EMS shall also be capable of setting the equipment performance thresholds in the range of $1x10^{-5}$ to $1x10^{-12}$.

(3) There shall be a provision for near-end performance monitoring, far-end performance monitoring, performance-data collection and performance history. The main performance functionality to be provided shall be as under:

i. Configuration of threshold concerning the error counters.
ii. Performance monitoring by BIP check.
iii. Performance monitoring and reporting.
iv. Performance History (data logging).

(4) EMS shall store the performance data of the system including NE name, date and the time. The collection of the performance counters will have to be performed at pre-assigned rate. In addition, it shall also be possible to take print out of the statistics and histograms.

(5) It shall be possible to configure scheduling of performance measurement, collection, storage and transfer of traffic/ performance statistics for at least one month in the EMS system, after which it shall be possible to transfer the data to external media like USB, CD or any other server. It shall also be possible to generate daily, weekly, monthly reports for the individual element as well as complete domain. The report generation

shall be supported in Text/CSV/Excel/pdf format and graphic reports as and when requested as well as at configurable interval automatically.

(6) The EMS shall store the performance data of the sub-network in terms of configured circuits.

(7) It shall be possible to generate customised reports for various types of faults, performance history, security management etc. It shall also be possible to generate reports at various client's levels to facilitate monitoring of performance statistics in predefined/customised format.

14.5 **Security Management:**

The management system shall provide adequate security in respect of the data and the access to the management system as per the following details:

(1) The EMS shall have the capability of supporting the management of network through local and remote operator terminals. The authorizations and the privileges of the operator terminals (Remote and Local) shall depend upon the Login and Password.

i. Low level protection for read only access to faults and performance information.

ii. Medium level protection for reads only access to configuration status and features.

iii. High level protection for access to change in the configuration and control parameters.

(2) The EMS shall support multi-level passwords as below-

i. EMS shall allow the System Administrator to define the level of access to the network capabilities or feature for each assigned password. It shall be desirable that the EMS shall block the access to the operator in case of wrong login password and ID and also for unauthorized commands being tried for five consecutive times in both the occasions.

ii. The system administrator shall be able to monitor and log all operator activities in the EMS including operator terminal and Local Craft Terminal.

iii. The dynamic password facility shall be provided in which the operator may change its password at any time.

(3) It should be mandatory for the system to have a record of all log-ins in read only password protected file for a period of at least six months after which a backup should be possible under system administrator command. All log-in and log-out attempts shall be logged in the security log file of the EMS system.

(5) The LCTs shall normally operate through the local interface of local NE. In case of EMS link failure between NE location and EMS, the LCT should be able to supervise/monitor the local NE assigned to it and can access up to 32 remote NE through Optical Supervisory Channel (OSC)"

(6) It shall be possible to provide the connectivity of EMS and the network elements through IP-MPLS-VPN network for providing the inherent security required for the management information in addition to the login and Password based authorization for the operators of the Network Manager.

(7) The EMS shall be able to back up and restore the data base to and from external storage media.

14.6 Inventory management:

(1) It shall indicate the presence or absence of any physical module in hardware elements. It shall also indicate the usage of module i.e. how many ports are in use, which interfaces are in use and which are free to be used.

(2) The EMS shall be able to discover, keep and display the device information

(3) The EMS shall be able to keep track and report chronologically on any change in the network inventory.

(4) The EMS shall be capable of providing the inventory information to the Network Management layer (NML)/Service Management Layer (SML) so that SML is able to create and activate a service to the customer.

(5) The EMS shall provide the complete view of location wise network elements and the interconnecting links, in map format, list or rack picture format etc. for each independent links/networks as well as for all the links/networks under management of the EMS.

14.7 Software Management:

It shall be possible for the EMS to carry out the following tasks under the software management function:

(1) Loading of new system software in EMS/local terminals/remote terminals and the LCTs.

(2) Managing different versions of software.

(3) Managing multiple versions of software for individual elements. In this case, one software version shall remain active and other versions shall be passive.

(4) Installation of software patches.

(5) Local & remote software download via management system to NEs and LCT shall be possible, including the means of identification of software module versions. No loss of data/traffic & connection-map shall take place during the software downloading process. At the time of downloading the software, the message shall be displayed that the software has been downloaded successfully or failed and at what stage.

(6) Downloading of Software, configuration, patches etc., to the Network Element through FTP/TFTP. No loss of data/loss of connection map shall take place during the software downloading process.

(7) Changing the system configuration, reconfiguration of input and output devices.

(8) All commands which are executed over the EMS program or data shall be logged in a file (read only) and it shall be possible to retrieve the same on demand whenever required, using Man-Machine Commands. The EMS shall have suitable system level backup mechanism for taking backup of EMS data of at least one month on DVD, CD or transfer to another storage through LAN. The file usage of up to 50%,

75% and 90% shall generate alerts in the server platform, of suitable category prompting the operator to initiate the backup operation.

(9) During the log-in by the system administrator, the system will provide the visibility of at least last 20 commands on the screen as system log or the system should provide audit log for last 24 hours.

(10) The EMS of the DWDM equipment shall have e-protection from the virus.

14.8 EMS Server

(1) EMS system shall consist of Application and Database servers and it shall possible to mount these servers on different or on single server.

(2) The memory of the Database Server shall be sufficient to store the data of minimum 500 fully loaded NEs with a capability of storing performance/ fault history of 30 days.

(3) Application and Database servers as well as firewall system (if provided) shall have redundancy for disk, power supply and LAN interface.

(4) Industry standard Relational Database Management system (RDBMS)/NoSQL DB or Cassandra or Elastic Search for storing all the data related to the network and the system shall be used.

(5) TEC 48140:2018 (earlier numbered as TEC GR No. TEC/GR/IT/SRV-001/02/MAR-18) or latest may be referred for servers.

14.9 Firewall [optional requirement]:

If EMS is required to be connected to public network, it is desirable to provide security to EMS from public network. In such case a dual redundant hardware based Firewall system may be provided at each of the EMS locations for providing security to the various servers at the EMS. For Firewall System specifications TEC GR No. TEC 49090:2014 (Earlier numbered as TEC/GR/IT/FWS-001/04.MAR.2014) or latest may be referred.

Note: For offering DWDM system for Type Approval, Firewall shall not be mandatory.

14.10 Local Crafts Terminal/Client Terminal/Work Station:

(1) Local Craft Terminal performs two types of functions in a network at NE level namely Configuration Management and Fault Management.

(2) LCT shall be capable of performing its function for at least 32 NEs. LCT can be installed on a client PC or Laptop. The LCT shall be able to access a local NE through a LAN or a serial port on DWDM equipment and any remote NE through data communications channel (DCC) of the DWDM system. For fault management it shall handle only basic alarm functions like Alarm Monitoring Policy Settings, Alarm Viewing and Alarm Deletion etc.

14.11 Typical minimum Desktop/Laptop configuration for LCT/EMS terminal shall be as follows or latest:

"Desktop, Workstation/ Remote terminal:

CPU Intel Core i3, 8 generation core or equivalent or better Processor, 300 GB SATA HDD with 4 GB DDR RAM, 17" TFT/LED flat screen display for Remote Terminal and 21" TFT/LED for NOC workstation, 1 MB cache, Ethernet interface 10/100/1000 Mbps) with industry standard Operating system like Windows8 or higher version/Linux, Optical mouse, Keyboard, Four USB ports, 4x CD RW/DVD Drive or above, Antivirus Software with 3 years' validity or better. "

Laptops:

CPU Intel core i5, 8 generation core or equivalent or better, 3 MB 1.3 Cache, 4 GB DDR3 RAM, 15" TFT/LED display, 500 GB (or higher) Hard Disc Drive, Integrated LAN & Wi-Fi, Integrated Audio with in-built speaker & Mike, Three USB port, and one VGA or HDMI, Integrated Bluetooth 4.0, Touch pad, Windows10 or higher, more than 4 Hrs of Battery Life, AC Adaptor and Carry Bag, MacAfee/Quick heal/Norton Antivirus Software with 3 years support or better.

14.12 EMS Architecture

14.12.1 Though the EMS can be PC based system for a small network, for a network having large numbers of NEs, Centralised EMS with server based architecture should be provided.

(1) To ensure EMS connectivity to the sub-network under control-card failure, it shall be possible to dual home the EMS to two Gateway NEs (GNEs) in a sub-network so that performance and fault data for the sub-network shall be available even if the master control-card at one GNE fails.

(2) In case of loss of EMS connectivity, the LCT privilege shall not be affected for monitoring and for local configurations, as per the privileges assigned by EMS administrator.

(3) It shall be possible to operate the Main and DR locations in 1+1 mode, either with manual switchover or with automatic switchover. The system shall have data replication and synchronisation mechanism so that servers at both locations have same data. Synchronisation interval shall be settable in steps of 15 minutes.

(4) Any failure in EMS including software bugs shall not affect the healthy working of the DWDM system.

(5) It shall be possible to assign rights to each local and remote terminal for EMS function for monitoring and issue of commands for all links or any number of independent links or sub-networks by the EMS administrator.

14.12.2 Scalability Aspects:

(1) The EMS should be able to support at least 500 NEs. NE is an OADM or TM or ILA with fully equipped line and client side interfaces. These elements may be spread over any number of independent links or sub-networks of the capacity up to 10G/40G/100G.

(2) Operating system and applications for EMS including database server shall be multi-user with minimum 25 concurrent users including local terminals at EMS site and remote terminals which access the EMS through a WAN.

(3) The EMS shall be equipped to connect to at least 10 local terminals at EMS site. It shall also be upgradeable to 25 local terminals.

(4) EMS of the system shall have the capability of supporting dual stack 32/128 bit IP addressing, for internal communication with the equipment. The GNE shall automatically assign internal IP addresses for each equipment with in its domain via DHCP protocol or any other suitable/standard mechanism.

14.13 Management Interface:

14.13.1 Southbound Interface of EMS:

EMS shall provide south bound interface towards NE as implemented in the Gateway NEs(GNEs).

14.13.2 Northbound Interface:

The North bound interface meant for connectivity with NMS shall be open interface such as SNMP v2 or better/ XML/TL-1/ MTNM TMF-508/613/814 specified CORBA, using standard MIBs/ GDMO/ PICS etc., as per ITU-T Rec. G.873.1.

15.0 DWDM Equipment required for Type Approval

The minimum DWDM equipment, which the manufacturer/supplier is required to provide for type approval under DWDM Point-to-point, Linear Add/Drop System, Ring Configuration and for DWDM Mesh configuration is given at Annexure-II of this Standard.

CHAPTER-2

Guidelines for Purchaser

Following are the guidelines, which the purchaser may follow while deciding for the procurement or maintenance of the DWDM system including Element Management System. However, the purchaser needs to make decision on various aspects/parameters of this standard.

16.0 Equipped channel capacity:

The purchaser may ask the DWDM system vendor to provide an end to end capacity for 40/80channels @100G/200Gbit-rate comprising of a combination of SDH, OTN and Ethernet interfaces, on day one. The required number of actual equipped channels with Transponders/Muxponders of various 'types' is to be decided by the purchaser. Proper termination of the unused channels shall be provided by the manufacturer as part of system design. It may be possible to utilize the unequipped channels at a later date without affecting the existing traffic.

17.0 DWDM applications:

As required by the purchaser, the DWDM system is to be designed for use in transport networks as a protocol transparent solution for a variety of client/services. The DWDM is to find its applications for the following variety of services and protocols e.g., SDH @ STM-64 as well as 10GigE/40GE/100GE as per IEEE 802.3/802.3ae/802.3ba-2010standards.

18.0 Application codes:

The standard envisages two different application codes for a point to point, linear-chain & ring in accordance with Table-1a, 1b, 2a, 2b, 3 & 4/Annexure-I of the standard. Under all network topologies, viz., point to point, linear add/drop, DWDM ring and mesh architecture, all fibre-spans

between ‘MPI-S & MPI-R’, S’ & R’ and ‘Sn & Rn’ reference points of figure no 16, is to be limited by Table-1a, 1b, 2a, 2b, 3 & 4/Annexure-I specifications for both application codes for the worst-case channel. All the optical amplifiers (ILA) and OADMs are to be designed for 17-22db span-loss for Long Haul applications and 23-28db span-loss for Very Long Haul applications at a minimum.

The attenuation per span between the Optical Line Amplifiers (Booster Amplifier, In Line Amplifiers and Pre-amplifier) and Optical Add/Drop Multiplex shall be as follows:

i) Long haul application : 17-22 dB (80km)
ii) Very long haul application : 23-28 dB (100km)

i) Longhaul application code

The LH equipment to acquire approximately 800 km route length for 100G and 500 km route length for 200G before acquiring 3R regeneration. This is based on 0.28 db/km loss over single mode optical fibre as per ITU-T Rec. G.652. Based on these projections, total dispersions requirements shall be 14400 ps/nm for LH configuration @18ps/nm.km over C-band for G.652 SMF. The dispersion shall be compensated by Coherent Channel System 100 G/200 G upon reaching these limits. Span-loss between MPI-S & R’, S’& MPI-R and S’ & R’ reference points for all spans shall be 17-22 dB with Forward Error Correction (FEC) enabled. There may be upto 8 such spans or more for 100 and upto 6 spans for 200 G.

ii) Very Longhaul application code

The VLH equipment to acquire approximately 600 km route length for 100G and 300 km route length for 200G before acquiring 3R regeneration. This is based on 0.28 db/km loss over single mode optical fibre as per ITU-T Recs. G.652. Based on these projections,

total dispersions requirements will be 10800 ps/nm for VLH configuration @18 ps/nm.km over C-band for ITU-T Rec. G.652 SMF. The dispersion shall be compensated by Coherent Channel System for 100G/200G system. Span-loss between MPI-S & R', S'& MPI-R and S' & R' reference points for all spans shall be 23-28 dB, with Forward Error Correction (FEC) enabled. There may be upto 5 such spans or more for 100G and upto 3 spans for 200 G.

Note 1: The above power-budgets is to be valid even for the worst-case channel for which proper channel equalization scheme should be implemented in the system to adhere to end-to-end OSNR requirements in uniformity with other channels as per Table-1a, 1b, 2a, 2b, 3 & 4/Annexure-I of the standard.

Note 2: The exact distances covered to be subject to actual fibre-attenuation coefficient and dispersion parameters for the worst-case channel.

Note 3: The actual number of possible OADMs in the link, for all application codes, as well as continuous add/drop of the same wavelength/s in subsequent spans to be supported, for the entire spans in the link. The LH links shall support 8 such OADMs in a link.

Note 4: All enroute nodes for both application codes –Longhaul & Very Longhaul, shall be ILAs, OADMs or a combination of them. The insertion-loss of OADMs shall be compensated by the OA element contained within OADM node. The OA element shall be designed accordingly.

Note 5: In linear add/drop and ring topologies, all parametric specifications at 'S' & 'R' reference points of OADM's add/drop ports shall also comply as specified for In Line Amplifiers in Table-1a, 1b, 2a, 2b, 3 & 4/Annexure-I of the standard. The "Sn/Rn" reference points shall provide parametric compliance to Table-1a, 1b, 2a, 2b, 3 & 4/Annexure-I.

19.0 Span attenuation:

The section-loss of the optical cable including splice-losses and cable-margin etc to be as per Note-5 above, for respective application codes. The section-losses specified in the clause are beginning-of-life values and a margin for the ageing of fibre and optical amplifiers etc., to adhere to end-of-life values shall be tested. Testing of the link shall be performed for a span-loss 3db higher than beginning-of-life values during testing.

20.0 Number of spans without 3R:

For a comprehensive network planning, the purchaser may ask the vendor to provide the relevant network planning tool for the network design.

Since the DWDM equipment is required to function in both Longhaul as well as Very Longhaul applications and the no. of spans in respect of both these applications varies depending upon the type of NEs used i.e., TMs, ILAs, OADMs, the purchaser may ask the vendor to carry out the complete network planning as per the network information provided by the purchaser. It is presumed that ILAs in metro networks may not be used in a large extent, it is therefore proposed that the requirement of ILA in Metro Networks may be decided by the purchaser as per his need.

The 100G DWDM link over the Single-mode Optical fibre shall support the no. of spans as under:

a) Longhaul application shall be up to 8 spans or more.
b) Very Longhaul application shall be up to 5 spans or more.

The 200G DWDM link over the Single-mode Optical fibre shall support the no. of spans as under:

a) Long haul application shall be up to 6 spans.
b) Very Long haul application shall be up to 3 spans.

The Longhaul equipment shall work satisfactorily for 800 km or more without 3-R regeneration. This is based on 0.28 db/km fibre-loss assumption (inclusive of splice-loss and cable-margin etc.) over single-mode optical fibre as per ITU-T Rec. G.652. Similarly, Very Longhaul equipment shall work satisfactorily for 600 km or more without regeneration, based on the same assumption of fibre-loss.

21.0 Accessories:

The purchaser may ask the supplier to provide one complete set of:

a) All the necessary interfaces, connectors, connecting cables and accessories required for satisfactory and convenient operation of the equipment. Types of connectors, adapters to be used and the accessories of the approved quality to be clearly indicated in the operating manuals, which should be in conformity with the detailed list in the standard;
b) Software and the arrangement to load the software at site.

Note: Additional sets may be ordered optionally.

21.1 Special tools, extender boards, extender cables and accessories essential for installation, operation and maintenance of the equipment to be clearly indicated and supplied along with the equipment.

21.2 Special tools, extender boards, extender cables and accessories essential for repair of the equipment to be clearly indicated and supplied in case the same are ordered.

22.0 Maintenance requirements:

Maintenance philosophy is to replace faulty units/subsystems after quick on-line analysis through monitoring sockets, alarm indications and Built-in Test Equipment/ hand-held terminal/laptop PC. The actual repair will be undertaken at centralized repair-centres. The corrective measures at site

shall involve replacement of faulty units/sub-systems.

22.1 The equipment should have easy access for servicing and maintenance.

22.2 Suitable alarms to be provided for identification of faults in the system and faulty units.

22.3 Suitable provision to be made for extension of summary alarms.

22.4 Ratings and types of fuses used are to be indicated by the supplier

23.0 Contentionless ROADM (Optional Feature)

The colourless and directionless ROADM network has some limitations that could require manual intervention in some cases. Thus, the colourless/directionless ROADM network is not completely flexible. The problem is that wavelength blocking can occur when two wavelengths of the same colour converge at the same WSS structure at the same time. This will cause network contention. This blocking/contention situation is avoided by partitioning the add/drop structures so that different coloured wavelengths are associated with different structures – thus eliminating the possibility for two wavelengths of same colour to converge on the same add/drop structure simultaneously. While this level of engineering does resolve wavelength contention potential from a provisioned perspective. It means that operators sacrifice a level of dynamic flexibility and may require additional add/drop structures to accommodate particular wavelength channels. The new concept is that of contention-less ROADMs networks. A contention-less architecture, allows multiple signal of the same wavelength on a single add/drop structure (without any partitioning restrictions). A colourless /directionless architecture combined with true contention-less functionality is the ultimate goal for transport network. Such architectures are known as Colourless, Directionless and Contention-less (CDC) Network and give the ultimate level of flexibility at the optical layer.

24.0 EMS Requirement:

24.1 As a cost effective measure, two display units are adequate for all the servers (application, database, and for firewall). Purchaser is at discretion to convey any additional requirements. It shall be possible to access any server from any of the display.

24.2 The purchaser shall communicate requirements for (1+1) server backup or internal constituents of server.

24.3 The purchaser may validate vendor's claim for management functions as well as protocol compliance through Protocol Analyzer etc.

24.4 For Application Server, typically Category-I Blade Server (CISC) can be selected as per TEC Standard No. TEC 48140:2018 (earlier No. TEC/GR/IT/SRV-01/04/MAR-18) or latest. However, the exact dimensioning is to be decided by the purchaser based on the actual requirement and future growth of the network.

24.5 For Database Server, typically Category-II Blade Server (CISC)/Category-II X 2 Blade Server (RISC) can be selected as per TEC Standard No. TEC 48140:2018 (earlier No. TEC/GR/IT/SRV-01/04/MAR-18) or latest. However, the required dimensioning is to be decided by the purchaser based on the actual requirement and future growth of the network.

24.6 For Combined Server, typically Category-I X 3 Blade Server (CISC)/ Category-II X 3 Blade Server (RISC) can be selected as TEC Standard No. TEC 48140:2018 (earlier No. TEC/GR/IT/SRV-01/04/MAR-18) or latest. However, the required dimensioning shall be decided by the purchaser based on the actual requirement and future growth of the network.

24.7 The requirement of EMS at DR site may be decided by the purchaser.

24.8 Minimum of four operator terminals will be provided at the EMS site. The purchaser however, can decide about the actual numbers of operator terminal at EMS site and also about the requirement of LAN switch. For LAN switch TEC Standard No. TEC 48060:2014 (Earlier No. TEC/GR/IT/LSW-001/05.MAR.2014 or latest may be referred.

24.9 The supplier is to provide infrastructure requirements to the purchaser for setting up the EMS. The items of infrastructure include A/C power Air-conditioning load, space etc.

24.10 Installation & commissioning of the EMS shall include supply & installation of cables, distribution frames, electrical switches etc shall be prescribed by purchaser.

24.11 Format for creation of database of links, OTMs, ILAs, OADMs etc., and their numbering scheme, details of built up points across various rings other commissioning details, supplementary information, order reference, dates etc. shall be prescribed by purchaser. This can be done at the time of validation of EMS. The purchaser may also ask for customisation of reports pertaining to functional requirement of DWDM system.

24.12 The purchaser may prescribe that for validation of all the components of EMS, instruments necessary for carrying out validation test shall be arranged by supplier.

24.13 The purchaser may ask the manufacturer to arrange testing for various interfaces during the testing as per the PICS and MIBs (as applicable) and shall support the factory test results of its EMS during testing of their products. The manufacturer should also submit the soft as well as hard copy of his PICS and MIBs (as applicable) along with the equipment for testing.

24.14 The functional as well as protocol compliance for the management system may be tested. Complete information on the EMS Northbound, Southbound interfaces and the EMS implementation protocol stacks shall be disclosed in details, in writing to during the testing process.

24.15 The manufacturer is to submit the soft as well as hard copy of his PICS & MIBs (as applicable) along with equipment for testing.

24.16 External Security Measures {Optional Requirements}

The purchaser may decide to provide network security by deploying external devices/machines/ firm-ware at the Network Operation Centre [NOC], like-

i. Firewalls
ii. Access control servers
iii. Data encryption devices/use of PKI keys
iv. Anti-virus packages.
v. in the data communication network (DCN) for management system, VLAN tags/MPLS labels may be used for security to information flows from Gateway NEs (GNEs) to DCN Gateways with IPSec, PKI security options.
vi. In order to avoid attacks to the DWDM network via DCN, the DCN transmits all the management data with encryption. The encryption should be done by 128bit encryption key.

24.17 Manufacturer may be asked to provide soft copy of his EMS on a CD on per-ink order-ring basis (or as asked for by the purchaser). The setup/procedure to download the software shall be clearly mentioned in the system manual of the equipment.

24.18 The supplier may be asked provide all necessary interface details (with the documents) for integration of its EMS with existing or proposed NMS

(irrespective of its brand/make) and also provide time bound support for its integration.

24.19 The centralized EMS may consist of standalone application server, database server and firewall server or it can be a standalone EMS server subject to scaling requirements. The supplier may be asked to provide any other server required for meeting the purchaser requirements.

24.20 Operating system and applications for EMS including database server shall be multi-user with minimum 25 concurrent users (including local terminals at EMS site and remote terminals i.e. LCTs). Any more requirements may be communicated by purchaser.

24.21 Complete details of the interface variants and the protocols pertaining to each layer of the protocol-stack implemented in the management system, may be asked to be made available, for the purpose of integrating the local management capabilities with the centralized NMS. The requirement may include the following:

- Protocol details at all layers of OSI or TCP/IP (as applicable).
- PHY I/F at each layer.
- Database structures.
- Number formats.
- Node addressing system.
- Management signalling details.
- Complete application software details etc.
- NMS/EMS software check-sum.

24.22 For connecting remote terminals to the centralised EMS, typically leased lines or MPLS based WAN will be required to set up. For this purpose, LAN switch/Router at central location and leased line/MPLS terminating equipment will be planned by the purchaser.

25.0 **Documentation:**

Technical literature in English with complete layout, detailed block schematic and circuit diagram of various assemblies with test voltages/waveforms at different test-points of the units to be provided. All aspects of installation, operation, maintenance and repair to be covered in the manuals. The soft copy as well as hard copy of the manuals shall also be provided. The manuals include the following:

i) Installation, Operation and Maintenance Manual-

a) Safety measures to be observed in handling the equipment;
b) Precautions for installation, operation and maintenance;
c) Test jigs and fixtures required and procedures for routine maintenance, preventive maintenance, trouble-shooting and sub-assembly replacement;
d) Illustration of internal and external mechanical parts.
e) The detailed description about the operation of the software used in the equipment including its installation, loading and debugging etc.

ii) Repair Manual (to be supplied when ordered)-

a) List of replaceable parts used to mention their sources and the approving authority;
b) Detailed ordering information for all the replaceable parts shall be listed in the manual to facilitate reordering of spares as and when required;
a) Procedure with flow chart for troubleshooting and sub-assembly replacement shall be provided Test fixtures and accessories required for repair shall also be indicated. Systematic trouble-shooting charts (fault-tree) shall be given for the probable faults with their remedial actions.

26.0 The purchaser may indicate the exact number of add/drop channels for

fixed OADM (Static).

27.0 Various combination of colorless & directionless configuration is up to the discretion of purchaser based on his network requirements. Purchaser can fulfil his requirements in any of the following combinations, however for realizing the optical layer ASON, directionless feature is must requirement.

28.0 The system shall also support Reconfigurable Optical Add Drop Multiplexer (ROADM) in a specific manner as per the requirements of the purchaser. All features of the ROADMs mentioned are optional features and may be decided by the purchaser as per the requirement. However, for ILA sites, size of the chassis may be decided by the purchaser.

29.0 Each ROADM node shall be a multi-degree node supporting up to 8 directions. However, during the evaluation testing, support of at least 4 directions can be demonstrated. Purchaser can indicate the actual no. of directions to be supplied.

30.0 In case the purchaser requires the link engineering support/link engineering exercise, the manufacturer shall provide such support using link planning/design tools or any other method.

31.0 Opting for the Planning Tool shall be optional and will decided by the purchaser.

32.0 Application codes other than those mentioned in standard may be demanded by the purchaser.

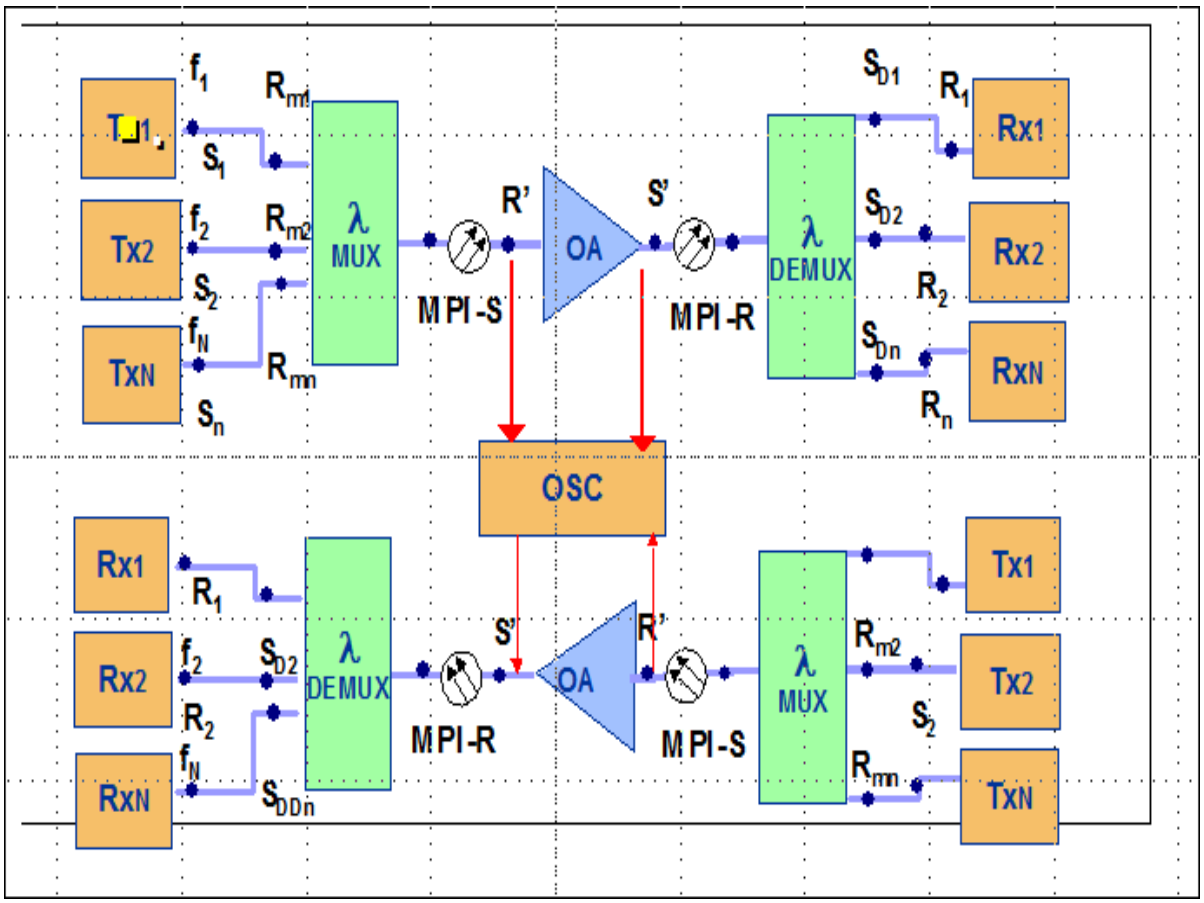


Figure 16 : Main Path Interface Reference Points

ABBREVIATIONS

Abbreviation	*Expanded Form*
ALS	: Automatic Laser Shutdown
BER	: Bit Error Ratio
BIP	: Bit Interleaved Parity
BSNL	: Bharat Sanchar Nigam Limited
CD	: Chromatic Dispersion
CD-ROM	: Compact Disc- Read Only Memory
CISPR	: Special International Committee on Radio Interference
CORBA	: Common Object Request Broker Architecture
DC	: Direct Current
DCM	: Dispersion Compensation Module
DCN	: Data Communication Network
DHCP	: Dynamic Host Control Protocol
DUCS	: Dispersion Under Compensation Scheme
DVD	: Digital Versatile Disc
DWDM	: Dense Wavelength Division Multiplexing
EDFA	: Erbium Doped Fibre Amplifier
EMC	: Electro Magnetic Compatibility
EMS	: Element Management System
EOW	: Engineering Order Wire
ETSI	: European Telecommunications Standards Institute
EWS	: East West Separation
FC/APC	: Fibre Connector/ Angle Polished Connector
FDF	: Fibre Distribution Frame
FEC	: Forward Error Correction
FTP	: File Transfer Protocol
FWM	: Four Wave Mixing
GbE	: Gigabit Ethernet
GDMO	: Generic Guidelines for Definition of Model Objects
GFP	: General Framing Procedure

GNE	:	Gateway Network Element
GR	:	Generic Requirements
GUI	:	Graphical User Interface
HDD	:	Hard Disc Drive
IaDI	:	Intra Domain Interface
IEC	:	International Engineering Consortium
IEC	:	International Electro-Technical Commission
IEEE	:	Institute of Electrical and Electronics Engineers
IETF	:	Internet Engineering Task Force
ILA	:	In Line Amplifier
IP	:	Internet Protocol
IPSec	:	Internet Protocol Security
IrDI	:	Inter Domain Interface
ISO	:	International Standard Organization
ITU	:	International Telecommunication Union
LAN	:	Local Area Network
LCT	:	Local Craft Terminal
LOF	:	Loss of Frame
LOM	:	Loss of Multiframe
LOS	:	Loss of Signal
MEMS	:	Micro Electromechanical System
MIB	:	Management Information Board
MPI	:	Multiple Path Interference
MPI-R	:	Main Path Interface at the receiver
MPI-S	:	Main Path Interface at the transmitter
MPLS	:	Multi-Protocol Label Switching
MSPP	:	Multi-service Provisioning Platform
MTBF	:	Mean Time Between Failures
MTNM	:	Multi-Technology EMS/NMS
NDA	:	Non-Disclosure Agreement
NE	:	Network Element
NML	:	Network Management Layer
NMS	:	Network Management System

NOC	:	Network Operation Centre
NZDSF	:	Non-Zero Dispersion Shifted Fibre
OA	:	Optical Amplifier
OADM	:	Optical Add Drop Mux
OCI	:	Open Connection Indication
OD	:	Optical Demultiplexer
ODF	:	Optical Distribution Frame
ODU	:	Optical Data Unit
OLS	:	Optical Laser Source
OM	:	Optical Multiplexer
OPU	:	Optical Payload Unit
OS	:	Operating System
OSC	:	Optical Supervisory Channel
OSI	:	Open Systems Interconnection
OSNR	:	Optical Signal to Noise Ratio
OTM	:	Optical Terminal Mux
OTN	:	Optical Transport Network
OTU	:	Optical Transport Unit
PCB	:	Printed Circuit Board
PICS	:	Protocol Information Compliance Statement
PKI	:	Public-Key Infrastructure
PLM	:	Payload Mismatch
PMD	:	Polarization Mode Dispersion
QA	:	Quality Assurance
QM	:	Quality Manual
RAID	:	Redundant Array of Independent Disks
RDBMS	:	Relational Database Management System
RFC	:	Request for Comments
RISC	:	Reduced Instructions Set Computing
ROADM	:	Reconfigurable Optical Add Drop Mux
ROM	:	Read Only Memory
RX	:	Receiver
SC	:	Square Connector

SDH	:	Synchronous Digital Hierarchy
SFEC	:	Super Forward Error Correction
SFP	:	Small Form Factor Pluggable Transceiver
SLM	:	Single-Longitudinal Mode
SMF	:	Single Mode Fibre
SML	:	Service Layer Management
SNMP	:	Simple Network Management Protocol
SNR	:	Signal to Noise Ratio
SPM	:	Self Phase Modulation
SRS	:	Stimulated Raman Scattering
STM-16	:	Synchronous Transport Module at 2.5Gbps
STM-64	:	Synchronous Transport Module at 10Gbps
TCP	:	Transmission Control Protocol
TIM	:	Trace Identifier Mismatch
TM	:	Terminal Multiplexer
TMF	:	Tele Management Forum
TRE	:	Terminal Receiving Equipment
TX	:	Transmitter
UDP	:	User Datagram Protocol
UNIX	:	Uniplexed Information and Computing System
VLAN	:	Virtual LAN
VOA	:	Variable Optical Attenuator
VPN	:	Virtual Private Network
WAN	:	Wide Area network
WSS	:	Wavelength Selective Switch
XFP	:	10 Gigabit Small Form Factor Pluggable
XPM	:	Cross Phase Modulation

------End of the document-----

ANNEXURE-I

Table-1a: Parametric values of 40 Channel DWDM system @ OTU4 for Long Haul Application

Parametric values of 40 Channel DWDM system @ OTU4		
Parameters	**Units**	**Value**
No. Of Channels		40
Bit rate per channel		OTU4
No. of spans	Nos.	G.652D: 8 G.655: 8 G.657A: 8
Individual Transmitter output at Sn point		
Launched Power range	dBm	-11 ~ 5
Maximum Spectral Width	nm	0.5 nm (@-20 dB)
Extinction ratio - minimum	dB	12
Central Frequency	THz	193.1 +/- n x 0.1
Minimum Wavelength Spacing	GHz	100
Maximum Wavelength Deviation	pm	+/- 25 pm
Optical Interface at MPI - S_M&S_M		
Optical Trans side Cross talk	dB	< -22dB for adjacent channel < -25dB for non-adjacent channel
Mean channel output Power	dBm	
Channel output power -max	dBm	4
Channel output power- min	dBm	-2
Total launched power		
min	dBm	0@1 Channel
Max	dBm	17
Max. Channel power difference	dB	2.5
Optical Line Amplifier		
Multi-Channel gain variation	dB	< 1
Multi-Channel gain tilt	dB	<+/- 0.8
Multi-channel gain change difference	dB	2
Total received power		
min	dBm	-29
max	dBm	-3.5
Total Launched Power -min	dBm	0@1 Channel
max	dBm	17
Signal spontaneous Noise Figure	dB	7
Optical path(MPI-S_M ~ MPI-R_M)		
Maximum Discrete Reflectance	dB	< -27
Minimum Return Loss	dB	24
Optical interface at MPI-R_M& R_M		
Mean channel input Power		
max	dBm	-17

min	dBm	-25
Total Input Power Min	dBm	-29
max	dBm	-3.5
Channel Signal to Noise Ratio- min (S-FEC)	dB	15
Max. Channel power difference at MPI-R & R'	dB	2.5
Maximum differential group delay(1dB OSNR penalty)	ps	24
Optical Cross talk at individual Channel output ports	dB	< -22dB for adjacent channel < -25db for non-adjacent channel
Individual Receiver inputs at Rn Points		
Receiver sensitivity	dBm	-18
Receiver Overload	dBm	0
Receiver Reflectance	dB	-27
Receiver OSNR Tolerance (EOL)	dB	15
Minimum receiver wavelength	nm	1529
Maximum Receive wavelength	nm	1565

Table-1b: Parametric values of 40 Channel DWDM system @ OTU4 for Very Long Haul Application

Parametric values of 40 Channel DWDM system @ OTU4		
Parameters	**Units**	**Values**
No. Of Channels		40
Bit rate per channel		OTU4
No. of spans	Nos.	G.652D: 5 G.655: 5 G.657A: 5
Individual Transmitter output at Sn point		
Launched Power range	dBm	-11 ~ 5
Maximum Spectral Width	GHz	50 GHz
Extinction ratio - minimum	dB	12
Central Frequency	THz	193.1 +/- n x 0.1
Minimum Wavelength Spacing	GHz	100
Maximum Wavelength Deviation	pm	+/-25 pm
Optical Interface at MPI – Ss& Sm		
Optical Trans side Cross talk	dB	< - 22 dB for adjacent channel < -25 dB for non-adjacent channel
Mean channel output Power	dBm	
Max. mean channel output power	dBm	4
Mini. mean channel output power	dBm	-2
Total launched power min	dBm	0 @ 1 Channel
Max	dBm	17
Max. Channel power difference	dB	2.5
Optical Line Amplifier		
Multi-Channel gain variation	dB	< 1

Multi-Channel gain tilt	dB	< +/- 0.8
Multi-channel gain change difference	dB	2
Total received power min	dBm	-29
max	dBm	-3.5
Total Launched Power -min	dBm	0 @ 1 Channel
Max	dBm	17
Signal spontaneous Noise Figure	dB	7
Optical path(MPI-SM～MPI-RM)		
Maximum Discrete Reflectance	dB	< -27
Minimum Return Loss	dB	24
Optical interface at MPI-Rs & RM		
Mean channel input Power max	dBm	- 17
min	dBm	-28
Total Input Power Min	dBm	-29
max	dBm	-3.5
Channel Signal to Noise Ratio- min (S-FEC)	dB	15
Max. Channel power difference at MPI-R & R'	dB	5
Maximum differential group delay(1dB OSNR penalty)	ps	24
Optical Cross talk at individual Channel output ports	dB	< -22dB for adjacent channel < -25db for non-adjacent channel
Individual Receiver inputs at Rn Points		
Receiver sensitivity	dBm	-18
Receiver Overload	dBm	0
Receiver Reflectance	dB	-27
Receiver OSNR Tolerance (EOL)	dB	15
Minimum receive frequency	nm	1529
Maximum Receive frequency	nm	1565

Table-2a: Parametric values of 80 Channel DWDM system @ OTU4 Long Haul Application

Parametric values of 80 Channel DWDM system @ OTU4		
Parameters	**Units**	**Values**
No. Of Channels		80
Bit rate per channel		OTU4
No. of spans	Nos.	G.652D: 8 G.655: 8 G.657A: 8
Individual Transmitter output at Sn point		
Launched Power range	dBm	-11 ～ 5
Maximum Spectral Width	nm	0.5 nm (@-20 dB)
Extinction ratio - minimum	dB	12
Central Frequency	THz	193.1 +/- n x 0.05

Minimum Wavelength Spacing	GHz	50
Maximum Wavelength Deviation	pm	+/- 25 pm
Optical Interface at MPI - S_M&S_M		
Optical Trans side Cross talk	dB	< -22dB for adjacent channel < -25dB for non-adjacent channel
Mean channel output Power	dBm	
Channel output power -max	dBm	4
Channel output power- min	dBm	-2
Total launched power		
Min	dBm	0@1 Channel
Max	dBm	20
Max. Channel power difference	dB	2.5
Optical Line Amplifier		
Multi-Channel gain variation	dB	< 1
Multi-Channel gain tilt	dB	< +/-0.8
Multi-channel gain change difference	dB	2
Total received power		
min	dBm	-29
max	dBm	-3.5
Total Launched Power -min	dBm	0@1 Channel
Max	dBm	20
Signal spontaneous Noise Figure	dB	7
Optical path(MPI-S_M～MPI-R_M)		
Maximum Discrete Reflectance	dB	< -27
Minimum Return Loss	dB	24
Optical interface at MPI-R_M& R_M		
Mean channel input Power		
max	dBm	-17
min	dBm	-25
Total Input Power min	dBm	-29
Max	dBm	-3.5
Channel Signal to Noise Ratio- min (S-FEC)	dB	15
Max. Channel power difference at MPI-R & R'	dB	2.0
Maximum differential group delay(1dB OSNR penalty)	ps	24
Optical Cross talk at individual Channel output ports	dB	< -22dB for adjacent channel < -25db for non-adjacent channel
Individual Receiver inputs at Rn Points		
Receiver sensitivity	dBm	-18
Receiver Overload	dBm	0
Receiver Reflectance	dB	-27
Receiver OSNR Tolerance (EOL)	dB	15
Minimum receiver wavelength	nm	1529
Maximum Receive wavelength	nm	1565

Table-2b: Parametric values of 80 Channel DWDM system @ OTU4, Very Long-Haul applications

Parametric values of 80 Channel DWDM system @ OTU4		
Parameters	**Units**	**Values**
No. Of Channels		80
Bit rate per channel		OTU4
No. of spans	Nos.	G.652D: 5 G.655: 5 G.657A: 5
Individual Transmitter output at Sn point		
Launched Power range	dBm	-11～ 5
Maximum Spectral Width	GHz	0.5 nm (@-20 dB)
Extinction ratio - minimum	dB	12
Central Frequency	THz	193.1 +/- n x 0.05
Minimum Wavelength Spacing	GHz	50
Maximum Wavelength Deviation	pm	+/-25 pm
Optical Interface at MPI – Ss& SM		
Optical Trans side Cross talk	dB	< - 22 dB for adjacent channel < -25 dB for non-adjacent channel
Mean channel output Power	dBm	
Max. mean channel output power	dBm	4
Mini. mean channel output power	dBm	-2
Total launched powermin	dBm	0 @ 1 Channel
Max	dBm	20
Max. Channel power difference	dB	5
Optical Line Amplifier		
Multi-Channel gain variation	dB	< 1
Multi-Channel gain tilt	dB	< +/- 0.8
Multi-channel gain change difference	dB	2
Total received power min	dBm	-29
max	dBm	-3.5
Total Launched Power -min	dBm	0 @ 1 Channel
Max	dBm	20
Signal spontaneous Noise Figure	dB	7
Optical path (MPI-SM～MPI-RM)		
Maximum Discrete Reflectance	dB	< -27
Minimum Return Loss	dB	24
Optical interface at MPI-Rs & RM		
Mean channel input Power max	dBm	- 17
min	dBm	-28
Total Input Power Min	dBm	-29
max	dBm	-3.5
Channel Signal to Noise Ratio- min (S-FEC)	dB	15
Max. Channel power difference at MPI-R & R'	dB	5
Maximum differential group delay(1dB	ps	24

OSNR penalty)		
Optical Cross talk at individual Channel output ports	dB	< -22dB for adjacent channel < -25db for non-adjacent channel
Individual Receiver inputs at Rn Points		
Receiver sensitivity	dBm	-18
Receiver Overload	dBm	0
Receiver Reflectance	dB	-27
Receiver OSNR Tolerance (EOL)	dB	15
Minimum receive frequency	nm	1529
Maximum Receive frequency	nm	1565

Table 3: Parametric values of 40 Channel DWDM system @ 200G

Parametric values of 40 Channel DWDM system @ 200G		
Parameters	**Units**	**Values**
No. Of Channels		40
Bit rate per channel		200G
Modulation Scheme		8QAM/16QAM
No. of spans	Nos.	G.652D: 3 G.655: 3 G.657A: 3
Individual Transmitter output at Sn point		
Launched Power range	dBm	-10～ 1
Maximum Spectral Width	nm	0.5 nm (@-20 dB)
Extinction ratio - minimum	dB	12
Central Frequency	THz	193.1 + n x 0.1
Minimum Wavelength Spacing	GHz	100
Maximum Wavelength Deviation	pm	+/-25 pm
Optical Interface at MPI – Ss& SM		
Optical Trans side Cross talk	dB	< - 16 dB for adjacent channel <- 20 dB for non-adjacent channel
Mean channel output Power	dBm	
Maximum mean channel output power –	dBm	4
Minimum mean channel output power	dBm	-2
Total launched power		
min	dBm	0@1 Channel
Max		17
Max. Channel power difference	dB	5
Optical Line Amplifier		
Multi-Channel gain variation	dB	< 2
Multi-Channel gain tilt	dB	< +/- 2
Multi-channel gain change difference	dB	2

Total received power		
min	dBm	29
max	dBm	-3.5
Total Launched Power -min	dBm	0@1 channel
Max	dBm	17
Signal spontaneous Noise Figure	dB	7
Optical path(MPI-SM～MPI-RM)		
Maximum Discrete Reflectance	dB	< -27
Minimum Return Loss	dB	24
Optical interface at MPI-Rs & RM		
Mean channel input Power		
max	dBm	-17
min	dBm	-25
Total Input Power Min	dBm	-29
max	dBm	-3.5
Channel Signal to Noise Ratio- min (S-FEC)	dB	8QAM: 18 /16QAM: 20
Max. Channel power difference at MPI-R & R'	dB	2.5
Maximum differential group delay(1dB OSNR penalty)	Ps	24
Optical Cross talk at individual Channel output ports	dB	< -22dB for adjacent channel < -25db for non-adjacent channel
Individual Receiver inputs at Rn Points		
Receiver sensitivity	dBm	-18
Receiver Overload	dBm	0
Receiver Reflectance	dB	-27
Receiver OSNR Tolerance (EOL)	dB	8QAM: 18 /16QAM: 20
Minimum receivfrequency	nm	1529nm
Maximum Receive frequency	nm	1565nm

Table 4: Parametric values of 80 Channel DWDM system @ 200G

Parametric values of 80 Channel DWDM system @ 200G		
Parameters	**Units**	**Values**
No. Of Channels		80
Bit rate per channel		200G
Modulation Scheme		8QAM/16QAM
No. of spans	Nos.	G.652D: 3 G.655: 3 G.657A: 3
Individual Transmitter output at Sn point		
Launched Power range	dBm	-10 ～ 1
Maximum Spectral Width	nm	0.5 nm (@-20 dB)
Extinction ratio - minimum	dB	12
Central Frequency	THz	193.1 +/- n x 0.05

Minimum Wavelength Spacing	GHz	50
Maximum Wavelength Deviation	GHz	+/-1.8
Optical Interface at MPI – Ss& SM		
Optical Trans side Cross talk	dB	< - 16 dB for adjacent channel < -22 dB for non-adjacent channel
Mean channel output Power	dBm	
Maximum mean channel output power –	dBm	4
Minimum mean channel output power	dBm	-2
Total launched power		
min	dBm	0@1 Channel
Max		20
Max. Channel power difference	dB	5
Optical Line Amplifier		
Multi-Channel gain variation	dB	< 2
Multi-Channel gain tilt	dB	< +/- 2
Multi-channel gain change difference	dB	2
Total received power		
min	dBm	-29
max	dBm	-3.5
Total Launched Power -min	dBm	0@1 Channel
Max	dBm	20
Signal spontaneous Noise Figure	dB	7
Optical path(MPI-SM～MPI-RM)		
Maximum Discrete Reflectance	dB	< -27
Minimum Return Loss	dB	24
Optical interface at MPI-Rs & RM		
Mean channel input Power		
max	dBm	-17
min	dBm	-25
Total Input Power Min	dBm	-29
max	dBm	-3.5
Channel Signal to Noise Ratio- min (S-FEC)	dB	8QAM: 18 /16QAM: 20
Max. Channel power difference at MPI-R & R'	dB	2.5
Maximum differential group delay(1dB OSNR penalty)	Ps	24
Optical Cross talk at individual Channel output ports	dB	< -22dB for adjacent channel < -25db for non-adjacent channel
Individual Receiver inputs at Rn Points		
Receiver sensitivity	dBm	-18
Receiver Overload	dBm	0
Receiver Reflectance	dB	-27
Receiver OSNR Tolerance (EOL)	dB	8QAM: 18 /16QAM: 20

Minimum receivfrequency	nm	1529nm
Maximum Receive frequency	nm	1565nm

Table-5

Parameters specified for STM-16 optical interfaces ITU-T G.957

	Unit	Values					
Digital signal Nominal bit rate	kbit/s	STM-16 according to Recommendation G.707 2 488 320					
Application code (Table 1)		I-16	S-16.1	S-16.2	L-16.1	L-16.2	L-16.3
Operating wavelength range	nm	1266[a)]-1360	1260[a)]-1360	1430-1580	1280-1335	1500-1580	1500-1580
Transmitter at reference point 'S' -							
Source type		MLM	SLM	SLM	SLM	SLM	SLM
Spectral characteristics:							
– maximum RMS width (σ)	nm	4	–	–	–	–	–
– maximum –20 dB width	nm	–	1	< 1[b)]	1	< 1[b)]	< 1[b)]
– minimum side mode – suppression ratio	dB	–	30	30	30	30	30
Mean launched power:							
– maximum	dBm	–3	0	0	+3	+3	+3
– minimum	dBm	–10	–5	–5	–2	–2	–2
Minimum extinction ratio	dB	8.2	8.2	8.2	8.2	8.2	8.2
Optical path between S and R							
Attenuationrange[c)]	dB	0-7	0-12	0-12	10-24[e)]	10-24[e)]	10-24[e)]
Maximum dispersion	ps/nm	12	NA	[b)]	NA	1200-1600[b),d)]	[b)]
Minimum optical return loss of cable plant at S, including any connectors	dB	24	24	24	24	24	24
Maximum discrete reflectance Between S and R	dB	–27	–27	–27	–27	–27	–27
Receiver at reference point R							
Minimum sensitivity[c)]	dBm	–18	–18	–18	–27	–28	–27
Minimum overload	dBm	–3	0	0	–9	–9	–9
Maximum optical path penalty	dB	1	1	1	1	2	1

Maximum reflectance of receiver, measured at R	dB	–27	–27	–27	–27	–27	–27

Table-6

Table 8-3/G.959.1 – Single-channel IrDI parameters and values for optical tributary signal class NRZ 10G intra-office applications							
Parameter	**Units**	**P1I1-2D1r**	**P1I1-2D1**	**P1I1-2D2r**	**P1I1-2D2**	**P1I1-2D3**	**P1I1-2D5**
G.691 Application code		I-64.1r	I-64.1	I-64.2r	I-64.2	I-64.3	I-64.5
Parameters given in		G.693	G.693	G.693			
As code		VSR600-2R1	VSR2000-2R1	VSR2000-2L2			
General information	–						
Maximum number of channels	–	1	1	1	1	1	1
Bit rate/line coding of optical tributary signals	–				NRZ 10G	NRZ 10G	NRZ 10G
Maximum bit error ratio	–				10^{-12}	10^{-12}	10^{-12}
Fibre type	–				G.652	G.653	G.655
Interface at point MPI-S							
Operating wavelength range	nm				1500-1580	1500-1580	1500-1580
Source type					SLM	SLM	SLM
Maximum spectral power density	mW/10 MHz				ffs	ffs	ffs
Minimum side mode suppression ratio	dB				30	30	30
Maximum mean output power	dBm				–1	–1	–1
Minimum mean output power	dBm				–5	–5	–5
Minimum extinction ratio	dB				8.2	8.2	8.2

Table 8-3/G.959.1 – Single-channel IrDI parameters and values for optical tributary signal class NRZ 10G intra-office applications							
Parameter	Units	P1I1-2D1r	P1I1-2D1	P1I1-2D2r	P1I1-2D2	P1I1-2D3	P1I1-2D5
Eye Mask	–				NRZ 10G 1550 nm region	NRZ 10G 1550 nm region	NRZ 10G 1550 nm region
Optical path from point MPI-S to MPI-R							
Maximum attenuation	dB				7	7	7
Minimum attenuation	dB				0	0	0
Maximum chromatic dispersion	ps/nm				500	80	ffs
Minimum optical return loss at MPI-S	dB				24	24	24
Maximum discrete reflectance between MPI-S and MPI-R	dB				–27	–27	–27
Maximum differential group delay	ps				30	30	30
Interface at point MPI-R							
Maximum mean input power	dBm				–1	–1	–1
Minimum sensitivity	dBm				–14	–13	–13
Maximum optical path penalty	dB				2	1	2
Maximum reflectance of optical network element	dB				–27	–27	–27

Table-7

Table 8-4/G.959.1 – Single-channel IrDI parameters and values for optical tributary signal class NRZ 10G short-haul applications						
Parameter	Units	P1S1-2D1	P1S1-2D2a	P1S1-2D2b	P1S1-2D3a P1S1-2D5a	P1S1-2D3b P1S1-2D5b
G.691 Application code		S-64.1	S-64.2a	S-64.2b	S-64.3a S-64.5a	S-64.3b S-64.5b
General information	–					
Maximum number of channels	–	1	1	1	1	1
Bit rate/line coding of optical tributary signals	–	NRZ 10G	NRZ 10G	NRZ 10G	NRZ 10G	NRZ 10G
Maximum bit error ratio	–	10^{-12}	10^{-12}	10^{-12}	10^{-12}	10^{-12}
Fibre type	–	G.652	G.652	G.652	G.653, G.655	G.653, G.655
Interface at point MPI-S						
Operating wavelength range	nm	1290-1330	1530-1565	1530-1565	1530-1565	1530-1565
Source type	–		SLM	SLM	SLM.	SLM
Maximum spectral power density	mW/10 MHz	ffs	ffs	ffs	ffs	ffs
Minimum side mode suppression ratio	dB	30	30	30	30	30
Maximum mean output power	dBm	+5	-1	+2	-1	+2
Minimum mean output power	dBm	+1	-5	-1	-5	-1
Minimum extinction ratio	dB	6	8.2	8.2	8.2	8.2
Eye Mask	-	NRZ 10G 1310 nm region	NRZ 10G 1550 nm region	NRZ 10G 1550 nm region	NRZ 10G 1550 nm region	NRZ 10G 1550 nm region
Optical path from MPI-S to MPI-R						

Table 8-4/G.959.1 – Single-channel IrDI parameters and values for optical tributary signal class NRZ 10G short-haul applications						
Parameter	Units	P1S1-2D1	P1S1-2D2a	P1S1-2D2b	P1S1-2D3a P1S1-2D5a	P1S1-2D3b P1S1-2D5b
Maximum attenuation	dB	11	11	11	11	11
Minimum attenuation	dB	6	7	3	7	3
Maximum chromatic dispersion	ps/nm	70	800	800	130	130
Minimum optical return loss at MPI-S	dB	14	24	24	24	24
Maximum discrete reflectance between MPI-S and MPI-R	dB	–27	–27	–27	–27	–27
Maximum differential group delay	ps	30	30	30	30	30
Interface at point MPI-R						
Maximum mean input power	dBm	–1	–8	–1	–8	–1
Minimum sensitivity	dBm	–11	–18	–14	–17	–13
Maximum optical path penalty	dB	1	2	2	1	1
Maximum reflectance of optical network element	dB	–14	–27	–27	–27	–27
NOTE – Application codes with a suffix "a" have transmitter power levels appropriate to APD receivers; application codes with the suffix "b" have transmitter power levels appropriate to PIN receivers.						

Table-8

(Table 52-7/IEEE: 10GBASE-S transmit characteristics)

Description	10GBASE-SW	10GBASE-SR	Unit
Signaling speed (nominal)	9.95328	10.3125	GBd
Signaling speed variation from nominal (max)	±20	±100	ppm
Center wavelength (range)	840 to 860		nm
RMS spectral width[a](max)	See foot note b		
Average launch power (max)	See foot note c		
Average launch power[d] (min)	–7.3		dBm
Launch power (min) in OMA	See foot note b		
Average launch power of OFF transmitter (max)	–30		dBm
Extinction ratio (min)	3		dB
RIN12OMA (max)	–128		dB/Hz
Optical Return Loss Tolerance (max)	12		dB
Encircled flux	See foot note f		
Transmittereyemaskdefinition {X1, X2, X3, Y1, Y2, Y3}	{0.25, 0.40, 0.45, 0.25, 0.28, 0.40}		
Transmitter and dispersion penalty (max)	3.9 dB		dB

a. RMS spectral width is the standard deviation of the spectrum.
b. Trade-offs are available between spectral width, center wavelength and minimum optical modulation amplitude. See Figure 52–3 and Table 52–8.
c. The 10GBASE-S launch power shall be the lesser of the class 1 safety limit as defined by 52.10.2 or the average receive power (max) defined by Table 52–9.

d. Average launch power (min) is informative and not the principal indicator of signal strength. A transmitter with launch power below this value cannot be compliant; however, a value above this does not ensure compliance.
e. Examples of an OFF transmitter are: no power supplied to the PMD, laser shutdown for safety conditions, activation of PMD_global_transmit_disable or other optional transmitter shut down conditions.
f. The encircled flux at 19 μm shall be greater than or equal to 86% and the encircled flux at 4.5 μm shall be less than or
g. The encircled flux at 19 μm shall be greater than or equal to 86% and the encircled flux at 4.5 μm shall be less than or equal to 30% when measured into Type A1a (50/125 μm multimode) fiber per ANSI/TIA/EIA-455-203-2001.
h. TDP(max) and OMA(min) are at the respective wavelength and spectral width as specified in Table 52–8.

Table-9

(Table 52-9/IEEE: 10GBASE-S receive characteristics)

Description	10GBASE-S	Unit
Signaling speed (nominal) 10GBASE-SR 10GBASE-SW	10.3125 9.95328	GBd
Signaling speed variation from nominal (max)	±100	ppm
Center wavelength (range)	840 to 860	nm
Average receive power[a](max)	–1.0	dBm
Average receive power[b] (min)	–9.9	dBm
Receiver sensitivity (max) in OMA[c]	0.077 (–11.1)	mW (dBm)
Receiver Reflectance (max)	–12	dB
Stressed receiver sensitivity in OMA[d,e](max)	0.18 (–7.5)	mW (dBm)
Vertical eye closure penalty[f] (min)	3.5	dB
Stressed eye jitter[g] (min)	0.3	UI pk-pk
Receive electrical 3 dB upper cutoff frequency (max)	12.3	GHz

a. The receiver shall be able to tolerate, without damage, continuous exposure to an optical input signal having a power level equal to the Average Receive Power (max) plus at least 1 dB.

b. Average receive power (min) is informative and not the principal indicator of signal strength. A received power below this value cannot be compliant; however, a value above this does not ensure compliance.

c. Receiver sensitivity is informative.

d. Measured with conformance test signal at TP3 (see 52.9.9.2) for BER = 10–12.

e. The stressed sensitivity values in the table are for system level BER measurements which include the effects of CDR circuits. It is recommended that at least 0.4 dB additional margin be allocated if component level measurements are made without the effect of CDR circuits

f. Vertical eye closure penalty is a test condition for measuring stressed receiver sensitivity. It is not a required characteristic of the receiver.

g. Stressed eye jitter is a test condition for measuring stressed receiver sensitivity. It is not a required characteristic of the receiver.

Table-10

(Table 52–12/IEEE: 10GBASE-L transmit characteristics)

Description	10GBASE-LW	10GBASE-LR	Unit
Signaling speed (nominal)	9.95328	10.3125	GBd
Signaling speed variation from nominal (max)	±20	±100	ppm
Center wavelength (range)	1260 to 1355		nm
Side Mode Suppression Ratio (min)	30		dB
Average launch power (max)	0.5		dBm
Average launch power[a] (min)	–8.2		dBm
Launch power (min) in OMA minus TDP[b]	–6.2		dBm
Optical Modulation Amplitude[c](min)	–5.2		dBm
Transmitter and dispersion penalty (max)	3.2		dB
Average launch power of OFF transmitter[d] (max)	–30		dBm
Extinction ratio (min)	3.5		dB
RIN12OMA (max)	–128		dB/Hz
Optical Return Loss Tolerance (max)	12		dB
Transmitter Reflectance[e] (max)	–12		dB
Transmittereyemaskdefinition {X1, X2, X3, Y1, Y2, Y3}	{0.25, 0.40, 0.45, 0.25, 0.28, 0.40}		

a. Average launch power (min) is informative and not the principal indicator of signal strength. A transmitter with launch power below this value cannot be compliant; however, a value above this does not ensure compliance.

b. TDP is transmitter and dispersion penalty.

c. Even if the TDP < 1 dB, the OMA(min) must exceed this value.

d. Examples of an OFF transmitter are: no power supplied to the PMD, laser shutdown for safety conditions, activation of a PMD_global_transmit_disable or other optional transmitter shut down conditions.

e. Transmitter reflectance is defined looking into the transmitter.

Table-11

(Table 52–13/IEEE: 10GBASE-L receive characteristics)

Description	10GBASE-L	Unit
Signaling speed (nominal) 10GBASE-LR 10GBASE-LW	10.3125 9.95328	GBd
Signaling speed variation from nominal (max)	±100	ppm
Center wavelength (range)	1260 to 1355	nm
Average receive power[a] (max)	0.5	dBm
Average receive power[b] (min)	–14.4	dBm
Receiver sensitivity (max) in OMA[c]	0.055 (-12.6)	mW (dBm)
Receiver Reflectance (max)	–12	dB
Stressed receiver sensitivity (max) in OMA[d,e]	0.093 (–10.3)	mW (dBm)
Vertical eye closure penalty[f] (min)	2.2	dB
Stressed eye jitter[g](min)	0.3	UI pk-pk
Receive electrical 3 dB upper cutoff frequency (max)	12.3	GHz

a. The receiver shall be able to tolerate, without damage, continuous exposure to an optical input signal having a power level equal to the Average Receive Power (max) plus at least 1 dB.

b. Average receive power (min) is informative and not the principal indicator of signal strength. A received power below this value cannot be compliant; however, a value above this does not ensure compliance.

c. Receiver sensitivity is informative.

d. Measured with conformance test signal at TP3 (see 52.9.9.2) for BER = 10-12.

e. The stressed sensitivity values in the table are for system level BER measurements which include the effects of CDR circuits. It is recommended that at least 0.4 dB additional margin be allocated if component level measurements are made without the effect of CDR circuits.

f. Vertical eye closure penalty is a test condition for measuring stressed receiver sensitivity. It is not a required characteristic of the receiver.

g. Stressed eye jitter is a test condition for measuring stressed receiver sensitivity. It is not a required characteristic of the receiver.

Table-12

(Table 52-16-10GBASE-E Transmit characteristics)

Description	10GBASE-EW	10GBASE-ER	Unit
Signaling speed (nominal)	9.95328	10.3125	GBd
Signaling speed variation from nominal (max)	±20	±100	ppm
Center wavelength (range)	1530 to 1565		nm
Side Mode Suppression Ratio (min)	30		dB
Average receive power (max)	4.0		dBm
Average receive power [a] (min)	-4.7		dBm
Launch power (min) in OMA minus TDP [b]	-2.1		dBm
Average launch power of OFF transmitter [c] (max)	-30		dBm
Optical Modulation Amplitude [d] (min)	-1.7		dBm
Transmitter and dispersion penalty (max)	3.0		dB
Extinction ratio (min)	3		dB
RIN_{21} OMA [e] (max)	-128		dB/Hz
Optical Return Loss Tolerance (max)	21		dB
Transmittereyemaskdefinition (X1, X2, X3, Y1, Y2, Y3)	(0.25,0.40,0.45,0.25,0.28,0.40)		

a. Average launch power (min) is informative and not the principle indicator of signal strength. A transmitter with launch power below this value cannot be compliant; however, a value above this does not ensure compliance.
b. TDP is transmitter and dispersion penalty.
c. Examples of an OFF transmitter are; no power supplied to the PMD, laser shutdown for safety conditions, activation of a PMD_global_transmit_disable or other optional transmitter shut-down conditions.
d. Even if the TDP<0.4 dB, the OMA(min) must exceed this value.
e. RIN measurement is made with a return loss at 21 dB.

Table-13

(Table 52-17-10GBASE-E receive characteristics)

Description	10GBASE-E	Unit
Signaling speed (nominal) 10GBASE-ER 10GBASE-EW	10.3125 9.95328	GBd
Signaling speed variation from nominal (max)	± 100	ppm
Center wavelength (range)	1530 to 1565	nm
Average receive power (max)	-1.0	dBm
Average receive power [a] (min)	-15.8	dBm
Maximum receive power (for damage)	4.0	dBm
Receiver sensitivity (max) in OMA [b]	0.039(-14.1)	mW (dBm)
Receiver Reflectance (max)	-26	dB
Stressed receiver sensitivity (max) in OMA[c,d]	0.074(-11.3)	mW (dBm)
Vertical eye closure penalty [e] (min)	2.7	dB
Stressed eye jitter (min) [f]	0.3	UI pk-pk
Receive electrical 3 dB upper cutoff frequency (max)	12.3	GHz

a. Average receive power (min) is informative and not the principle indicator of signal strength. A received power below this value cannot be compliant; however, a value above this does not ensure compliance.

b. Receiver sensitivity is informative.

c. Measured with conformance test signal at TP3 (see 52.9.9.2) for BER = 10-12

d. The stressed sensitivity values in the table are for system level BER measurements which includes the effects of CDR circuits. It is recommended that at least 0.4dB additional margin be allocated if component level measurements are made without the effects of CDR circuits.

e. Vertical eye closure penalty is a test condition for measuring stressed receiver sensitivity. It is not a required characteristic of the receiver.

f. Stressed eye jitter is a test condition for measuring stressed receiver sensitivity. It is not a required characteristic of the receiver.

Table-14

(Table 52-18-10GBASE-E link power budgets [a, d])

Parameter	10GBASE-E		Unit
Power budget	15.0		dB
Operating distance	30	40	km
Channel insertion loss [d, e]	10.9	10.9	dB
Maximum Discrete Reflectance (max)	-26		dB
Allocation for penalties	3.6	4.1	dB
Additional insertion loss allowed	0.5	0.0	dB

a. Budget numbers are rounded to nearest 0.1 dB.
b. Link penalties are built into the transmitter specifications by testing the PMD with a maximum dispersion fiber.
c. Links longer than 30 km are considered engineered links. Attenuation for such links needs to be less than that guaranteed by B1.1 or B1.3 single mode fiber.
d. Operating distance used to calculate the channel insertion loss are that maximum values specified in Table 52-15.
e. A wavelength of 1565 nm and 3dB transmitter and dispersion penalty (TDP) is used to calculate channel insertion loss and allocation for penalties.

Table-15
(100G DWDM side fixed Module specifications)

Parameters and Optical Module Type	Unit	Value for 40000ps/nm-C Band-Tunable Wavelength-Single Carrier Coherent-QPSK(HDFEC/SDFEC)
Line code format	-	Single Carrier Coherent-DP-QPSK(HDFEC)
Transmitter parameter specifications at point S		
Center frequency	THz	191.21 to 196.1
Maximum mean launched power	dBM	+5
Minimum mean launched power	dBM	-5
Center frequency deviation	GHz	±2.5
Maximum -3 dB spectral width	GHz	37.5
Dispersion tolerance (back-to-back)	Ps/nm	40000
Receiver parameter specifications at point R		
Receiver type	-	PIN
Operating wavelength range	nm	1529 to 1565
OSNR B2B Cut off Value	dB	15
Receiver sensitivity	dBm	-18
Minimum receiver overload	dBm	0
Maximum reflectance	dB	-27

Table-16
(100G DWDM side fixed Module specifications)

Parameter and Optical Module Type	**Unit**	**Value for 55000ps/nm-C Band-Tunable Wavelength-Single Carrier Coherent-QPSK(SDFEC)**
Line code format	-	Single Carrier Coherent-QPSK(SDFEC)
Transmitter parameter specifications at point S		
Center frequency	THz	192.1 to 196.05
Maximum mean launched power	dBM	0
Minimum mean launched power	dBM	-5
Center frequency deviation	GHz	±2.5
Maximum -3 dB spectral width	nm	0.4
Dispersion tolerance (back-to-back)	Ps/nm	55000
Receiver parameter specifications at point R		
Receiver Type	-	PIN
Operating Wavelength range	nm	
Receiver Sensitivity	dBm	-16
Minimum receiver overload	dBm	0
Maximum reflectance	dB	-27

Table-17
(200G DWDM side fixed Module specifications)

Parameters and Optical Module Type	**Unit**	**Value for 20000ps/nm-C Band-Tunable Wavelength-Single Carrier Coherent-8QAM (SDFEC)**
Line code format	-	Single Carrier Coherent-8QAM (SDFEC)
Transmitter parameter specifications at point S		
Center frequency	THz	191.2 to 196.1
Maximum mean launched power	dBM	0
Minimum mean launched power	dBM	-10
Center frequency deviation	GHz	±2.5
Maximum -3 dB spectral width	GHz	50
Dispersion tolerance (back-to-back)	Ps/nm	20000
Receiver parameter specifications at point R		
Receiver type	-	PIN
Operating wavelength range	nm	1529 to 1565
OSNR B2B cut-off	dB	18
Receiver sensitivity	dBm	-16
Minimum receiver overload	dBm	0
Maximum reflectance	dB	-27

Table-18
(200G DWDM side fixed Module specifications)

Parameters and Optical Module Type	**Unit**	**Value for 16000ps/nm-C Band-Tunable Wavelength-Single Carrier Coherent-16QAM (SDFEC)**
Line code format	-	Single Carrier Coherent-16QAM (SDFEC)
Transmitter parameter specifications at point S		
Center frequency	THz	191.2 to 196.1
Maximum mean launched power	dBM	0
Minimum mean launched power	dBM	-10
Center frequency deviation	GHz	±2.5
Maximum -3 dB spectral width	GHz	50
Dispersion tolerance (back-to-back)	Ps/nm	16000
Receiver parameter specifications at point R		
Receiver type	-	PIN
Operating wavelength range	nm	1529 to 1565
OSNR B2B cut-off	dB	21
Receiver sensitivity	dBm	-15
Minimum receiver overload	dBm	-3
Maximum reflectance	dB	-27

Table 19

(40GClient-Side Pluggable Optical Module specifications)

Parameter Optical Module Type	Unit	40GBase-LR4-10Km-CFP	40GBase-ER4-40Km-CFP
Line Code Format	-	NRZ	NRZ
Target transmission distance	Km	10	40
Signalling Speed/Lane	Gbit/s	10.3125	10.3125
Signalling Speed Accuracy	ppm	-100 to 100	-100 to 100
Minimum Lane Center Wavelength	nm	1264.5	1264.5
		1284.5	1284.5
		1304.5	1304.5
		1324.5	1324.5
Maximum Lane CenterWavelength	nm	1277.5	1277.5
		1297.5	1297.5
		1317.5	1317.5
		1337.5	1337.5
Total Average Launch Power(Min)	dBm	-1	5.1
Total Average Launch Power(Max)	dBm	8.3	9.8
Transmit OMA per Lane(Min)	dBm	-4	0.5
Transmit OMA per Lane(Max)	dBm	3.5	5
Average Launch Power per Lane (Min)	dBm	-7	-1.1
Average Launch Power per Lane (Max)	dBm	2.3	4.5
Optical Extinction Ratio (Min)	dB	3.5	7
Side Mode Suppression Ratio (Min)	dB	30	30
Receiver type	-	PIN	PIN
Signalling Speed per Lane	Gbit/s	10.3125	10.3125
Signalling Speed Accuracy	ppm	-100 to 100	-100 to 100
Minimum Lane Centre Wavelength	nm	1264.5	1264.5
		1284.5	1284.5
		1304.5	1304.5
		1324.5	1324.5
Maximum Lane Centre Wavelength	nm	1277.5	1277.5
		1297.5	1297.5
		1317.5	1317.5
		1337.5	1337.5
Average Receiver Power per Lane (Min)	dBm	-13.7	-18
Average Receiver Power per Lane (Max)	dBm	2.3	3.8
Minimum receiver overload (OMA) per Lane	dBm	2.3	-1
Receiver sensitivity (OMA) per Lane	dBm	-13.7	-19.5
Maximum reflectance	dB	-26	-26

Table-20

(100GClient-Side Pluggable Optical Module specifications, 100GE Services)

Parameter Optical Module Type	Unit	100GBase-LR4-10Km-CFP	100GBase-ER4-40Km-CFP
Line Code Format	-	NRZ	NRZ
Target transmission distance	Km	10	40
Transmitter parameter specifications at point S			
Signalling Speed/Lane	Gbit/s	25.78125	25.78125
Signalling Speed Accuracy	ppm	-100 to 100	-100 to 100
Minimum Lane Centre Wavelength	nm	1294.53	1294.53
		1299.02	1299.02
		1303.54	1303.54
		1308.09	1308.09
Maximum Lane Centre Wavelength	nm	1296.59	1296.59
		1301.09	1301.09
		1305.63	1305.63
		1310.19	1310.19
Total Average Launch Power(Min)	dBm	1.7	3.1
Total Average Launch Power (Max)	dBm	10.5	8.9
Transmit OMA per Lane (Min)	dBm	-1.3	0.1
Transmit OMA per Lane (Max)	dBm	4.5	4.5
Average Launch Power per Lane (Min)	dBm	-4.3	-2.9
Average Launch Power per Lane (Max)	dBm	4.5	2.9
Optical Extinction Ratio (Min)	dB	4	8
Side Mode Suppression Ratio (Min)	dB	30	30
Receiver parameter specifications at point R			
Receiver type	-	PIN	PIN
Signalling Speed per Lane	Gbit/s	25.78125	25.78125
Signalling Speed Accuracy	ppm	-100 to 100	-100 to 100
Minimum Lane Centre Wavelength	nm	1294.53	1294.53
		1299.02	1299.02
		1303.54	1303.54
		1308.09	1308.09
Maximum Lane Centre Wavelength	nm	1296.59	1296.59
		1301.09	1301.09
		1305.63	1305.63
		1310.19	1310.19
Average Receiver Power per Lane (Min)	dBm	-10.6	-20.9

Average Receiver Power per Lane (Max)	dBm	4.5	4.5
Minimum receiver overload (OMA) per Lane	dBm	4.5	4.5
Receiver sensitivity	dBm	-8.6	-21.4
Maximum reflectance	dB	-26	-26

Note: The OMA values are designed to ensure normal equipment operation. They are not provided for equipment commissioning. In practical, equipment commissioning is performed based on the average receiver power per lane and total average launched power. It is recommended that the total average launched power be used as the reference for equipment commissioning.

Table-21

(100G Client-side pluggable optical module specifications, 100GE services-)

Parameter	Unit	Value
Optical Module Type		100G BASE-10×10G-10 km-CFP
Line code format	-	NRZ
Optical source type	-	SLM
Target transmission distance	-	10 km (6.2 mi.)
Transmitter parameter specifications at point S		
Signaling Speed per Lane	Gbit/s	10.3125
Signaling Speed Accuracy	Ppm	-100 to 100
Minimum Lane Center Wavelength	Nm	1521
		1529
		1537
		1545
		1553
		1561
		1569
		1577
		1585
		1593
Maximum Lane Center Wavelength	Nm	1525
		1533

Parameter	Unit	Value
Optical Module Type		100G BASE-10×10G-10 km-CFP
		1541
		1549
		1557
		1565
		1573
		1581
		1589
		1597
Total Average Launch Power (Min)	dBm	4.2
Total Average Launch Power (Max)	dBm	13.5
Average Launch Power per Lane (Min)	dBm	-5.8
Average Launch Power per Lane (Max)	dBm	3.5
Transmit OMA per Lane (Min)	dBm	-2.8
Transmit OMA per Lane (Typ)	dBm	-0.8
Transmit OMA per Lane (Max)	dBm	3.5
Optical Extinction Ratio (Min)	dB	2.5
Side Mode Suppression Ratio (Min)	dB	30

Parameter	Unit	Value
Optical Module Type		100G BASE-10×10G-10 km-CFP
Receiver parameter specifications at point R		
Receiver type	-	PIN
Signaling Speed per Lane	Gbit/s	10.3125
Signaling Speed Accuracy	ppm	-100 to 100
Minimum Lane Center Wavelength	nm	1521
		1529
		1537
		1545
		1553
		1561
		1569
		1577
		1585
		1593
Maximum Lane Center Wavelength	nm	1525
		1533
		1541
		1549
		1557
		1565

Parameter	Unit	Value
Optical Module Type		100G BASE-10×10G-10 km-CFP
		1573
		1581
		1589
		1597
Receiver Power per Lane (Min)	dBm	-10.8
Receiver Power per Lane (Max)	dBm	3.5
Minimum receiver overload (OMA) per Lane	dBm	3.5
Receiver Sensitivity (OMA) per Lane	dBm	-8.8
Maximum reflectance	dB	-26

NOTE

The OMA values are designed to ensure normal equipment operation. They are not provided for equipment commissioning. In practical, equipment commissioning is performed based on the average receiver power per lane and total average launched power. It is recommended that the total average launched power be used as the reference for equipment commissioning.

Table-22

(100G Client-side pluggable optical module specifications,100GE/OTU4 services)

Parameter	Unit	Value
Optical Module Type		(100G BASE-4×25G)/(OTU4-4×28G)-10 km-CFP
Line code format	-	NRZ
Optical source type	-	SLM
Target transmission distance	-	10 km (6.2 mi.)
Transmitter parameter specifications at point S		
Signaling Speed per Lane	Gbit/s	100GE: 25.78125 OTU4: 27.952493
Signaling Speed Accuracy	ppm	100GE: -100 to 100 OTU4: -20 to 20
Minimum Lane Center Wavelength	nm	1294.53
		1299.02
		1303.54
		1308.09
Maximum Lane Center Wavelength	nm	1296.59
		1301.09
		1305.63
		1310.19
Total Average Launch Power (Min)	dBm	100GE: 1.7 OTU4: 3.5
Total Average Launch Power	dBm	100GE: 10.5

Parameter	Unit	Value
Optical Module Type		(100G BASE-4×25G)/(OTU4-4×28G)-10 km-CFP
(Max)		OTU4: 8.9
Average Launch Power per Lane (Min)	dBm	100GE: -4.3 OTU4: -2.5
Average Launch Power per Lane (Max)	dBm	100GE: 4.5 OTU4: 2.9
Transmit OMA per Lane (Min)	dBm	-1.3 (Only for 100GE)
Transmit OMA per Lane (Max)	dBm	4.5 (Only for 100GE)
Eye pattern mask	-	100GE: IEEE 802.3ba - compliant OTU4: ITU-T G.959 – compliant
Optical Extinction Ratio (Min)	dB	100GE: 4 OTU4: 7
Side Mode Suppression Ratio (Min)	dB	30
Receiver parameter specifications at point R		
Receiver type	-	PIN
Signaling Speed per Lane	Gbit/s	100GE: 25.78125 OTU4: 27.952493
Signaling Speed Accuracy	ppm	100GE: -100 to 100 OTU4: -20 to 20
Minimum Lane Center	nm	1294.53

Parameter	Unit	Value
Optical Module Type		(100G BASE-4×25G)/(OTU4-4×28G)-10 km-CFP
Wavelength		1299.02
		1303.54
		1308.09
Maximum Lane Center Wavelength	nm	1296.59
		1301.09
		1305.63
		1310.19
Receiver Power per Lane (Min)	dBm	100GE: -10.6 OTU4: -8.8
Receiver Power per Lane (Max)	dBm	100GE: 4.5 OTU4: 2.9
Minimum receiver overload (OMA) per Lane	dBm	4.5 (Only for 100GE)
Receiver sensitivity (OMA) per Lane	dBm	-8.6 (Only for 100GE)
Receiver equivalent sensitivity per Lane	dBm	-10.3 (Only for OTU4)
Minimum receiver overload per Lane	dBm	2.9 (Only for OTU4)
Maximum reflectance	dB	-26

Parameter	Unit	Value
Optical Module Type		(100G BASE-4×25G)/(OTU4-4×28G)-10 km-CFP
NOTE: The OMA values are designed to ensure normal equipment operation. They are not provided for equipment commissioning. In practical, equipment commissioning is performed based on the average receiver power per lane and total average launched power. It is recommended that the total average launched power be used as the reference for equipment commissioning.		

Note: Purchaser will have a choice for any one or all of them subject to the condition that they all meet the conditions of reachability upto10kms for client side pluggable.

ANNEXURE-II

Minimum Equipment for Type Approval:

The minimum equipment required for type approval shall be as follows:

1. DWDM Point-to-point & Linear Add/Drop System:

S. No.	Item	Quantity
1	Terminals (inclusive of transponders for all channels & MUX/De-MUX for both directions of traffic along with protection related redundant equipment)	2 nos. of TE equipped for 16 channels. Four wavelengths for extreme ends and Four wavelengths in center and other Four can be configured over 80 channels Grid.
2	In-Line Amplifiers	• 4 nos. for Longhaul equipment • 2 nos. for Very Longhaul equipment. (If OADM not offered for testing, there shall be 7 & 4 ILAs for longhaul and very longhaul application codes respectively).
3	OADM (inclusive of transponders for both directions of added/dropped traffic) for linear-chain DWDM system	• 3 Nos. equipped for a total of 3 bi-directional channels in both fibre directions for Long Haul • 2 nos. equipped for a total of 3 bi-directional channels in both fibre-directions for Very Longhaul equipment. Two wavelengths from extreme ends and anyone additional wavelength which can be configured over 80-channels Grid. All three

		wavelengths can be re-configured to other wavelengths for testing purpose. (Applies only to the applied application code).
4	Common equipment with an EMS & LCT along with software.	1 no. each

Note 1: The system offered is for 40/80 Channels. In case equipment offered for testing is not fully equipped and loaded for lesser configuration for Type Approval, the number of channels tested shall be mentioned in Type Approval Certificate.

Note 2: In case the equipment is not fully loaded, the manufacturer will submit a certificate of undertaking that "The system shall be able to perform satisfactorily without any degradation in fully loaded condition.". A certificate of undertaking from the manufacturer shall be acceptable.

2. DWDM Ring:

a. Hub Ring Topology

SN	Items	Current Configuration
1.	Ring Head-end	1 no. TE equipped with 16 wavelengths (8 Wavelength in each direction) (Including Transponders, Mux De-Mux etc). To have 3 Add/Drop channels on each OADM. Head-end will be demonstrated with total 16 bi-directional channels (8 channels in each direction) loaded with Mux-Ponders / Transponnders. All wavelengths can be dropped on OADMs.
2.	In-line Amplifiers	4 Nos. for Long Haul Applications
3.	OADM	3 Nos. equipped for a total of 3 bi-

		directional channels in both fibre directions for Long Haul 2 nos. equipped for a total of 3 bi-directional channels in both fibre-directions for Very Longhaul equipment. Two wavelengths from extreme ends and anyone additional wavelength which can be configured over 80-channels Grid. All three wavelengths can be re-configured to other wavelengths for testing purpose.
4.	Common equipment with an EMS and LCT along with software	1 no. each

Note 1: The system offered is for 40/80 Channels. In case equipment offered for testing is not fully equipped and loaded for lesser configuration for Type Approval, the number of channels tested shall be mentioned in Type Approval Certificate.

Note 2: In case the equipment is not fully loaded, the manufacturer will submit a certificate of undertaking that "The system shall be able to perform satisfactorily without any degradation in fully loaded condition.". A certificate of undertaking from the manufacturer shall be acceptable.

b. 2-Fiber Closed Ring

Sl. No.	Item	Quantity
1	Ring 'Head-end' (inclusive of transponders for all channels & MUX/De-MUX both directions of traffic along with protection related redundant equipment)	ROADM with total 16 bi-directional channels (8 in each direction) in place of Ring Head-end for closed ring topology Head-end TE will be replaced with OADM having total 16 bi-directional channels (8 channels in each direction).

2	In-Line Amplifiers	• 4 nos. for Longhaul equipment • 2 nos. for Very Longhaul equipment. (If OADM not offered for testing, there shall be 7 & 4 ILAs for longhaul and very longhaul application codes respectively).
3	OADM (inclusive of transponders both directions of added/dropped traffic)	• 3 Nos. equipped for a total of 3 bi-directional channels in both fibre directions for Long Haul • 2 nos. equipped for a total of 3 bi-directional channels in both fibre-directions for Very Longhaul equipment. Two wavelengths from extreme ends and anyone additional wavelength which can be configured over 80-channels Grid. All three wavelengths can be re-configured to other wavelengths for testing purpose.(Applies only to the applied application code).
4	Common equipment with an EMS & LCT along with software.	1 no. each

Note 1: The system offered is for 40/80 Channels. In case equipment offered for testing is not fully equipped and loaded for lesser configuration for Type Approval, the number of channels tested shall be mentioned in Type Approval Certificate.

Note 2: In case the equipment is not fully loaded, the manufacturer will submit a certificate of undertaking that "The system shall be able to perform satisfactorily without any degradation in fully loaded condition.". A certificate of undertaking from the manufacturer shall be acceptable.

3.Mesh Topology:

SN	Items	Recommended Configuration
1.	OADM	5 Nos. Equipped for a total of 3 bi-directional channels towards star node for Long Haul Remark: Additional wavelength can be configured for point to point nodes.
2.	In-line Amplifiers	4 Nos. for Long Haul Applications
3.	Common equipment with an EMS and LCT along with software	1 no. each

Note 1: The system offered is for 40/80 Channels. In case equipment offered for testing is not fully equipped and loaded for lesser configuration for Type Approval, the number of channels tested shall be mentioned in Type Approval Certificate.

Note 2: In case the equipment is not fully loaded, the manufacturer will submit a certificate of undertaking that “The system shall be able to perform satisfactorily without any degradation in fully loaded condition.”. A certificate of undertaking from the manufacturer shall be acceptable.

The details for minimum equipment required for type approval are elaborated as follows:

For 40/80 channels for 100G:

Long haul application for 100G:

1. DWDM Multiplexer &Demultiplexer at each terminal : 2 nos. each
2. Optical Line Amplifiers : 4 nos.
3. Optical Add /Drop Mux along with channel add/drop RX & TX-Transponders: 3 Nos. (Total 05 Nos. OADMs for Mesh configuration with no TE required)
4. Muxponder/ Transponders / 100GE Ethernet Transponders (Combination of all three) : 50 nos
5. Optical fibre 22dB loss irrespective of length: 8 spools for 8 spans

Very Long haul application 100G:

1. DWDM Multiplexer &Demultiplexer at each terminal : 2 nos. each
2. Optical Line Amplifiers : 2 nos.
3. Optical Add /Drop Mux along with channel add/drop RX & TX Transponders: 2 nos. (Total 05 Nos. OADMs for Mesh configuration with no TE required).
4. Muxponder/ Transponders / 100GE Ethernet Transponders (Combination of all three) :44 nos
5. Optical fibre 28dB loss irrespective of length: 5 spools for 5 spans

For 40/80 Channels for 200G

Long haul application for 200G:

1. DWDM Multiplexer &Demultiplexer at each terminal : 2 nos. each
2. Optical Line Amplifiers : 2 nos.
3. Optical Add /Drop Mux along with channel add/drop RX & TX-Transponders: 2 nos.
4. Muxponder/ Transponders : 50 nos
5. Optical fibre 25dB loss irrespective of length: 6 spools for 6 spans

Very Long haul application 200G:

1. DWDM Multiplexer &Demultiplexer at each terminal : 2 nos. each
2. Optical Line Amplifiers : 1 nos.
3. Optical Add /Drop Mux along with channel add/drop RX & TX Transponders: 1nos.
4. Muxponder/Transponders:44 nos
5. Optical fibre 28dB loss irrespective of length: 3 spools for 3 spans

Note 1: The TAC can be applied against any two of the DWDM network topologies- point-to-point, linear add/drop & ring. The same shall be outlined on the TAC.

Note 2: The TAC can be applied for any of the application codes – Longhaul and Very Longhaul.

Note 3: No QM-333 environmental tests shall be conducted on the EMS Server/LCT PC.

ANNEXURE-III

100G Transponder, 10X10G and 200G Muxponder alarms

100G Transponder Alarms	10*10G Muxponder Alarms	200G Muxponder Alarms
OCh_FDI	OCh_FDI	OTUC-LOF
OCh_FDI_O	OCh_FDI_O	ODUCk-AIS
OCh_FDI_P	OCh_FDI_P	ODUCk-SF
OCh_LOS_P	OCh_LOS_P	ODUCk-SD
OCh_OCI	OCh_OCI	
OCh_SSF	OCh_SSF	
OCh_SSF_O	OCh_SSF_O	
OCh_SSF_P	OCh_SSF_P	
ODU4_PM_AIS	ODU2_LOFLOM	
ODU4_PM_BDI	ODU2_PM_AIS	
ODU4_PM_DEG	ODU2_PM_BDI	
ODU4_PM_LCK	ODU2_PM_DEG	
ODU4_PM_OCI	ODU2_PM_LCK	
ODU4_PM_SSF	ODU2_PM_OCI	
ODU4_PM_TIM	ODU2_PM_SSF	
ODU4_TCMn_AIS	ODU2_PM_TIM	
ODU4_TCMn_BDI	ODU2_TCMn_AIS	
ODU4_TCMn_DEG	ODU2_TCMn_BDI	
ODU4_TCMn_LCK	ODU2_TCMn_DEG	
ODU4_TCMn_LTC	ODU2_TCMn_LCK	
ODU4_TCMn_OCI	ODU2_TCMn_LTC	
ODU4_TCMn_SSF	ODU2_TCMn_OCI	
ODU4_TCMn_TIM	ODU2_TCMn_SSF	
OPA_FAIL_INDI	ODU2_TCMn_TIM	
OPU4_PLM	ODU4_PM_AIS	
OTU4_BDI	ODU4_PM_BDI	
OTU4_DEG	ODU4_PM_DEG	
OTU4_LOF	ODU4_PM_LCK	
OTU4_LOM	ODU4_PM_OCI	
OTU4_SSF	ODU4_PM_SSF	
OTU4_TIM	ODU4_PM_TIM	
OUT_PWR_HIGH	ODU4_TCMn_AIS	
OUT_PWR_LOW	ODU4_TCMn_BDI	
	ODU4_TCMn_DEG	
	ODU4_TCMn_LCK	
	ODU4_TCMn_LTC	
	ODU4_TCMn_OCI	
	ODU4_TCMn_SSF	
	ODU4_TCMn_TIM	

	ODUFLEX_LOFLOM	
	ODUFLEX_PM_AIS	
	ODUFLEX_PM_BDI	
	ODUFLEX_PM_DEG	
	ODUFLEX_PM_LCK	
	ODUFLEX_PM_OCI	
	ODUFLEX_PM_SSF	
	ODUFLEX_PM_TIM	
	ODUFLEX_TCMn_AIS	
	ODUFLEX_TCMn_BDI	
	ODUFLEX_TCMn_DEG	
	ODUFLEX_TCMn_LCK	
	ODUFLEX_TCMn_LTC	
	ODUFLEX_TCMn_OCI	
	ODUFLEX_TCMn_SSF	
	ODUFLEX_TCMn_TIM	
	OPA_FAIL_INDI	
	OPU2_CSF	
	OPU2_MSIM	
	OPU2_PLM	
	OPU4_PLM	
	OPUFLEX_CSF	
	OPUFLEX_MSIM	
	OPUFLEX_PLM	
	OTU2_AIS	
	OTU2_BDI	
	OTU2_DEG	
	OTU2_LOF	
	OTU2_LOM	
	OTU2_SSF	
	OTU2_TIM	
	OTU4_AIS	
	OTU4_BDI	
	OTU4_DEG	
	OTU4_LOF	
	OTU4_LOM	
	OTU4_SSF	
	OTU4_TIM	
	OUT_PWR_HIGH	
	OUT_PWR_LOW	