वर्गीय आवश्यकताओं के लिए मानक

टीईसी 71120:2022

STANDARD FOR GENERIC REQUIREMENTS

TEC 71120:2022

कन्वर्ज मल्टी-सर्विस एप्लीकेशन एक्सेस इक्विपमेंट

Converged Multi-Service Application Access Equipment

ISO 9001:2015

दूरसंचार अभियांत्रिकी केंद्र

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FOREWORD

Telecommunication Engineering Centre (TEC) is the technical arm of 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 Centers (RTECs) have been established which are located at New Delhi, Bangalore, Mumbai, and Kolkata.

ABSTRACT

This document describes the generic requirements and specifications for network architectures based on Multi Service Application equipment for Access Platform that could be services like PON, Layer-2/Layer-3 ethernet, xDSL, access transport DWDM etc. According to their respective standards like IEEE, ITU-T for use in Indian telecom network.

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HISTORY SHEET

Sl. No.	Standard / document No.	Title	Remarks
1)	TEC 71120:2022	Converged Multi-Service Application Access Equipment	First Release

REFERENCES

S. No.	*Standard No.*	*Designation*
1	IEC-60825-1	Safety of laser products – Part 1: Equipment classification, requirements and user's guide
2	IEC 60950-1	Information technology equipment –Safety –Part 1:General requirements
3	IEC Publication 61000-4-2	Testing and measurement techniques of Electrostatic discharge immunity test
4	IEC Publication 61000-4-3	Radiated RF electromagnetic field immunity test
5	IEC Publication 61000-4-4	Testing and measurement techniques of electrical fast transients/burst immunity test
6	IEC Publication 61000-4-5	Test & Measurement techniques for surge immunity tests
7	IEC Publication 61000-4-6	Immunity to conducted disturbances
8	IEEE 802.3	IEEE Standard for Ethernet
9	IEEE 802.11	IEEE Standard For Information Technology--Telecommunications And Information Exchange Between Systems Local And Metropolitan Area Networks--Specific Requirements - Part 11: Wireless LAN Medium Access Control (MAC) And Physical Layer (PHY) Specification
10	RFC-2544	Bench marking methodology for Network inter connected devices
11	IEEE 1588	IEEE Standard for a Precision Clock Synchronization Protocol for Networked Measurement and Control Systems
12	IS 13252 part 1	Information Technology Equipment -- Safety, Part 1: General Requirements
13	ITU-T G.652	Characteristics of a single-mode optical fiber and cable.
14	ITU-T G.657	Characteristics of a bending-loss insensitive single-mode optical fiber and cable for the

		access network
15	ITU-T G.664	Optical safety procedures and requirements for optical transmission systems
16	ITU-T G.784	Management aspects of synchronous digital hierarchy (SDH) transport network elements
17	ITU-T G.812	Timing requirements of slave clocks suitable for use as node clocks in synchronization networks
18	ITU-T G.8262	Timing characteristics of a synchronous equipment slave clock
19	ITU-T G.984.5	Gigabit-capable passive optical networks (GPON): Enhancement Band.
20	ITU-T G.984.6	Gigabit-capable passive optical networks (GPON): Reach extension.
21	ITU-T G.987	10-Gigabit-capable passive optical network (XG-PON) systems: Definitions, abbreviations, and acronyms.
22	ITU-T G.987.1	10 Gigabit-capable passive optical networks (XG-PON): General requirements
23	ITU-T G.987.2	10-Gigabit-capable passive optical networks (XG-PON): Physical media dependent (PMD) layer specification
24	ITU-T G.987.3	10-Gigabit-capable passive optical networks (XG-PON): Transmission convergence (TC) layer specification.
25	ITU-T G.987.4	10-Gigabit-capable passive optical networks (XG-PON): Reach extension.
26	ITU-T G.993.2	Very high speed digital subscriber line transceivers 2 (VDSL2).
27	ITU-T G.9700	Fast access to subscriber terminals (G.fast) - Power spectral density specification
28	ITU-T G.9701	Fast access to subscriber terminals (G.fast) - Physical layer specification

29	ITU-T G.9807.1	10-Gigabit-capable symmetric passive optical Network (XGS-PON)
30	ITU-T G.9960	Unified high-speed wireline-based home networking transceivers - System architecture and physical layer specification
31	ITU-T G.9961	Unified high-speed wireline-based home networking transceivers - Data link layer specification
32	TEC 11016:2016	Electromagnetic Compatibility Standard for telecommunication Equipment
33	TEC 14016:2010	QM-333 - Specification for environmental testing of electronic equipment for transmission and switching use
34	TEC 48050:2014	Router for MPLS Based Transport Network
35	TEC 49090:2014	Firewall System
36	TEC 49070:2012	Precision Time Protocol (PTP) Slave Clock
37	TEC 49170:2020	Precision Time Protocol (PTP) Grandmaster Clock
38	TEC 72010:2021	TEC Standard on Optical Splitter and WDM coupler for optical Access Technology
39	TEC 74046:2020	TEC Standard for Energy Consumption Rating and Energy Passport for Telecommunications Products, Equipment and Network/ Services
40	TEC 89070:2012	TEC standard for GR on Ethernet Media Converter
41	TEC 70080:2018	TEC standard for GR on IP DSLAM
42	TEC 70070:2018	TEC standard for GR on VDSL &VDSL2
43	TEC 70060:2018	TEC standard for GR on ADSL2+
44	TEC 70090:2019	TEC standard for GR on G.Fast equipment

Note: Unless otherwise explicitly stated, the latest approved issue of the standard, with all amendments in force, listed in references, on the issuance date of this standard applicable"

CHAPTER-1

Technical Requirements

1.0. Introduction

1.1 Access Networks are mostly used to delivering the all the data, voice, video communications and last mile connectivity. The Network on which the service applications are required to be carried has to be resilient with all the transport capabilities. With the rapid change happening on Applications space due to technology innovations, it is required to have an Access platform with the capability to deliver all possible Point to Point & Point to Multi-point Voice, Video, Data & Wi-fi Services. This document addresses the generic requirements for the PON, Layer 2, Layer 3 IP MPLS Routing capabilities (limited features are taken from IP/MPLS GR TEC: 48050-2022), xDSL, DWDM (DWDM Means-Colour interface support on uplink interface to interface with DWDM network as per ITU-T Standard G.694.1. Other DWDM components need to consider as per respective DWDM GR for 10G DWDM GR: TEC 86080:2016), hence ensuring the converged platform for Access Network. It helps in getting rid of multiple devices at Access locations.

1.2 A Converged Network Platform (C-MSAAE), in general, consists of Layer 2 Switching, Layer 3 Routing, MPLS functionality, GPON/XGSPON/XG-PON technology along with optionally sub interfaces such as E1, STM-N, xDSL etc as per their respective standards references are ITU-T G.703 , G.691, TEC 70060:2018/ TEC 70070:2018/ TEC 70080:2018/ TEC 70090:2019. C-MSAAE Network will be comprising of equipment at the Central Office (CO) and a set of associated Customer Premise equipment(CPE) installed at various locations in the network with minimal component of Active equipment deployments between CO & CPE. In such a manner, the distributed architecture shall provide flexibility and may thus extend the services as well as reach offered by the centralized architecture.

1.3 The operations, administration and management (OAM) and other management requirements shall be as per implementation philosophy of technology developer.

1.4 The general characteristics and architecture of GPON/XGS-PON/Multi-PON shall be compliant to ITU-T G.984.x series, ITU-T G.9807.1, G.984.5.

1.5 The GR outlines the general characteristics of C-MSAAE systems including network services, User Network Interfaces (UNI) and Service Network Interfaces (SNI). Also, it outlines the basic deployment configurations. However, specific implementation shall be subjected to networking requirements of the Service Providers.

2.0. Distribution Network Architecture and Requirements

A System includes a C-MSAAE in the Central Office and distributed Customer Premise Equipment (CPE) to terminate customer traffic through an optical distribution network (ODN) between them. The access node in the architecture for network termination installed within user premises can be referred as CPE. An Optical distribution network (ODN) connects the CO and CPE in point to multipoint configuration (Ref. Figure 1.) through single mode fibre. The ODN can be either a simple ODN or a composite ODN. The composite ODN comprises of optical splitters, combiners, filters interconnected by active devices.

2.1 Network Architecture and Requirements

A PON access network system includes a CO in the Central Office and distributed Optical Network Terminations (CPE) to terminate customer traffic through an optical distribution network (ODN) between them. The composite ODN comprises of optical splitters, combiners, filters interconnected by active devices.

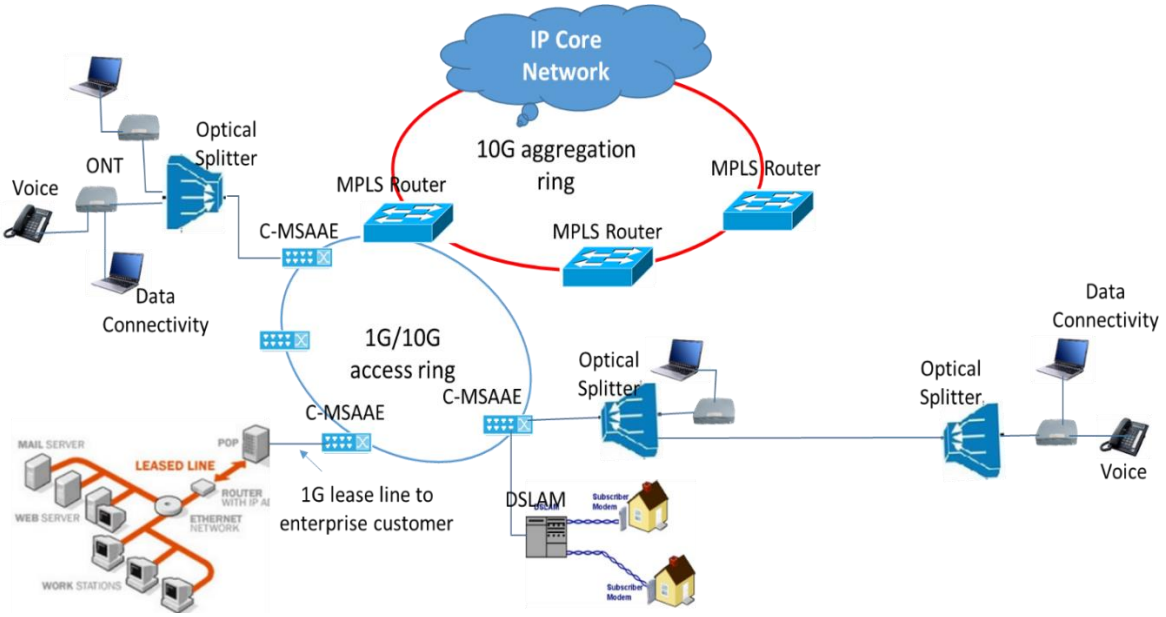

Figure 1: Schematic showing Converged Architectures

An PON ODN may consist of a single passive optical distribution (ODS) or a group of ODSs interconnected with active reach extenders or coexistence elements.

2.1.1 Constituents of C-MSAAE deployment

This TEC Standard envisages deployment of C-MSAAE using PON, Layer 2, layer 3 and MPLS technology in accordance to ITU-T, IEEE & IETF standards. Depending upon the deployed architecture, there shall be variations in placement of various PON constituents, as described in clause 3 detailing various FTTX architectures.

2.1.2. CPE

The Network Terminations in FTTH/FTTCell/FTTO architecture installed within user premises is termed as CPE. Whereas the network terminations in FTTB/FTTC/FTTCab architectures is installed at other locations i.e. Curb/Cabinet/MDU (or MTU) basement of building.

In FTTB/C/Cab architecture, the users generally need to install additional network termination (NT) device to access the CPE at a typical distance of 500m-1000m. The possible choices of NT for households shall be ADSL2+/VDSL2/G.fast/G.hn whereas, in FTTB scenario, the user can access the CPE installed in the MTU/MDU over Ethernet or ADSL2+/VDSL2/G.fast/G.hn interfaces.

The last mile connected equipment can be categorized into either of the following:

1. GPON ONT
2. XGPON ONT
3. XGSPON ONT
4. Layer 2 Ethernet Switch
5. Layer 3 Ethernet Switch
6. xDSL interface

For the functionality of the CPE, the equivalent TEC GRs should be referred as below.

Respective last mile equipment GR are:

1. GPON ONT: TEC 71010:2017(TEC/GR/FA/PON - 01/03/Mar.2017)
2. XGPON ONT: TEC 71050:2018(TEC/GR/FA/XGA--001/02/NOV-2018)
3. XGSPON ONT: TEC 71030:2018(TEC/GR/FA/XGS-001/01 OCT 2018)
4. Layer 2/Layer 3 Ethernet Switch: TEC 48060:2014 (TEC/GR/IT/LSW - 001/05.MAR.2014)
5. xDSL interface: TEC 70060:2018/ TEC 70070:2018/ TEC 70080:2018/ TEC 70090:2019

2.1.3. C-MSAAE

An C-MSAAE shall provide aggregation and switching functionality between the core network and PON interfaces. It shall offer PON interfaces (towards CPE) & Service interfaces (towards core network). The interfaces towards CPEs are called PON interfaces and the interfaces towards core network are called Uplink interfaces (SNI).

2.1.4. Optical Splitters

Optical splitters capable of providing upto 1:128 optical split, on end to end basis, per PON interface on OLT are envisaged as per TEC Standard No. TEC 72010:2021. There shall be various options provided to the purchaser such as m: N where m=1 or 2 and N= 4, 8, 16, 32, 64 or 128. Optical splitters capable of 1:256 optical splits shall be optional. The purchaser may use a combination of these split options. The purchaser shall communicate the exact requirement.

2.1.5. Fibre plant: Passive Optical Network

Already existing ITU-T Rec. G.652 fibre shall primarily be used between OLT and ONUs/ONTs. Newer fibre types exhibiting low-bend radius characteristics defined by ITU-T G.657 shall also be supported.

The user shall access the Ethernet over copper wires/optical fibres from the ONTs or xDSL CPEs.

2.2. FTTX architectures: in Converged Access Architecture

As quite prevalent in today's world, broadband is delivered using optical fiber through FTTX technology. The 'X' in FTTX stands for a lot of things, often not very different, but for practical purposes, they can all be grouped as under.

1) Fibre all the way to the customer residential premises/office/cell-site back hauling unit: These are:

- Fibre to the Home (FTTH)
- Fibre to the Office (FTTO)
- Fibre to the Cell (FTT Cell)

2) Fibre all the way to the multi dwelling units, business, and multi-tenant unit: Here the fibre reaches to a particular point in the building, further connectivity to each residence and office is provided by copper wires which carry Ethernet data.

- Fibre to building/business (FTTB)

- Fibre to the curb/cab (FTTC/FTTCab)

3) Fibre partial: Fiber reachability to a point far from the actual user. The connectivity to each customer is provided by copper pairs using ADSL2+/VDSL2/G.fast/G.hn.

- Fibre to the cabinet (FTTCab)
- Fibre to the curb (FTTC)

In FTTC/FTTCab architectures, fibre penetration takes place up to the curb (200-400m) and cabinet (1000-2000m) from user locations. These architectures are useful for densely populated areas.

2.3 Equipment interfaces and service support

2.3.1 Equipment interfaces in Converged architectures.

The C-MSAAE equipment shall provide minimal three types of interfaces, namely

- Ethernet LAN interfaces
- xPON Interfaces for connectivity towards ODN to connect to xPON CPE devices
- Network Side Interface towards IP MPLS Core Network.
- Optionally xDSL interfaces may be supported in case when required by Procuring agency.

2.4. Physical layer requirements for PON system

2.4.1 Optical wavelengths of PON

Optical wavelengths for GPON upstream shall be 1310nm and downlink 1490nm, XG-PON upstream ranging from 1260 to 1280nm and downlink wavelength shall be 1575nm to 1580nm. XGS-PON either same as GPON if no current GPON or XG-PON for overlay. NG-PON2 upstream ranging from 1524 to 1544nm and downlink wavelength shall be 1596nm to 1603nm.

2.4.2 Bit rates

The GPON system shall support a bit rate of 2488.32 Mb/s in the downstream OLT – ONT/ONU and 1244.16 Mb/s in the upstream ONT/ONU – OLT directions.

The XGS-PON system shall support symmetrical bit rates of 9.95328 Gbps in the upstream and downstream directions.

The XG-PON system shall support bit rates of 2.48832 Gbps in the upstream (ONT/ONU to OLT) and 9.95328 Gbps downstream (OLT to ONT/ONU) directions.

2.4.3 Optical power budget

The GPON system having optical power budget in the range of 28dB to 37dB by using different type of SFP modules and power class.

XGS-PON must be able to operate on nominally 28/29 dB loss ODNs, depending on the wavelength set plan used. The Basic wavelength set aligns with the N1 class of XG-PON for 29 dB, considering the extra loss in the WDM1r for this band. The Optional wavelength set aligns with the B+ class of G-PON for 28 dB, considering the lower loss in the WDM1r for this band. In addition to these loss budgets, provision is also made to accommodate the N2 (31 dB), E1 (33 dB) and E2 (35 dB) power budgets from XG-PON and C+ (32 dB) power budget from G-PON. When reusing the G-PON wavelength is adopted, since the G-PON port of the WDM1r will be reused, legacy B+ or C+ power budget classes are to be considered.

XG-PON shall support the two nominal (N1: 29 dB & N2: 31dB) and two extended (E1: 33dB & E2: 35dB) optical power budgets.For coexistence of GPON and XG-PON, an ODN having an optical budget of class B+ is the nominal requirement. For coexistence of GPON and XG-PON on the ODN featuring C+ optical, extended power budget would be required.

2.4.4 Fibre characteristics

The fibre between OLT and ONT shall comply with ITU-T G.652, which is used in other PON systems. This is to ensure co-existence of the XGS-PON and other PON systems, and to utilise the existing ODN for XGS-PON systems.

Newer fibre types exhibiting low-bend radius characteristics defined by ITU-T G.657 shall also be supported.

2.4.5 Split Ratio

G-PON: The PON system shall support mxN architecture. A 1:128, 1:64, 1:32, 1:16, 1:8, 1:4 split options per PON interface on OLT shall be supported. The exact requirement of optical interfaces for 1xN and 2xN splitters shall be specified by the purchaser based on the optical power-budget calculation.

XGS-PON: 1:32 to 1:64 split for Gigabit PONs, 1:64 split (subject to the overall loss budget) shall be the minimum requirement for XGS-PON to allow the coexistence of G-PON, XG-PON and XGS-PON and can go up to 1:128 split with different class optics. Support for 1:256 split shall be optional to allow extension of PON in the backhaul section and/or to extend PON towards the end users to provide flexible splitter configurations and efficiently support a variety of deployment scenarios.

XG-PON: 1:32 split shall be the minimum requirement for XG-PON to allow the co-existence of GPON and XG-PON and can go upto 1:128 split with different class optics. Support for 1:256 split to improve the overall economics shall be optional.

2.4.6 Fibre Distance

PON must support the maximum fibre distance of at least 20 km.

2.4.7 Physical interface requirements at UNI

Ethernet interface shall be provisioned for Residential ONT and both types of interfaces, Ethernet and ADSL2+/VDSL2/G.fast/G.hn shall be provisioned in case of ONUs.

2.4.8 CPE equipment architecture

The equipment architecture of CPE is kept out of the scope of the GR and as such the implementation is entirely left open to the equipment manufacturer/supplier. Thus, a complete ONU/ONT may comprise of the basic module providing optical interface on the PON side and some sub-modules providing UNI interfaces on the user side.

3.0 C-MSAAE specifications

3.1 Fixed configuration Hardware capability

i. Number of PON interfaces in the box:

A. Number of PON interfaces supported in the box:

The equipment shall support 8 or 16 OLT interfaces.

ii. Number of interfaces towards the IP Network:

A Mini C-MSAAE shall have the provision to terminate the following interfaces:

A. For 8 PON interface configuration:

In case GPON OLT: A minimum of 2 X 10G and 4 x 1G interfaces shall be supported towards the core network to cater to the IP Network.

In case XGS/XGPON OLT: A minimum of 6 X 10G LAN or 2X25G LAN and 2 x 1G/10G LAN interfaces shall be supported towards the core network to cater to the IP Network.

B. For 16 PON interface configuration:

In case GPON OLT: A minimum of 4 X 10G and 4 x 1G interfaces shall be supported towards the core network to cater to the IP Network.

In case XGS/XGPON OLT: A minimum of 8 x 10G LAN OR 3x25G LAN OR 2x40G LAN OR 1x100G LAN and 2 x 1G/10G LAN interfaces shall be supported towards the core network to cater to the IP Network.

C. For 8 Multi-PON interface configuration refer G.984.5 amendment-2: A minimum of 6 X 10G LAN OR 2X25G LAN OR 1x100G and 2 x 1G/10G LAN interfaces shall be supported towards the core network to cater to the IP Network.

D. For 16 Multi-PON interface configuration refer G.984.5 amendment-2: A minimum of 8 x 10G LAN OR 3x25G LAN OR 2x40G LAN OR 1x100G and 2 x 1G/10G interfaces shall be supported towards the core network to cater to the IP Network.

iii. DSLAM interfaces are optional & should be specified by procuring agency if required.

iv. In case XGPON/XGSPON interfaces are required in fixed configuration hardware, procuring agency should define the number of ports.

Note: The actual number of the Interfaces shall be as per the Purchaser's Requirement.

3.2 Chassis based C-MSAAE capability

A. For 32 PON interface configuration: **A** minimum of 8 x 10G LAN OR 3x25G LAN OR 2x40G LAN OR 2x100G LAN and 4 x 1G/10G LAN across two modules for redundancy. SNI interfaces shall be supported towards the core network to cater to the Ring or Linear topology.

B. **For 64 PON interface configuration: A** minimum of 8 x 10G LAN OR 3x25G LAN OR 2x40G LAN OR 2x100G LAN and 4 x 1G/10G LAN across two modules for redundancy. SNI interfaces shall be supported towards the core network to cater to the linear or ring topology.

C. **For 128 PON interface configuration: A** minimum of 8 x 10G LAN OR 3x25G LAN OR 2x40G LAN OR 2x100G LAN and 4 x 1G/10G LAN across two modules for redundancy. SNI interfaces shall be supported towards the core network to cater to the linear or ring topology.

D. Optionally chassis can support DSLAM modules in interface slot of different capacity as per purchaser requirement.

Note: The actual number of the Interfaces shall be as per the Purchaser's Requirement.

3.3 **Functional and architectural requirements**

i. C-MSAAE shall support universal application card-slots for either PON or may be utilized for any other application.

ii. **Protection requirements**

A. The protection mechanism for the PON line should support dual homing (Optional).
B. There shall be 1:1 protection for PON (type B & type C protection).
C. 1:1 or 1+1 redundancy may also be provisioned for SNI.

3.4 **Features and capabilities**

The equipment shall have local status monitoring

i. The equipment shall supports LED status indication per OLT port
ii. **Power:** Indicates power on/off status
iii. **Fail:** Indicates internal device failure status
iv. **Alarm:** Indicate alarm status
v. C-MSAAE shall support the following PON link diagnostics measurement:

A. Measurement of received optical power per ONT.
B. BER measurement per ONT/ONU (applicable in case of E1 interfaces only).

3.5 **DBA**

i. Maximum bandwidth limiting
ii. Minimum guaranteed bandwidth
iii. Two or more level (preferred four) classes of classification
iv. DBRu report
v. Idle GEM DBA
vi. To provide access to a variety of packet-based services, such as IPTV, VoIP, L2/L3 VPNs and high-speed Internet access, XGS-PON must provide at least four classes of services to map UNI flows.

3.6 **VLAN function**

The Mini-OLT shall support the following VLAN operation

i. VLAN insertion in ingress process
ii. VLAN removal in egress process
iii. VLAN stacking per 802.1ad.

3.7 **Filtering functions at CMSAAE**

i. Filtering by destination MAC address
ii. Filtering by source MAC address
iii. Filtering of 802.1x packets (Optional)

3.8 **QoS and Security Support for packet classification functions.**

i. Classification based on VLAN ID
ii. Classification based on 802.1p bit
iii. DSCP to 802.1p mapping
iv. The Mini-OLT chassis should be able to configure up to 4094 (1-4094) VLAN. VLAN 0 and 4095 are reserved and not used in the XGS Mini-OLT system.
v. The database of learning should be based on IVL (Independent VLAN Learning)
vi. Support of RSTP or RPF or MSTP(support of any)
vii. Support of IGMP proxy
viii. 802.1x port based security (optional)

3.9 **Security**

i. >100 ACL support (based on switch port, MAC address, Ether Type)

ii. DOS prevention, SSH v1/2 for CLI

3.10 **Duplicity Check**

i. ONT with duplicate serial number/ Duplicate MAC address should not be allowed in the network and it shall be possible to check this from the CMSAAE.

3.11 Layer 2 MAC Address Learning / Limiting: (Refer IP/MPLS GR TEC: 48050-2022, clause no-3.9.3)

i. The equipment shall support L2 Learning parameters: Sources learning per Port/VLAN/Source address.

ii. The equipment shall support to set per port dynamic MAC learning limit.

iii. The equipment shall support to limit the number of source MAC addresses learnt from bridge port in order to prevent MAC address flooding DoS attack. This limit is configurable per bridged port.

iv. The equipment shall support dropping of Frames with new source MAC-addresses exceeding the configured value.

v. The equipment shall support per VLAN MAC learning to ensure MAC addresses are learnt only from a VLAN perspective and automatic/manual disabling of MAC addresses learning for the VLAN where there are less than two ports in that VLAN.

vi. The equipment shall support MAC limiting per Ethernet flow point (EFP) or bridge domain

vii. The equipment shall support MAC address limitation and aging

viii. All static entries shall NOT be aged.

ix. The equipment shall support Hardware based aging of MAC Address Table entries.

x. The equipment shall support to enable L2 Aging on every port.

xi. The equipment shall support MAC address learning disabling

xii. The equipment shall support to filter and discard all Ethernet frames received on bridged ports in the upstream direction with a specific MAC destination address (DA)

xiii. The equipment shall support list of allowable MAC destination address

xiv. The equipment shall not learn MAC address from bridge port X if the same MAC address appears in the learning table pointing to bridge port Y (port X and port Y on the same LSW and same VLAN), except in the cases where the aggregation network forwards according to MAC Learning table.

xv. The equipment shall support unique MAC address per device to prevent spoofing and provide traceability.

3.12 Layer 2 VLAN Features

i. The equipment shall support creation of VLAN among ports of different types as well as on all ports of the interface cards. (Refer IP/MPLS GR TEC: 48050-2022, clause no-3.9.12.1)

ii. The equipment shall support VLAN bridging (for outer tag only) as per IEEE 802.1ad (Refer IP/MPLS GR TEC: 48050-2022, clause no-3.9.4.1)

iii. The equipment shall support user isolation per outer VLAN tag. This behavior shall be configurable on a per port basis. (Refer IP/MPLS GR TEC: 48050-2022, clause no-3.9.12.3)

iv. The equipment shall support VLAN ingress filtering to prevent VLAN leakage. (Refer IP/MPLS GR TEC: 48050-2022, clause no-3.9.12.4)

v. The equipment shall support VLAN tag overlapping allowing some ports to be member of more than one VLAN. (Refer IP/MPLS GR TEC: 48050-2022, clause no-3.9.12.5)

3.13 Layer 3 Routing Protocols

3.13.1 Static Routing

i. The equipment shall support requirements for IP Version 4 Routing as per RFC 1812 (Refer IP/MPLS GR TEC: 48050-2022, clause no-3.10.1.1)

ii. The equipment shall support policy based routing based on source and destination IPv4 address and TCP/UDP Port. (Refer IP/MPLS GR TEC: 48050-2022, clause no-3.10.1.2)

iii. The equipment shall support IPv6 static Routing (Refer IP/MPLS GR TEC: 48050-2022, clause no-3.10.1.3)

3.13.2 OSPF V2/V3 Routing

i. The equipment shall support OSPF Version 2 as per RFC 2178 & RFC 2328 Routing (Refer IP/MPLS GR TEC: 48050-2022, clause no-3.10.6.1)

ii. The equipment shall support BGP-OSPF interaction (Refer IP/MPLS GR TEC: 48050-2022, clause no-3.10.6.5)

iii. The equipment shall support OSPF for IPv6 as per RFC2740 (Refer IP/MPLS GR TEC: 48050-2022, clause no-3.10.6.8)

iv. The equipment shall support Authentication/Confidentiality for OSPFv3 as per RFC 4552(Refer IP/MPLS GR TEC: 48050-2022, clause no-3.10.6.17)

v. The equipment shall support OSPFv3 dynamic interface cost support (Refer IP/MPLS GR TEC: 48050-2022, clause no-3.10.6.19)

vi. The equipment shall support OSPFv3 graceful restart (Refer IP/MPLS GR TEC: 48050-2022, clause no-3.10.6.21)

3.13.3 BGP

i. The equipment shall support BGPv4 as per RFC 4271 & RFC 2283 (Refer IP/MPLS GR TEC: 48050-2022, clause no-3.10.8.1)

ii. The equipment shall support for the application of the Border Gateway Protocol in the Internet shall be as per RFC 1772 (Refer IP/MPLS GR TEC: 48050-2022, clause no-3.10.8.2)

iii. The equipment shall support Interior BGP (iBGP) peering sessions. (Refer IP/MPLS GR TEC: 48050-2022, clause no-3.10.9.1)

iv. The equipment shall support Exterior BGP multi-path to support load balancing between two EBGP peers connected by two or more links. (Refer IP/MPLS GR TEC: 48050-2022, clause no-3.10.9.2)

3.14 Multicast Features

3.14.1 General:

i. The equipment shall support Prioritization of multicast traffic

ii. The equipment shall support to maintain static multicast entries in a separate multicast table.

iii. The equipment shall support Multicast ACL to ensure security

iv. The equipment shall support Multicast Load Balancing traffic across multiple interfaces

3.14.2 **IGMP (Refer IP/MPLS GR TEC: 48050-2022, clause no-3.11.2)**

i. The equipment shall support Internet Group Management Protocol, Version 3 as per RFC 3376

ii. The equipment shall support Host Extensions for IP Multicasting as per RFC 1112

iii. The equipment shall support Source based and shared distribution trees

3.14.3 **PIM**

i. The equipment shall support Protocol Independent Multicast (PIM) and Multicast Source Discovery Protocol (MSDP) (Refer IP/MPLS GR TEC: 48050-2022, clause no-3.11.3.1)

ii. The equipment shall support Protocol Independent Multicast - Sparse Mode (PIM-SM (Refer IP/MPLS GR TEC: 48050-2022, clause no-3.11.3.4)

iii. The equipment shall support PIM Source Specific Multicast (PIM-SSM) (Refer IP/MPLS GR TEC: 48050-2022, clause no-3.11.3.9)

3.15 Multi-protocol Label Switching (MPLS)

i. The equipment shall support Multi Protocol Label Switching Architecture (Refer IP/MPLS GR TEC: 48050-2022, clause no-3.12.1.1)

ii. The equipment shall support MPLS Label Stack Encoding (Refer IP/MPLS GR TEC: 48050-2022, clause no-3.12.1.2)

iii. The equipment shall support Time To Live (TTL) Processing in Multi-Protocol Label Switching (MPLS) Networks (Refer IP/MPLS GR TEC: 48050-2022, clause no-3.12.1.3)

I. The equipment shall support Framework for Multi-Protocol Label Switching (MPLS)-based Recovery . (Refer IP/MPLS GR TEC: 48050-2022, clause no-3.12.1.5)

iv. The equipment shall support MPLS Label Edge Routing functionality. (Refer IP/MPLS GR TEC: 48050-2022, clause no-3.12.1.8)

v. The equipment shall support Dynamic MPLS LSP setup with signaling protocol on its Ethernet interfaces. (Refer IP/MPLS GR TEC: 48050-2022, clause no-3.12.1.9)

vi. The equipment shall support LSP path optimization. When new LSPs are added, LSP re-optimization is performed to reroute LSPs to follow a lower cost path with no data loss to existing traffic. (Refer IP/MPLS GR TEC: 48050-2022, clause no-3.12.1.10)

vii. The equipment shall support MPLS class of service. (Refer IP/MPLS GR TEC: 48050-2022, clause no-3.12.1.11)

viii. The equipment shall limit the number of routes per VRF. (Refer IP/MPLS GR TEC: 48050-2022, clause no-3.12.1.13)

ix. The equipment shall set Thresholds to provide traps and alarms when a certain number of routes are exceeded. (Refer IP/MPLS GR TEC: 48050-2022, clause no-3.12.1.14)

3.16 **LDP:** The equipment shall support Label Distribution Protocol (LDP) (Refer IP/MPLS GR TEC: 48050-2022, clause no-3.12.2)

3.17 **MPLS VPN** : The equipment shall advertise both VPN routes and public internet routes in the BGP routing instance. (Refer IP/MPLS GR TEC: 48050-2022, clause no-3.12.3)

3.18 **MPLS Layer-3 VPN:** The equipment shall support BGP/MPLS IP Virtual Private Networks (VPNs) (Refer IP/MPLS GR TEC: 48050-2022, clause no-3.12.3)

3.19 **Autonomous System**

3.19.1 The equipment shall support Guidelines for creation, selection, and registration of an Autonomous System (AS) (Private and overlapping Autonomous System Numbers) as per RFC1930 (Refer IP/MPLS GR TEC: 48050-2022, clause no-3.12.7.1)

3.19.2 The equipment shall support Inter AS IPVPN (Refer IP/MPLS GR TEC: 48050-2022, clause no-3.12.7.2)

3.19.3 The equipment shall support Inter Area Autonomous System (InterAS) (Refer IP/MPLS GR TEC: 48050-2022, clause no-3.12.7.3)

3.20 Pseudo-Wire Emulation

3.20.1 The equipment shall support Pseudo-Wire Emulation Edge-to-Edge (PWE3) Architecture (Refer IP/MPLS GR TEC: 48050-2022, clause no-3.15.4.2)

3.20.2 The equipment shall support Pseudo wire Setup and Maintenance using LDP (Refer IP/MPLS GR TEC: 48050-2022, clause no-3.15.4.6)

3.21 Layer 2 VPNs through MPLS-TP (Optional)

3.21.1 The equipment shall support MPLS-TP requirements (Refer IP/MPLS GR TEC: 48050-2022, clause no-3.12.8.1)

3.21.2 The equipment shall support MPLS Generic Associated Channel (GAL/G-ACH) (Refer IP/MPLS GR TEC: 48050-2022, clause no-3.12.8.8)

3.21.3 The equipment shall support Pseudowire (Refer IP/MPLS GR TEC: 48050-2022, clause no-3.12.8.11)

3.21.4 The equipment shall support Proactive Connectivity Verification, Continuity Check, and Remote Defect Indication for the MPLS Transport Profile (Refer IP/MPLS GR TEC: 48050-2022, clause no-3.12.8.13)

3.22 Quality of Service Requirements

3.22.1 Diff-Serv

3.22.1.1 The equipment shall support Diff-Serv. (Refer IP/MPLS GR TEC: 48050-2022, clause no-3.16.2.1)

3.22.1.2 The equipment shall support Definition and Architecture of the Differentiated Services Field (DS Field) in the IPv4 and IPv6 Headers (Refer IP/MPLS GR TEC: 48050-2022, clause no-3.16.2.3)

3.22.2 Classification/Prioritization:

3.22.2.1 The equipment shall support Policy based bandwidth classification (Refer IP/MPLS GR TEC: 48050-2022, clause no-3.16.3.1)

3.22.2.2 The equipment shall support Service QoS flow identification. (Refer IP/MPLS GR TEC: 48050-2022, clause no-3.16.3.2)

3.22.2.3 The equipment shall support classification of ingress traffic for a specific service based on IP DSCP Mapping (Refer IP/MPLS GR TEC: 48050-2022, clause no-3.16.3.3)

3.22.2.4 The equipment shall aggregate incoming traffic into Traffic Classes on Port or Protocol level (Refer IP/MPLS GR TEC: 48050-2022, clause no-3.16.3.4)

3.22.2.5 The equipment shall support traffic prioritization. (Refer IP/MPLS GR TEC: 48050-2022, clause no-3.16.3.6)

3.22.3 Mapping:

3.22.3.1 The equipment shall support mapping of DSCP to VLAN or other traffic engineering capabilities in the Regional Network. (Refer IP/MPLS GR TEC: 48050-2022, clause no-3.16.4.1)

3.22.3.2 The equipment shall support mapping of IEEE 802.1p and IP TOS bits into MPLS EXP bits. (Refer IP/MPLS GR TEC: 48050-2022, clause no-3.16.4.3)

3.22.3.3 The equipment shall support mapping of IEEE 802.1q VLAN tags into MPLS labels (Refer IP/MPLS GR TEC: 48050-2022, clause no-3.16.4.4)

3.22.4 Marking/Policing/Shaping:(Refer IP/MPLS GR TEC:48050-2022,clause no-3.16.5)

The equipment shall support the Marking/Policing/Shaping requirements based on IEEE 802.1p, Single rate three colour marking (srTCM), Two rate three colour metering (trTCM)

3.22.5 Rate Limiting: (Refer IP/MPLS GR TEC: 48050-2022, clause no-3.16.6)

3.22.5.1 The equipment shall support Rate limiting of bandwidth per Port and per class (or flow)

3.22.5.2 The equipment shall support configuration of user bandwidth in steps of

- 64kbps for less than 1 Mbps
- 1 Mbps for 1-1000Mbps
- 100 Mbps granularity for 1-10 Gbps.

3.22.5.3 The equipment shall support defining Committed Information Rate (CIR) and an Excess Information Rate (EIR) for each flow in steps of 1Mbps

3.22.5.4 The equipment shall support flow based rate limiting method based on per source address, destination address or both.

3.22.6 Queuing: (Refer IP/MPLS GR TEC: 48050-2022, clause no-3.16.7)

The equipment shall support the SP(Strict Priority Queuing), WFQ/DWRR(Weighted fair Queuing / Deficit Weighted Round Robin) Queuing .

3.22.7 Scheduling: (Refer IP/MPLS GR TEC: 48050-2022, clause no-3.16.8)

3.22.7.1 The equipment shall support scheduling of queues to strict priority with 2 or more priority levels

3.22.7.2 The equipment s shall support WRED/SP/WFQ/DWRR as congestion avoidance mechanisms

3.22.7.3 The equipment shall support Scheduling/ queuing for 4/8 classes that provide configurable minimum bandwidth allocation to each class, based on IEEE 802.1p and IP TOS bits.

3.23 IPv6 features (Refer IP/MPLS GR TEC: 48050-2022, clause no-3.16.10)

3.23.1 The equipment shall support Ipv6 routing

3.23.2 The equipment shall support packet classification,traffic shaping, traffic policing, packet marking/re-marking

3.23.3 The equipment shall support IPv6 QoS queuing and weighted random early detection (WRED)- based drop.

3.24 Network Synchronization Requirements (Refer IP/MPLS GR TEC: 48050-2022, clause no-3.18)

3.24.1 General

3.24.1.1 The equipment shall be able to synchronize with an external reference clock.

3.24.1.2 The equipment shall support Synchronous clock selection algorithm based on the following parameters:

1. Quality of Signal
2. Signal fail
3. Priority
4. External Commands

3.24.1.3 Synchronization shall be provided either through NTP/SyncE/1588v2.

3.25 Protection Switching Requirements (Refer IP/MPLS GR TEC: 48050-2022, clause no-3.19)

3.25.1 Protection Switching Time:

3.25.1.1 For all the modes of protection, the equipment shall support automatic switching.

3.25.2 Ring Protection Mechanism:

3.25.2.1 The equipment shall support Ethernet ring protection Scheme (ERPSv2 & Open ERPS) as per ITU-T G.8032, switching time is sub 50ms.

3.25.3 Linear protection mechanisms(Optional):

3.25.3.1 The equipment shall support MPLS-TP Linear Protection

3.25.4 OAM Requirements:

3.25.4.1 The switching mechanism is generally realized by the OAM function; therefore, the required OAM information field is reserved in the OAM frame

3.26 Scalability Requirements

The equipment shall support minimal layer 3 scalability parameters as stated below however the actual requirement can be stated by Procuring Agency:

I. MAC Address-16K
II. VLAN-4K

III. Ipv4 Routes- 8K
IV. Ipv6 Routes-1K
V. LSP Entries- 256
VI. OSPF-4K
VII. Static Routing-4K
VIII. Multicast Routes-256
IX. Multicast Group-32
X. Pseudowire Services-1K
XI. BGP Peers-4
XII. QoS Traffic Policers-256
XIII. ACL entries-256

3.26.1 Operation, Administration and Management Protocols (Refer IP/MPLS GR TEC: 48050-2022, clause no-3.21)

3.26.1.1 The equipment shall support debugging of control plane including OSPF/ IS-IS, BGP, Route Table Manager (RTM), VRRP, RSVP, LDP, MPLS, VPN services.

3.26.1.2 Non Ethernet OAM features:The equipment shall support Service Ping, IP Ping, IP Trace Route

3.26.1.3 MPLS Non Ethernet OAM Features: The equipment shall support MPLS traceroute, IP-VPN Ping, IP-VPN trace route, LSP Ping and trace route, BFD, Trace for P2MP LSPs, Virtual Circuit Connectivity Verification [VCCV], MPLS TE LSP trace and MPLS TE SNMP notification.

3.27 SNMP Manageability**:** (Refer IP/MPLS GR TEC: 48050-2022, clause no-3.21.8)

3.27.1 The equipment shall support SNMP v2/ SNMP v3

3.27.2 The equipment shall support RMON (Remote Monitoring) MIB I, II

3.27.3 Console or Out-of-Band Management: The equipment shall have console management access, with the provision for remote out-of-band management capability using asynchronous serial interface

3.28 Security (Refer IP/MPLS GR TEC: 48050-2022, clause no-8.0)

3.28.1 Broadcast Storm control:

3.28.1.1 The Router shall support unicast, multicast and broadcast storm control blocking on any interface or port.

3.28.1.2 The Router shall support to control multicast, broadcast, DLF traffic on per tunnel basis. Frames is dropped once the per-second counter goes beyond the configured limit

3.28.1.3 The Router shall support Unknown Unicast Flood Blocking (UUFB)

3.28.2 Unicast Reverse Path forwarding (URPF): (Refer IP/MPLS GR TEC: 48050-2022, clause no-8.1.7)-The Router shall compare the source address of a packet with its routing entries to verify if the data has been received on the legitimate interface. The packet would be forwarded only if the reverse path has been verified to be legitimate thus preventing malicious users from changing their source addresses.

3.28.3 DOS Attacks: (Refer IP/MPLS GR TEC: 48050-2022, clause no-8.1.8) The Router shall support Blocking IP DoS attacks from:

i. Unknown Protocol
ii. UDP Short header/Flood
iii. TCP Packets without flag
iv. Oversized TCP packets
v. SYN attack
vi. IP Spoofing
vii. IP Stream Option
viii. IP short header
ix. Internet Control Message Protocol (ICMP) Source quench /Mask request/ Mask reply/Large
x. packet/Info Request and Reply/ Flood
xi. Too many fragments
xii. Call gapping

3.28.4 Access Control List (ACL): (Refer IP/MPLS GR TEC: 48050-2022, clause no-8.1.12)

The Router shall support ACLs to prevent unauthorized access. It shall support Standard Access Lists and Extended Access Lists to implement access control supervision and control. It shall be possible to deny traffic based on the following:

i. Source Interface type
ii. Source/ destination MAC
iii. VLAN ID

4.0. Network requirements

4.1. Passive optical network

a) The transmission methodology should be bidirectional on a single fibre or unidirectional over two fibre compliant with ITU-T Rec. G.652.

b) Bidirectional transmission shall be accomplished using WDM technique on a single-fibre.

c) The wavelength in the range 1575-1580nm (1575-1581nm for outdoor deployment) shall be used for downstream. There shall be option to purchaser for use of 1550nm for overlay RF video applications.

d) The wavelength in the range 1260-1280nm shall be used for upstream.

e) The PON system shall support m x N architecture. A 1:256, 1:128, 1:64 split options per PON interface on OLT shall be supported. The exact requirement of optical interfaces for 1xN and 2xN splitters shall be specified by the purchaser based on the optical power-budget calculation.

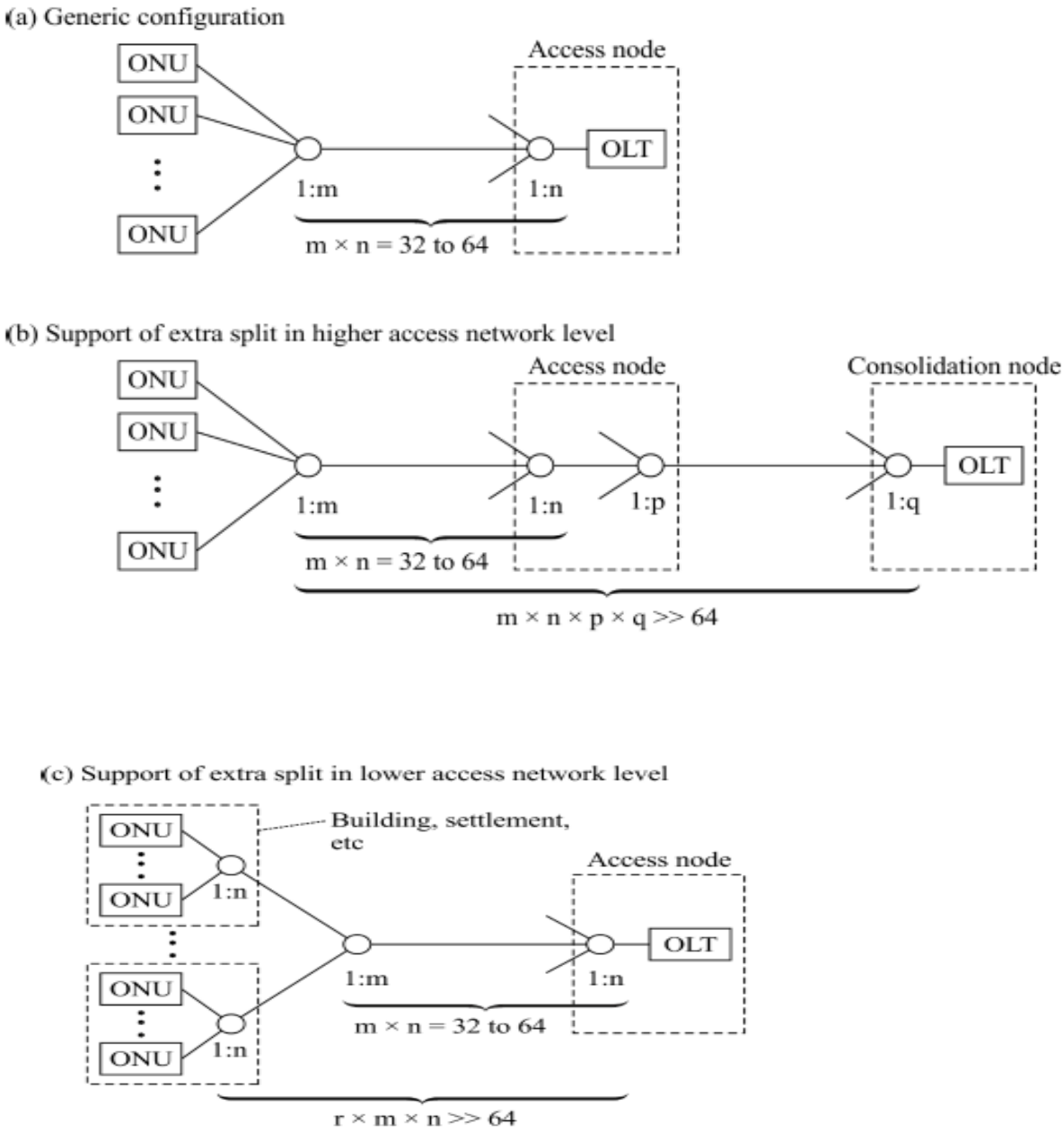

Figure 2: Various splitter configurations of X-PON

4.1.2. Optical Splitter specifications

For optical splitter specifications, standard for generic requirements TEC 72010:2021 shall be referred.

4.1.3. Optical WDM1r coupler specifications

For optical WDM1r coupler specifications, standard for generic requirements TEC 72010:2021 shall be referred.

5.0 Ethernet interfaces at C-MSAAE and CPE: Specifications

The following Ethernet interface options shall be supported. Actual interface type and number shall be communicated by purchaser.

a) 1000Base-SX (50µ multi-mode) interface
b) 1000Base-LX (10µ single-mode @1310nm) interface
c) 1000Base-ZX (10µ single-mode @ 1550) interfaces.
d) 10Gbps Ethernet for fibre interfaces as per IEEE 802.3ae.
e) 25/50Gbps Ethernet for fibre interfaces as per IEEE 802.3by and IEEE 802.3cd
f) 40/100Gbps Ethernet for fibre interfaces as per IEEE 802.3ba.

6.0. Protection on the PON section

From the viewpoint of administration of the access network, the protection architecture of PON is considered to enhance the reliability of the access networks. However, protection shall be considered as an optional mechanism because its implementation depends on the realization of economical systems.

The best resilience architecture needs to be defined by operator/purchaser. It should include duplex and dual parented duplex system configuration as defined in clause 14 of G.984.1 as well as Appendix II and III of the same recommendation.

This clause presents some possible duplex configurations and related requirements as examples of protected PON systems. In addition, the required OAM message for protection is mentioned.

There are some basic elements that can be protected in a PON network:

a) The C-MSAAE OLT PON ports
b) The PON section between OLT and optical splitter.
c) The passive optical splitter.
d) The PON section between optical splitter and ONU/ONT.

e) The ONU/ONT PON port.

There may be different categories of ONU/ONTs:

Category 1: ONU/ONT with one GPON interface

Category 2: ONU/ONT with one XG-PON interface

Category 3: ONU/ONT with one XGS-PON interface

Category 4: ONU/ONT with combination of interfaces

6.1. Possible protection switching types at PON Layer (optional)

There are two types of protection switching both of which are analogous to those of SDH systems.

a) Automatic switching; and
b) Forced switching.

The first one (Automatic Switching) is triggered by fault detection, such as loss of signal, loss of frame, signal degrade (BER becomes worse than the predetermined threshold), and so on in Type C protection.

The second one (Forced switching) is activated by administrative events, such as fiber rerouting, fiber replacement, etc. Both types should be possible in the XGS-PON system, if required, even though they are optional functions. The switching mechanism is generally realized by the OAM function; therefore, the required OAM information field should be reserved in the OAM frame.

The switching between working PON port and standby PON port should be reported as an alarm, when the port status changes from active to standby. LCT/EMS/NMS should report the port change status.

Figure 3 shows the duplex system model for the access network. The relevant part of the protection in the PON system should be a part of the protection between the ODN interface in the OLT and the ODN interface in the ONU via the ODN, excluding the SNI redundancy in the OLT.

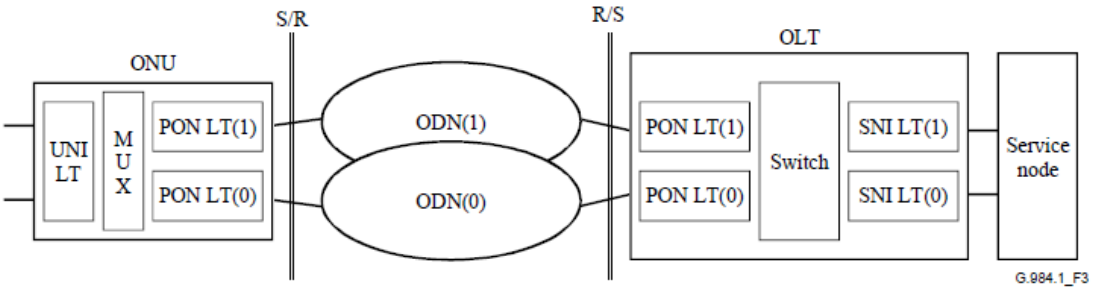

Figure 3: Duplex system Model

6.2 Possible duplex PON configurations and characteristics

There can be several types of duplex PON systems, as shown in Figure 4 & Figure 5. The control protocols for each configuration should be specified independently from one another. The purchaser has the option to procure any of the configurations depending upon the reliability of services.

For example, no switching protocol is required for the OLT/ONU in the Figure 4 & Figure 5 since the switching is only applied for the optical fibres.

Type B protection shall be supported, whereas other schemes shall be optional to purchaser's requirements.

Type B: The second configuration (Figure 4) doubles the PON ports and the optical fibres between the OLTs and the optical splitter, and the splitter has two input/output ports on the OLT side. This configuration reduces the cost of duplexing the ONUs, although only the OLT side can be recovered.

Type C: The third configuration (Figure 5) doubles not only the OLT side facilities but also the ONU side. In this configuration, recovery from failure at any point is possible by switching to the standby facilities. Therefore, the full duplex cost enables a high reliability.

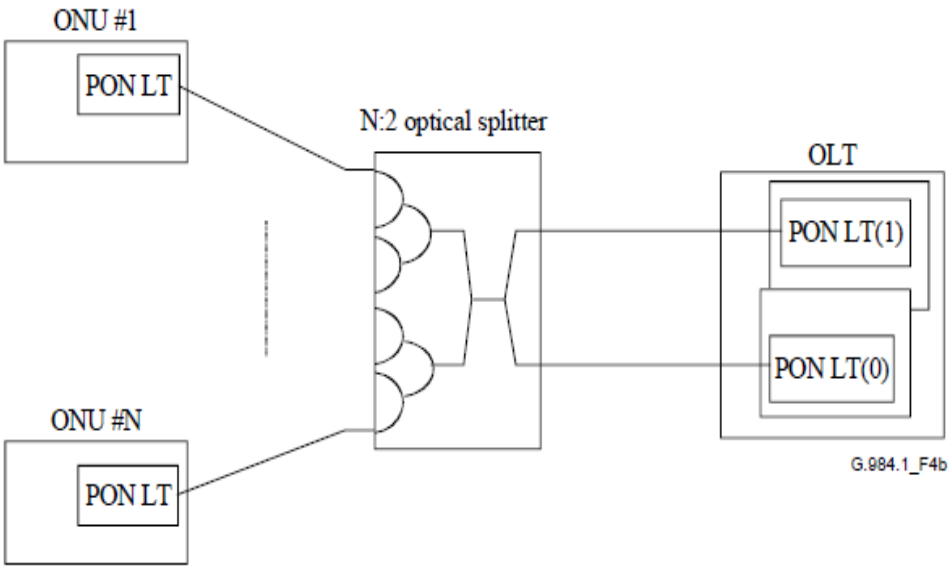

Figure 4: Duplex XGS-PON system: OLT-only duplex system Type B

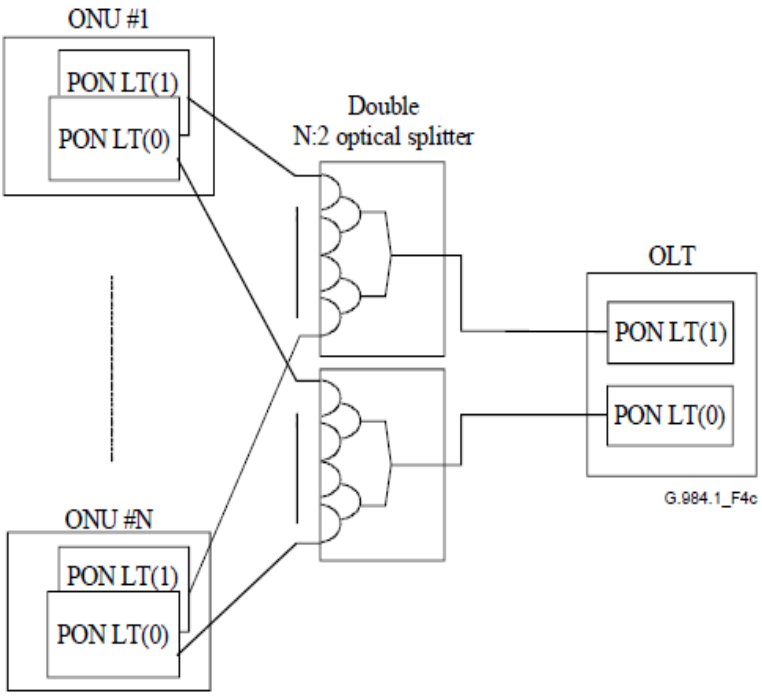

Figure 5: Duplex PON system: Full duplex system-Type C

7.0. Power supply Protection

There shall be provision for dual-feed arrangement to the C-MSAAE such that in case of failure of one feed, the system shall be able to function in a healthy manner without traffic interruption.

8.0. Performance requirements

The equipment shall be tested for error performance.

In laboratory: IETF RFC 2544 conformance/performance shall be tested for end-to-end Ethernet service. In the case E1 service is offered, BER performance over simulated hop shall be tested better than $1x10^{-10}$ for 24 hours over an emulated E1 (TDMoP) in an end-to-end configuration.

In field: IETF RFC 2544 conformance/performance shall be tested for end-to-end Ethernet service. In the case E1 service is offered, BER performance over simulated hop shall be tested better than $1x10^{-10}$ for 24 hours over an emulated E1 (TDMoP) in an end-to-end configuration.

9.0. Synchronization requirements

To deliver high bandwidth to mobile operators, accurate synchronization and timing is required in the PON network. For 2G operators, E1 interfaces have been used for synchronization. However, for 3G/4G wireless additional synchronization schemes need to be provided through IEEE 1588v2 Precision Time Protocol (PTP) (Optional).

Synchronising the CPE (ONTs): All ONTs shall operate with the PON clock transmitted by the OLT. The round trip delay of each ONT is known with high accuracy. If an accurate timing source is available at the OLT, it is possible to accurately recover the clock at ONT by tracking the phase and the frequency relation between the reference and the PON clock at the ONT.

Synchronising the C-MSAAE: C-MSAAE shall serve as the master timing source for ONUs. The following interfaces shall be available at the OLT for synchronisation. :

a. BITS (E1 clock)(Optional) or
b. GPS based source for high accuracy clock input (Optional)
c. IEEE 1588v2 over PON (Optional)
d. Sync as per ITU-T G.8262 (Optional).

Note: For packet synchronization, TEC Standard No TEC 49070:2012 and TEC standard no TEC 49170:2020 may be referred.

9.1. The Synchronizing references:

The synchronization timing reference shall be an external timing reference source at 2048 KHz (Optional) OR IEEE1588v2 (Optional) enabled Ethernet packet.

9.1.1. Frequency accuracy, hold-over mode accuracy, clock bandwidth and frequency pull- in and pull-out range shall be as per as per relevant ITU-T series Recs e.g. ITU-T G.984, G.987, G.9807..

9.2 Timing output interface

The OLT shall provide a timing-output interface at 2048 KHz for external synchronization. The output specifications shall conform to ITU-T Rec. G.812, as applicable. (Optional)

10.0 Maintenance, performance monitoring & supervisory signals

The maintenance signals philosophy shall be as per ITU-T Rec. G.987.x.

10.1 Alarms

The alarms and consequent actions shall be possible to monitor via EMS & LCT of the equipment be as per relevant ITU-T series Recs e.g. ITU-T G.984, G.987, G.9807.

11. Technologies references:

For other services like xDSL, GPON CPE, XGPON GPE, XGSPON CPE refer relevant standard document as below:

- For xDSL refer: TEC 70060:2018/ TEC 70070:2018/ TEC 70080:2018/ TEC 70090:2019.
- Modular GPON refer TEC/GR/TX/PON-001/03/MAR-17
- Piza Box GPON OLT refer TEC/GR/FA/PON-002/02/Nov-18
- XGS PON refer TEC/GR/FA/XGS-001/01/OCT-18
- XG PON refer TEC/GR/FA/XGA-001/02/NOV-18
- Layer 2/Layer 3 Ethernet Switch: TEC 48060:2014

---End of Chapter I---

CHAPTER 2

General Requirements

1.0 Reference documents

1.1 Whatever that has not been specifically stated in this document, shall be deemed to be as per relevant latest ITU-T Recommendations.

1.2 Relevant ITU-T/IEEE Recommendations & other specifications are given in the GR.

1.3 All references to TEC standards & other Recommendations imply for their latest issues.

2.0 Engineering requirements

2.1 The equipment shall be fully solid state and adopt state-of-the-art technology.

2.2 The equipment shall be compact and composite in construction and light-weight. The manufacturers shall furnish the actual dimensions and weight of the equipment.

2.3 All connectors shall be reliable and of standard type (CACT approved) to ensure failure free operation over long periods and under specified environmental conditions.

2.4 All connectors and the cable used shall be of low loss type and suitably shielded (CACT approved).

2.5 The equipment shall provide natural cooling arrangements. But the purchaser may allow use of fans if the natural cooling arrangement is not found adequate provided:

a. Fan failure is reported through LCT/EMS.
b. Fans are DC operated.
c. MTBF is better than 80,000 hours.

2.6 The plug-in units shall be of suitable type to allow their removal/insertion while the equipment is in energized condition.

2.7 The mechanical design and construction of each card/unit shall be inherently robust and rigid under all conditions of operation, adjustment, replacement, storage and transport and conforming to TEC standard TEC 14016:2010 – “Standard For Environmental Testing of Telecommunication Equipment”.

2.8 Each sub-assembly shall be clearly marked with schematic reference to show its function, so that it is identifiable from the layout diagram in the handbook.

2.9 Each terminal block and individual tags shall be numbered suitably with clear identification code and shall correspond to the associated wiring drawings.

2.10 All controls, switches, indicators etc., shall be clearly marked to show their circuit diagrams and functions.

2.11 Facility to mount fixed-attenuator, if required, shall be provided in the receive-chain of the system.

3.0 Operational requirements

3.1 The equipment shall be designed for continuous operation.

3.2 The equipment shall be able to perform satisfactorily without any degradation at an altitude up to 4000 meters above mean-sea-level. A test certificate from the manufacturer will be acceptable.

3.3 The equipment shall be able to work without any degradation in saline atmosphere near coastal areas and should be protected against corrosion.

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

3.5 Wherever the visual indications are provided, Green colour for healthy and Red colour unhealthy conditions would be provided. Some colour may be used for non-urgent alarms.

3.6 The equipment shall support Dual stack IP addresses (IPv4 & IPv6) for management and services.

4.0 Quality requirements

4.1 The equipment shall be manufactured in accordance with international quality standards such as ISO 9001:2015 to meet the quality requirement.

4.2 The equipment shall conform to the requirements for environment and other testes as specified in TEC standard TEC 14016:2010– "Standard for Environmental Testing of Telecommunication Equipment". The applicable tests shall be conducted for respective environmental categories as follows:

4.3 Environmental requirements for various equipment constituents.

a. CPE (ONU/ONT/xDSL) & C-MSAAE

i. Environmental requirements for various CPE or C-MSAAE shall be in general QM333 "B2". Purchaser may specify requirement of QM333 "D" depending upon the location requirements.

5.0 Maintenance requirements

5.1 Maintenance philosophy is to replace faulty units/subsystems after quick on-line analysis through monitoring sockets, alarm indications and Built-in Test Equipment. The actual repair will be undertaken at centralized repair centers. The corrective measures at site shall involve replacement of faulty units/sub-systems.

5.2 The equipment shall have easy access for servicing and maintenance.

5.3 Suitable alarms shall be provided for identification of faults in the system and faulty units.

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

5.5 The manufacturer/supplier shall furnish the list of recommended spares for three years maintenance.

5.6 The supplier shall have maintenance/repair facility in India.

5.7 Supplier should guarantee the spares so long as the equipment is in service, at least for 10 years from the date of supply. The purchaser would like to stock spares as and when the supplier decides to close down the production of the offered equipment. In such an event, supplier shall give a two years notice to the purchaser so as to stock the life-time spares.

6.0 Power supply

6.1 Power supply requirements for various equipment constituents:

b. Powering requirements: CPE

The primary power source shall be 230V+10%/-15%Vac, 50+/-2Hz.

The CPE shall be designed to have protection of power transient, power-surge and power blowouts. However,

i. In case of DC operation, the adaptor for AC↔DC may be external to CPE.
ii. The power rating shall be clearly marked on the device.
iii. The power backup requirement for CPE is left to the purchaser's discretion.

c. Powering requirements: C-MSAAE Equipment in CO/RO

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

i. The equipment shall be adequately protected in case of voltage variation beyond the range as specified above and also against input reverse polarity.
ii. The derived DC voltages in the equipment shall have protection against over-voltage, short-circuit and overload.

iii. The power consumption shall be minimal. The actual power rating/ consumption to be furnished by the manufacturer on the equipment.

iv. The OLT shall have the option of power feed through DC power source and/or AC power source using AC/DC Adapter and operating at nominal 230 volts AC with voltage variation of -15% to +10% at 50 Hz ± 2 Hz. The OLT shall be designed to have protection of power transient.

v. The C-MSAAE should also be provided with the feature of power monitoring and automatic shutdown to safe guard the system, before the power backup goes below the cutoff level (If power back is provided on the requirement by purchaser). The system shall also be equipped to test, monitor and report (through EMS and LCT) the following:

- Battery present or not (assessed by voltage of the battery)
- Battery useful or not (assessed by a short periodic discharge/charge test)
- Low capacity (means going to shutdown soon).

7.0 Energy Consumption Rating: Energy Consumption Rating and Energy Passport of equipment shall be calculated as per TEC standard TEC 74046:2022 (or latest version).

8.0 Accessories

The supplier shall provide complete set of:

a) All the necessary connectors, connecting cables and accessories required for satisfactory and convenient operation of the equipment. Types of connectors, adopters to be used and the accessories of the approved quality shall 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. *The quantity shall be as ordered by purchaser*.

c) Special tools, extender-boards, extender-cables and accessories essential for installation, operation and maintenance of the equipment shall be clearly indicated and supplied along with the equipment.

9.0 Documentation

Technical literature in English language only shall be accepted.

9.1 Installation, operation and maintenance manual

It should cover the following:

i. Safety measures to be observed in handling the equipment;
ii. Precautions for installation, operation and maintenance;
iii. Test jigs and fixtures required and procedures for routine maintenance, preventive maintenance, troubleshooting and sub-assembly replacement;
iv. Illustration of internal and external mechanical parts.

9.2 Repair manual

It should cover the following:

i. List of replaceable parts used including their sources and the approving authority.
ii. Detailed ordering information for all the replaceable parts shall be listed in the manual to facilitate recording of spares.
iii. Procedure for trouble-shooting and sub-assembly replacement shall be provided. Test fixture and accessories required for repair shall also be indicated. Systematic trouble shooting chart (fault-tree) shall be given for the probable faults with their remedial actions.

10.0 Mechanical standards

10.1 The chassis based CMSAAE shall be housed in the standard sub-racks preferably 19" width. The OLT Line Card shall be fitted with motherboard duly masked to avoid short-circuiting. The sub-rack shall have protruded impressions on the top and base-plate of sub-rack assembly to act as built-in guides known as “CNC guide forming” for holding the PCBs in the sub-rack. For Rack type of installation, the Mini–CMSAAE shall be housed in standard 19” racks with 600 mm depth or ETSI racks. The purchaser may specify specific requirements.

10.2 As the ONT is located in customer premises, it should be designed to support wall-mounting or table top.

10.3 In order to avoid bending/sagging of top and base-plates during transportation, installation and maintenance process, the metal-sheet used for these plates shall be minimum 1.2 mm in thickness for mild-steel material, 1.5 mm for Aluminum material and in case of stainless-steel material; the thickness of metal-sheet shall be 1.0 mm.

10.4 The connectors used on the PCB and their mating connectors on the mother-board shall have tight grip to avoid jacking problems. The connectors used shall be professional grade telecom connectors of international industry standards. (Euro-type or better).

10.5 The input/output terminations of tributary signals shall either follow extended mother-board using connectorised connections or directly from proper connectors at the mother-board.

11.0 Operating personnel safety requirements

11.1 The equipment shall conform to IEC 62368-1:2018 OR IS 13252 part 1: 2010+Amd 2013+Amd 2015 “Information Technology Equipment – Safety-Part 1: General Requirements” [equivalent to IEC 60950-1:2005+A1:2009+A2:2013 “Information Technology Equipment –Safety-Part 1: General Requirements”]. The manufacturer/supplier shall submit a certificate in respect of compliance to these requirements.

11.2 The laser product shall meet the optical safety requirement as per IEC-60825-1. The equipment shall meet the optical safety requirement as per ALSD/ APR procedure of ITU-T Rec. G.664 (latest edition) on Class B laser. The equipment shall have visual warning and controls ensuring danger-free operation.

11.3 The equipment shall follow proper construction practice to minimize unintended radiation due to leakage from any gap or monitoring points. All unused ports and monitoring points should be terminated. The power flux density shall not exceed 1 mW/cm2 at a distance of 2.5 cms.

11.4 Protection against short circuit/open circuit in the accessible points shall be provided. All switches/controls on front panel shall have suitable safeguards against accidental operations.

11.5 The optical access ports should be designed to protect themselves against the entry of dust when they are not occupied by an external fiber-optic connection. The optical access port shall be so positioned on the card as to be easy- to- clean by the user as well as for operation/handling purposes.

12.0 Minimum equipment requirements

Fully loaded pre-wired equipment for specific 'category/type' with input and output ports as specified in this standard. EMS and LCT shall also be offered. All test jigs, test instruments etc., shall be arranged by the manufacturer.

CPE(ONT/Switch/xDSL):	4 nos.each
C-MSAAE	1 no.
EMS/LCT	1 no.

13.0 Field trial

The purchaser may conduct filed trial for a minimum of 4 weeks. The manufacturer shall ensure that the equipment meets the field requirements of the purchaser.

---End of Chapter 2---

Chapter 3

EMC Requirements

1.0 Electromagnetic Interference

The equipment shall conform to the following EMC requirements:

General Electromagnetic Compatibility (EMC) Requirements: - The equipment 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 an accredited test agency.

a) Conducted and radiated emission (applicable to telecom equipment):

Name of EMC Standard: "As per CISPR 32 (2015) - Electromagnetic compatibility of multimedia equipment – Emission requirements "

i. ONU/ONT and Mini/Desktop CMSAAE shall comply with **Class B** and Chassis based CMSAAE to comply with **Class A** of CISPR 32 (2015).

ii. The values of limits shall be as per TEC Standard No. TEC 11016:2016**.**

iii. For Radiated Emission tests, limits below 1 GHz for measuring distance of 3m.

b) Immunity to Electrostatic discharge:

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

Limits: -

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

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

Performance Criteria shall be as per Table 1 under Clause 6 of TEC Standard No. TEC 11016:2016.

Applicable Performance Criteria shall be as per Table 3 under Clause 7.2 of TEC Standard No. TEC 11016:2016

c) **Immunity to radiated RF**:

Name of EMC Standard: As per IEC 61000-4-3 (2010) "Testing and measurement techniques-Radiated RF Electromagnetic Field Immunity test" for the following

Limits:-

For Telecom Equipment and Telecom Terminal Equipment with Voice interface (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 interface (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 ranges 800 MHz to 960 MHz and 1.4 GHz to 6.0 GHz.

Performance Criteria shall be as per Table 1 under Clause 6 of TEC Standard No. TEC 11016:2016.

Applicable Performance Criteria shall be as per Table 3 under Clause 7.2 of TEC Standard No. TEC 11016:2016

d) **Immunity to fast transients (burst):**

Name of EMC Standard: As per IEC 61000- 4- 4 {2012) "Testing and measurement techniques of electrical fast transients / burst immunity test" for the following.

Limits:-

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

Performance Criteria shall be as per Table 1 under Clause 6 of TEC Standard No. TEC 11016:2016.

Applicable Performance Criteria shall be as per Table 3 under Clause 7.2 of TEC Standard No. TEC 11016:2016

e) **Immunity to surges:**

Name of EMC Standard: As per IEC 61000-4-5 (2014) “Testing & Measurement techniques for Surge immunity test" for the following.

Limits:-

i) For mains power input ports:

(a) 1.0 kV peak open circuit voltage for line to ground coupling

(b) 0.5 kV peak open circuit voltage for line to line coupling

(c) 2.0 kV peak open circuit voltage for line to line coupling

ii) For telecom ports:

(a) 1.0 kV peak open circuit voltage for line to ground

(b) 0.5 KV peak open circuit voltage for line to line coupling.

(c) 2.0 KV peak open circuit voltage for line to line coupling.

Performance Criteria shall be as per Table 1 under Clause 6 of TEC Standard No. TEC 11016:2016.

Applicable Performance Criteria shall be as per Table 3 under Clause 7.2 of TEC Standard No. TEC 11016:2016

f) **Immunity to conducted disturbance induced by Radio frequency fields:**

Name of EMC Standard: As per IEC 61000-4-6 (2013) "Testing & measurement techniques-Immunity to conducted disturbances induced by radio- frequency fields" for the following.

Limits:-

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

Performance Criteria shall be as per Table 1 under Clause 6 of TEC Standard No. TEC 11016:2016.

Applicable Performance Criteria shall be as per Table 3 under Clause 7.2 of TEC Standard No. TEC 11016:2016

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

Name of EMC Standard: As per IEC 61000-4-11 (2004) “Testing & measurement techniques- voltage dips, short interruptions and voltage variations immunity tests" for the following.

Limits:-

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

ii. a voltage dip corresponding to a reduction of the supply voltage of 60% for 200ms; (i.e. 40% supply voltage for 200ms)

iii. a voltage interruption corresponding to a reduction of supply voltage of > 95% for 5s.

iv. a voltage interruption corresponding to a reduction of supply voltage of >95% for 10ms.

Performance Criteria shall be as per Table 1 under Clause 6 of TEC Standard No. TEC 11016:2016.

Applicable Performance Criteria shall be as per Table 3 under Clause 7.2 of TEC Standard No. TEC 11016:2016

h) **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 & measurement techniques-

voltage dips, short interruptions and voltage variations on DC input power port immunity tests" for the following.

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, 300ms and 1000ms. Applicable Performance Criteria shall be C

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

Note 1: Classification of the equipment:

Class B: Class B is a category of apparatus which satisfies the class B disturbance limits. Class B is intended primarily for use in the domestic environment and may include:

- Equipment with no fixed place of use; for example, portable equipment powered by built in batteries;
- Telecommunication terminal equipment powered by the telecommunication networks
- Personal computers and auxiliary connected equipment.

Please note that the domestic environment is an environment where the use of broadcast radio and television receivers may be expected within a distance of 10 m of the apparatus connected.

Class A: Class A is a category of all other equipment, which satisfies the class A limits but not the class B limits.

Note 2: The test agency for EMC tests shall be an accredited agency and details of accreditation shall be submitted.

Note 3: For checking compliance with the above EMC requirements, the method of measurements shall be in accordance with TEC Standard No. TEC 11016:2016 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). The details of IEC/CISPR and their corresponding Euro Norms are as follows:

IEC/CISPR	Euro Norm
CISPR 11	EN 55011
CISPR 22	EN 55022
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

Note 4: “The performance criteria B specified under IEC 61000-4- 29 :Immunity to voltage dips & short interruptions: Voltage interruptions with 0% of supply for 10ms may be modified as Performance criteria C for OLT equipment deployed and connected in telecom centre in which the battery backup is permanently connected to the DC distribution system. Bill of Material should clearly specify about permanent battery back-up connection status during operation and this information should be mentioned on certificate.

---End of Chapter 3---

Chapter 4

Element Management System and Local Craft Terminal

Part I: EMS Requirements

1.0 General operational and functional requirements

An EMS shall be provided along with the FTTX solution for centralized management and control of the access network. The EMS shall be multi-user system and based on Graphical User Interface (GUI).

1.1 The management system shall comply with the IEEE 802.3av/RFC 4837 for 10G EPON.

1.2 The access network management system shall be able to execute and configure the following.

1.3 The management menu selections should include the following functionality:

i. Alarm monitoring
ii. Customized EML functions as per the purchaser's requirement
iii. Remote view on ONT/ONU
iv. PON Management
v. IP management
vi. Alarm management
vii. Equipment management
viii. Service management
ix. Log management
x. Loopback Management
xi. Operational state
xii. Profile management
xiii. Performance monitoring
xiv. User security

1.4 Configuration of overall equipment with modules (ONU/ONTs, OLT and all related equipment modules).

i. EMS shall be able to display Graphical network topology
ii. All alarms and messages of the entire network to be displayed by EMS and for the local node by the LCT

iii. EMS/LCT shall be able to display Color coded graphical fault display

iv. Each individual site shall have the facility to be managed by Local craft terminal in the remote sites.

v. The operator should be able to check system status, alarm information, alarm logging, performance data and performance system diagnostic from GUI. The EMS shall access and security control for multiple classes access.

1.5 The EMS shall provide:

i. Security management (NE access control, EMS security control, and management privilege control)

ii. Configuration management (NE equipment provisioning, connection provisioning, and NE software download)

iii. Database management (system data, software version, and database backup).

1.6 It should be possible to generate customized reports for various types of faults, performance history, security management etc. It should also be possible to generate up time-reports to facilitate monitoring of performance statistics in a pre-defined/customized format. It shall be possible to generate and define the formats at any time, based on network needs.

1.7 It should be possible to have a view of selected FTTx network 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. The same shall be provided through user-friendly GUI commands.

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

1.9 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 color depending upon the status of the links. It is preferable that green color for healthy and amber/yellow color for degraded condition and red for unhealthy condition is used.

1.10 It shall 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.

1.11 The Element Manager shall have suitable system level backup mechanism for taking backup of EMS data of at least one month. There shall be no magnetic tapes used for the objective, only DVD, CD-ROM, SSDs or any other suitable backup device with purchaser consent shall be provided.

1.12 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.

1.13 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 color like green for healthy, red for non-operational, yellow for degraded mode of operation etc.

1.14 It shall be possible to take any Network Element out-of-service & in-service from the EMS. It shall be possible to restart the Network Element from EMS.

1.15 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 command with settable periodicity - @ 24 hrs, 1 week, and 1 month.

1.16 It shall be possible to log recent commands and be re-displayed, and re-issued on request through GUI if the southbound interface supported is TL.

1.17 The configuration of the various network elements like creating or discovering, viewing, and editing shall be possible from the EMS. The configurations of the network elements shall also be stored at suitable place in EMS from where it can be retrieved in case of failure.

1.18 It shall provide the graphical layout of the network elements with modules drawn using different colors to indicate their status.

1.19 Manufacturer shall provide soft copy of EMS on a CD on per-ink or per-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.

1.20 **Calendar Management:** 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.

1.21 **Messaging system:** The EMS shall have a messaging system which will generate and send alert messages in the form of e-mail or SMS to the designated personnel depending upon the location of NE, on generation of alarms.(Infrastructure required to support e-mail (ie, SMTP server) & SMS (ie; SMSC Server) shall be provided by the purchaser.

1.22 It is recommended that the response time for query/command on any operator terminal, local or remote shall be 10 seconds or better on GUI. For updation on topological information on the terminals, the response time shall be better than 20 seconds under all conditions. The response time shall however, be reviewed depending upon network conditions, total NE load and topology by purchaser during testing of EMS.

1.23 The supplier shall 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, under obligation of a Non-Disclosure Agreement (NDA).

1.24 The supplier shall provide infrastructure requirements to the purchasers for setting up the EMS. Purchaser shall provide all the items of infrastructure include A/C power, Air conditioning load, space etc.

1.25 All critical components and units of the EMS i.e. – LAN interfaces, hard-disk, processor etc., shall be fault resilient.

1.26 It shall be possible to produce customized reports. The purchaser shall be free to ask for customization of reports based on the data available in the database from time to time in line with contractual agreement between the EMS Solution supplier and the purchaser.

1.27 It shall be desirable to interconnect a Disaster Recovery EMS with an existing EMS, in future, with possible manual switchover between them. The issues regarding hardware and software compatibility with regards to existing server

platform shall be subject to a mutual understanding on the issue between purchaser and manufacturer. The expected downtime should be mentioned by the purchaser. Depending upon the expected downtime, deployment scenario, software and supporting hardware requirement may change. Purchaser should provide the required infrastructure to support automatic disaster recovery (if required).

1.28 Installation & commissioning of the EMS shall include supply & installation of cables, distribution frames, electrical switches etc. [Depends upon the decision taken by Purchaser as mentioned in point (x)].

1.29 Format for creation of database of network elements, circuits, ODN/OLT etc., and their numbering scheme, details of built up points across various rings other commissioning details, supplementary information, order reference, dates etc. shall be define by the supplier to meet the requirement prescribed by purchaser at the time of validation of EMS and agreement.

1.30 The purchaser shall validate all the components of EMS and features of EMS as part of Acceptance Testing (AT).

2.0 EMS Architecture and Server Hardware Specifications

2.1 Architecture

i. It shall be ensured that EMS connectivity to sub-network is not disrupted and there is no loss of EMS performance and fault data from the sub-network. To ensure EMS connectivity to the sub-network under control-card failure, there shall be provision to support control card redundancy. In case of total loss of EMS connectivity, the sub-network shall continue to provide the services without any deterioration.

ii. In case of total loss of EMS connectivity, it is recommended that the performance data of the NE shall be stored in the controller card and shall be sent to central EMS server upon restoration of EMS connectivity. It is recommended that 15 minutes performance data for one day and 24 hour summary performance data for two days and fault data messages containing a minimum of last 100 alarms shall be stored by the system. The response time

shall however, be reviewed depending upon total NE load and topology by purchaser during testing of EMS.

iii. In case of loss of EMS connectivity, the LCT privilege shall remain for managing the local equipment, as privileged by EMS administrator.

iv. 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. Any other server required for meeting the purchase requirements shall be quoted separately by the bidder.

v. Local Client connectivity to EMS for privileged operation shall be through a log-in password.

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

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

2.2 Scalability aspects

i. The EMS should be able to support at least 500 OLTs on a prescribed deployment setup (like Bare Metal, Virtual Machine, Containers) with appropriate deployment specifications. The EMS application shall also be scalable to 15000 ONT/ONUs subject to deployment setup scalability. Any more requirements may be communicated by purchaser. The maximum number of NE to be monitored by EMS should be informed to EMS solution provider. EMS solution may put software based restriction to avoid inclusion of extra NE by the purchaser.

ii. The 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.

iii. A minimum of four operator terminals will be provided at the EMS site. The EMS shall be equipped to connect to at least 5 local terminals at EMS site. It shall be

upgradeable to 15 local terminals. The operator terminals at the EMS site are recommended to be PC i3, 1TB HDD, 21" LCD/TFT video display, DVD or better configuration, Ethernet interface (10/100G) with industry standard operating system UNIX/Linux/Windows but having GUI. Any other requirements shall be communicated by purchaser to supplier.

iv. The EMS shall provide SNMP or TL1 options for southbound interfaces. The options for northbound interface shall be SOAP or XML or JSON or CORBA or better configuration.

2.3 EMS server specifications

i. EMS software solution can be deployed on a bare metal standalone system or on bare metal clustered systems setup or on Virtual Machines or on Containers. It is mandatory for the EMS solution provider to elicit the deployment setup requirements for a purchaser prescribed deployment type, purchaser prescribed level of performance for a purchaser prescribed load levels. It is the prerogative of the purchaser to mention the type of deployment that they require and it is the prerogative of the purchaser to decide if the setup is to be provided by the EMS solution supplier or purchaser shall make the deployment setup available to the supplier to deploy the EMS software solution. Procurement of the required setup depends upon the contractual agreement between the EMS solution supplier and the purchaser.

ii. A sample deployment setup for EMS Software solution can be as mentioned below.

iii. A 'Telecom Grade Enterprise Server' from a reputed national/international vendor with broad specifications, as below, shall be provided.

iv. The multi-process EMS design is recommended which shall enable distribution of functions over multiple processors. In addition, the RMI inter-process communication enables distribution of functions over multiple servers. Consequently, increasing system capability can be achieved by upgrading the existing platform (e.g. adding CPUs) or adding new servers into the cluster. The manufacturer shall indicate limitations regarding processing requests, notifications, updates, Network-map view refreshing etc., in the supplied system.

v. Both Application and Database servers shall have UNIX based operating system.

vi. The EMS shall be supplied with a Work Station offering Graphical User Interface (GUI) using 17" colour screen with key board and mouse etc. the Work Station shall be of latest type of machine with very high processing speed as available on the date of procurement of equipment. The Work Station shall support Ethernet ports as 10BaseT, 100BaseT and 1000BaseT. The operating system shall be Windows 10 or latest, Linux or Unix. The specifications are given in clause 2.7 of Chapter-4 (Part-I).

2.4 Application server specifications

Deployment setup related details mentioned in the above section 2.3 are applicable here as well. The EMS application server shall be multi-processor with minimum 4 processor with each processor having at least 8 cores, RISC/CISC based 64 bit system with at least 1.9 GHz clock, 32GB RAM, 1GB cache memory, 160GB HDD/500GB HDD with CD-ROM/DVD-ROM or any suitable back-up device (with purchaser consent), multiple Ethernet LAN interfaces and the server shall operate in high availability cluster mode.

2.5 Database server specifications

i. Deployment setup related details mentioned in the above section 2.3 are applicable here as well. The database server shall be multi-processor with minimum 4 processors with each processor having at least 8 cores, RISC/CISC based 64 bit system with at least 1.9 GHz clock, 32GB RAM, 1GB cache memory. However, the purchaser may choose single server as per network needs. The system shall support at least 6xDVD for loading of software configuration. The system shall have Hard-disk storage implemented on RAID 0, RAID 1, T+RAID 0+1 and RAID 5 architecture of disk storage which shall be configurable. The RAID system shall be hardware based and shall have redundant fibre based RAID controller. The hard-disk storage shall provide for no single point of failure. The server will operate in high availability cluster mode, on load sharing basis. Exact specifications may be issued by purchaser.

ii. Database hard-disk memory shall be sufficient to store all the information as indicated in the document and any other necessary system for at least one month duration.

iii. Each of the server i.e. EMS server and database server as well as firewall server shall have redundancy for control module, disk, power supply and LAN interface.

iv. Industry standard relational database (RDBMS) for storing all the data related to the network and the system shall be used.

v. The database interface shall be open so that a centralized EMS at a future date is able to retrieve information from the EMS database using TCP/IP stack and do post processing. The data base structure for all the databases used in the system shall be provided. [This point violates the IPR of the solution provider. It's the ingenuity of the solution provider how efficiently he designs the database and hence cannot be revealed. What can be made available are the APIs of interest w.r.t FCAPS functionalities (adhering to NG-PON2 standard Data Models - if any) through which data can be accessed by any third party solution with applicable performance matrices namely (a) allowed periodicity/frequency of access of specific APIs (b) allowed extent of data accessed per request (c) allowed format of data access etc.

vi. The memory of the Database server shall be sufficient to store the data of 500 full loaded OLTs and 15000 ONT/ONUs (as per respective type/category of equipment) at a minimum. It shall be capable of storing performance/fault history of 30 days of the network under its domain. This shall be ensured during the testing of the equipment. EMS may delete data older than 30 days to maintain enough storage for new data. The purchaser shall inform EMS supplier in advance if the limit of data maintenance has to be more than 30 days.

2.6 Firewall server [optional to purchaser's requirements]

i. In order to provide security to EMS from public networks, a dual redundant hardware based Firewall system may be provided at each of the NMS locations for providing security to the various servers at the EMS. The Firewall system shall be as per TEC GR No.: TEC 49090:2014. The Firewall System (FWS) shall have a capability of handling a concurrent sessions of around 20,000. The

Firewall system shall support 4 ports of 10/100/1000BaseT expandable to 12 ports.

ii. There shall be a common Firewall system. The Firewall system shall be used for providing the security cover to the Web-based Customer-care system from the internet. The same Firewall system shall also provide the security to the EMS database from the Internet and the Web-based Customer-care users & the systems.

iii. The Firewall shall be based on stateful connection-oriented fire-walling and shall be appliance/hardware based. The Firewall shall track the following parameters of each packet-source and destination address, Transmission Control Protocol (TCP) sequence numbers, port numbers and TCP flags.

Note: All the above servers can be standalone or house on one machine.

2.7 Specifications for local craft terminal/work station

The LCT desktop configuration as a PC or laptop shall be as given below at a minimum-

i. i7 processor or better
ii. 21" TFT/ LCD monitor
iii. 1TB HDD/ 8GB RAM or better
iv. DVD Drive or any suitable back-up device (with purchaser consent)
v. Dual Ethernet LAN port
vi. Min 2 nos. USB ports
vii. USB Keyboard port
viii. Licensed operating software preloaded/recovery CDs / recovery license key.

The Desktop/Laptop shall be supplied with the LCT software installed in it. The PC shall be from a reputed international/national PC manufacturer.

Note 1: No QM-333 environmental tests shall be conducted on the EMS server/LCT PC.

Note 2: Actual server sizing defined is left to purchaser requirements.

--End of Chapter 4 (Part - I) --

Chapter 4
Part II: FCAPS requirements

1.0 Network management functions

1.1 General functions

The equipment shall provide a centralized element management system (EMS) as well as shall provide local management capability through an LCT, which shall be capable of managing the required functions and shall also be used for carrying out supervisory, maintenance, fault localization & performance functions (FCAPS) as outlined in IEEE 802.3 for 10G-EPON. It shall be possible to manage various constituent of the system through local management interface) as well as through remote management interface.

The equipment EMS shall provide general management functions described in ITU-T Rec. G.784. The filters for performance and fault management shall also be as per ITU-T Rec. G.784. The other management functions as defined in ITU-T Rec. G.784 shall be as under:

1. Configuration management
2. Fault management
3. Performance management
4. Security management
5. Software management
6. Inventory management.

1.1.1 Configuration management

The equipment EMS shall support configuration and provisioning capabilities as per IEEE 802.3av. The system shall support ‘point & click’ provisioning in a vendor’s sub-network, subject to clearance by Inventory management, shall be supported as per the following configuration provisioning:

1.1.1.1 Network Element creation in the NE management domain.

1.1.1.2 Programming of a multiple interface units.

1.1.1.3 To create, update, delete and retrieve the managed network topology data.

1.1.1.4 Assigning the equipment protection to a unit/interface.

1.1.1.5 Error detection thresholds.

1.1.1.6 Network Element configuration.

1.1.1.7 Software download (local & remote).

1.1.1.8 Protection switching.

1.1.1.9 Ethernet interface bandwidth.

1.1.1.10 The layer-2 control protocol between ONU/ONT and OLT shall be MPCP Multipoint Control Protocol

1.1.2 Fault management

The equipment management system shall support 'Fault management functions' as described in RFC 4837.The EMS Network Element shall perform a persistency check on the fault-cause, before it declares a fault causing failure.

The equipment shall do surveillance of alarms & their detection, reporting of relevant events and conditions that lead to the generation of alarm after filtering. Further, the element management system shall support the following:

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

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

1.1.2.3 Alarm and status display.

1.1.2.4 Fault localization.

1.1.2.5 Fault correlation control.

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

1.1.2.7 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.

1.1.2.8 FCS errors for Ethernet clients.

1.1.2.9 Assigning alarm severity i.e., Critical, Major, Minor & Deferred.

1.1.3 Performance management

The performance management shall consist of set of functions that evaluate and report on the behavior of network element and their effectiveness relating to the communication taking place on the network. The performance management shall deal with definitions, evaluation and reporting of equipment performance.

It shall be possible to store all the performance and traffic statistics for a month. 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 for text and graphic reports.

The performance monitoring shall conform to IETF RFC 2544 for Ethernet clients. If the management protocol is based on SNMP then the performance monitoring will be based on RFC 2558. Performance history for minimum 30 days shall be supported with configurable launch-time and performance evaluation/integration period. The main performance functionality to be provided shall be as under:

1.1.3.1 Configuration of threshold concerning the error counters.

1.1.3.2 FCS error check for Ethernet clients

1.1.3.3 Frame/Packets dropped in case of Ethernet frames

1.1.3.4 Configuration of threshold concerning the error counters

1.1.3.5 Performance history (data logging).

1.1.3.6 The EMS shall store the performance data of the sub-network in terms of configured circuits. In addition to, the following shall also be some of the different parameters that shall be stored

1.1.3.7 The collection of the performance counters shall be performed at pre-assigned rate.

1.1.3.8 The EMS shall support configurable scheduling of the performance measurement, collection, storage and transfer of the performance statistics. It shall also support presentation of the performance statistics in graphical and text mode as and when requested and at repeated interval automatically.

1.1.4 Security management

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

1.1.4.1 The EMS shall have the capability of supporting the management of Network through local and remote operators. The authorizations and the privileges of the operators (remote and local) shall depend upon the Login and Password.

a. Low-level protection for read only access to faults and performance information.
b. Medium-level protection for access to configuration status and features.
c. High-level protection for control of access to change in the configuration and control parameters.

1.1.4.2 Network management security features shall include operator authentication, command, menu-restriction and operator privileges. The EMS shall support multi-level passwords as below-

a. 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 unauthorized commands being tried for five consecutive times. Also it is desirable that the EMS shall also not allow the entry into the EMS in case wrong password is provided more than five consecutive times during the login.
b. The system administrator shall be able to monitor and log all operator activities in the EMS and Local Craft Terminal.
c. The dynamic password facility shall be provided in which the operator may change his password at any time.

1.1.4.3 All log-in and log-out attempts shall be logged in the security log file of the EMS system.

1.1.4.4 The network and the management system shall be protected against intentional or accidental abuse, unauthorized access and loss of communication.

1.1.4.5 The man-machine communication programs shall have the facility of restricting the use of certain commands or procedures to certain passwords and terminals.

1.1.4.6 The Equipment shall normally operate through the centralized EMS. Only in case of failure of link between the Equipment location and the EMS, the LCT should be able to manage the local assigned to it.

1.1.4.7 It should be mandatory for the system to have a record of all log-ins for a period of at least six months after which a back up should be possible under system administrator command.

1.1.4.8 It shall be possible to connect EMS and the network elements to the IP-MPLS network. The EMS and components of the existing/proposed Network Management Layer (NML)/Service Management Layer (SML) of a purchaser shall be part of the common MPLS-VPN 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.

1.1.4.9 Back up for programmes and data.

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

1.1.4.11 External security measures (optional to purchaser's requirements)

Network security may require deployment of external devices/machines/firm-ware at the network operation centre [NOC], like-

a. Firewalls
b. Access control servers
c. Data encryption devices/use of PKI keys
d. Anti-virus packages.
e. In the data communication network (DCN) for management system, VLAN tags/MPLS labels may be used for security to information flows from NEs to DCN Gateways with IPSec, PKI security options.

The purchaser may communicate requirements as per his network security needs.

1.1.5 Inventory management

1.1.5.1 It shall indicate the absence or presence of any physical module in hardware elements. It shall also indicate the usage of module i.e., how many ports are in use, which interface is in use and which are free to be used etc.

1.1.5.2 The EMS shall be able to discover and keep the device information

1.1.5.3 The EMS shall be able to keep track on any change in the network inventory reported chronologically.

1.1.5.4 The EMS shall provide 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 automatically. This shall also assist SML in providing the network inventory to which the SML shall add the customer identification and maintain this information in its database.

1.1.5.5 The EML shall be able to show inventory based on the available device inventory in terms of circuits' utilization.

1.1.5.6 The EMS shall provide the complete view of the network elements and the interconnecting links.

1.1.6 Software management

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

1.1.6.1 Loading of new system software.

1.1.6.2 Manage different versions of software.

1.1.6.3 Shall have the capability of managing multiple versions of software for individual elements. In this case, one software version shall remain active and other versions shall be passive.

1.1.6.4 Installation of software patches.

1.1.6.5 Examine contents of all system memory and disk memory.

1.1.6.6 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.

1.1.6.7 The EMS shall support FTP/TFTP for downloading of Software, configuration, patches etc., to the Network Element.

1.1.6.8 The operator terminals (local & remote) shall not allow loading of any software without the terminal administrator's authorization.

1.1.6.9 The EMS shall enable operations like changing the system configuration, reconfiguration of input and output devices, loading a new software package, etc. Both automatic and manual reconfiguration capabilities shall be available.

1.1.6.10 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 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. This is applicable only if the south bound interface is TL-1.

1.1.6.11 It shall be possible through a single man-machine command to obtain a list and the total number of equipment of a particular domain in a state (e.g. in-service, blocked etc.).

1.1.6.12 While working on system level commends, it shall be possible to store at least the last 20 commands on the screen and by scrolling and editing any command shall be re-executable. This is applicable only if the south bound interface is TL-1.

1.1.7 Software download

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 down-loading process.

1.1.8 Management interface details

The complete details of the management interface and the protocols, as pertaining to each layer of the protocol-stack implemented in the management system, shall be made available, for the purpose of integrating the local management capabilities with the centralized NMS at a later date. The requirements, in brief, shall be:

i. Protocol details at all layers of TCP/IP stack.

ii. PHY I/F at each layer.

iii. Database structures.

iv. Number formats.

v. Node addressing system.

vi. Complete application software details etc.

vii. EMS software check-sum.

1.1.9 Southbound management interface

The system shall provide at least one remote management interface and one Local Management Interface (LMI) at each Network

The system shall provide an SNMP version2c [or later interface] with standard MIBs Browser. It shall be implemented on UDP/IP stack at all Gateway NEs (GNEs) to interact with a centralized Element Management System (EMS). Or else ITU-T specified Qx or Bellcore specified TL1 interface implemented on TCP/IP, remote management interface shall also be acceptable.

Note 1. The equipment shall provide an Ethernet port for Work Station/Network Server connectivity with standard RJ-45 connector.

Note 2. The purchaser may validate vendor's claim for management functions as well as protocol compliance for Qx or SNMPv2c interface (or later interface) through NMS Protocol Analyzer etc.

1.1.10 Northbound management interface

For remote management purposes, the equipment shall provide remote and local management interfaces at NEs as outlined in the GR. The northbound interface of the EMS towards NMS layer shall be TMF 814 CORBA [version 3.0] or SOAP or XML. And the southbound interface towards NEs shall be SNMPv2c [or later interface] implemented on UDP/IP stack. The purchaser may verify SNMP MIBs and CORBA IDLs during their testing.

1.1.11 Local management interface

The manufacturer shall provide a Work Station/Network Server, which shall act as a manager of management activities, i.e. monitoring and controlling NEs within its management domain. The Local Craft Terminal i.e., a

Personal Computer shall support the local management of NEs. The Local Craft Terminal and Network Server shall be operating simultaneously.

The inter-office communication shall be facilitated through in-band management channels or dedicated data-link. The equipment shall provide V.24/V.28/RS232/RS-485/RJ-45 for connecting a PC-server as a Local Craft Terminal.

1.1.12 User interface

The management system shall be provided with user-friendly interfaces based on Windows/UNIX icons & menus and mouse to accomplish management function that needs user interventions. The EMS start-up and shut-down shall be user friendly, and shall provide on-line help. The EMS shall be able to provide an on-screen nested geographical view of the managed network in the management domain of the manufacturer. It shall be possible to access any managed node within the whole network in the managed domain. The EMS shall be able to depict the failure state of each link and node in the displayed network.

Further, it shall also be possible from the EMS system to get the details of status of an individual managed NE, such as equipment presence, settings, alarm status etc.

1.2 Additional functional requirements

1.2.1 ONT/ONU requirements

1.2.1.1 ONU shall perform following tests/monitor relative to the battery to be reported through EMS and LCT:

i. Battery present or not (assessed by voltage of the battery)
ii. Battery useful or not (assessed by a short periodic discharge/charge test)
iii. Battery voltage

iv. Charging current

v. Low capacity (means going to shutdown soon).

1.2.1.2 Status reporting

i. ONU/ONT ID

ii. PON port link status

iii. UTP access port link status

iv. Loop back test status

v. Loop-back time-out status

vi. Power supply status

vii. Vendor code

viii. Model number.

1.2.1.3 ONT/ONU shall also support the following:

i. Vendor code and model number in EEPROM.

ii. Remote download firmware upgrade.

iii. Auto negotiation or manual configuration of 10M/100Mbps and half-duplex or full-duplex on ONT's user port.

iv. UTP port MDI-MDIX auto-detection.

v. Maximum frame size 1518 bytes

vi. **LED status indication**

A. **Power.** Indicates power on/off status

B. **Voice.** To show that there is at least 1 call active on the ONT, and prevent service interruption.

vii. **Voice-signaling:** ONT has registered with soft-switch

viii. **LEDs to E1 services for B-**ONT

ix. **Operation.** Indicates PON fiber link is normal and OAM channel is operational

x. Signal that voice/data NW is received

xi. Report that video overlay is received

xii. **Test** Indicates ONT is in loopback test status

xiii. **UTP connection.** Indicates ONT UTP access port link is normal

xiv. **Data.** Indicates ONT UTP access port activity

xv. **Full duplex.** Indicates ONT UTP access port at full-duplex mode (optional).

xvi. **Speed.** Indicates 10/100/1000M **speed** selection (as applicable) (Optional).

1.2.2 OLT requirements.

1.2.2.1 The OLT shall provide one craft port for local configuration access.

1.2.2.2 The OLT shall provide in-band management connection to the EMS through GigE from the network.

1.2.2.3 The OLT shall provide out-band management connection to the EMS through 10/100/1000BaseT Ethernet interface.

1.2.2.4 The OLT shall support alarm output and control

A. Critical alarm output

B. Major alarm output

C. Minor alarm output

1.2.2.5 Line rate, security, and performance requirements

1.2.2.6 The PON system shall support 10 Gbps line rate for downstream and 10/1 Gbps line-rate for upstream.

1.2.2.7 AES (key size of 128 bit) support per port-id.

1.2.2.8 RS (255,239) FEC shall be supported with operator enable/disable capability in both upstream and downstream.

1.2.2.9 Network diagnostic and healthy check.

1.2.2.10 Perform logical loopback test on specified ONT. This shall be relevant to an all-frames loopback on the Ethernet port of the ONT, towards the network.

---End of Chapter 4 (Part-II)---

ABBREVIATIONS

ACL	Access Control List
ADSL	Asymmetric Digital Subscriber Line
AES	Advanced Encryption Standard
AIS	Alarm Indicating Signal
APC	Angle Polished Connector
BITE	Built-In Test Equipment
BLS	Broadband Light Source
BSNL	Bharat Sanchar Nigam Limited
CATV	Cable Television
CISPR	Special International Committee on Radio Interference
CPRI	Common Public Radio Interface
CO	Central Office
CORBA	Common Object Request Broker Architecture
CPU	Computer Processing Unit
DEMUX	Demultiplexer
DHCP	Dynamic Host Control Protocol
DOS	Denial of Service
DSCP	Differential Services Code Point
DSLAM	Digital Subscriber Line Access Multiplexer
ECR	Energy Consumption Rating
EMC	Electro Magnetic Compatibility
EMS	Element Management System
FTTH	Fibre To The Home
FTTC	Fibre To The Curb
FTTCab	Fibre To The Cabinet
FTTB	Fibre To The Building
FTTO	Fibre To The Office
FWS	Firewall Server

Gbps	Giga bit per second
GPON	Gigabit Passive Optical Network
ICMP	Internet Control Message Protocol
IEEE	International electronic and Electrical Engineering
IETF	Internet Engineering Task Force
IGMP	Internet Group Multicast protocol
IP	Internet Protocol
ISO	international Standard Organisation
LCT	Local Craft Terminal
LED	Light Emitting Diode
LOS	Loss of Signal
MAC	Media access Control
MDI	Media dependent interface
MDIX	Media dependent interface crossover
MDU	Multi-Dwelling Unit
MTBF	Mean Time Between Failure
MTTR	Mean Time To Restore
MTU	Multi-Tenant Unit
MUX	Multiplexer
NE	Network Element
NMS	Network Management System
NNI	Network Node Interface
OAN	Optical Access Network
OBSAI	Open Base Station Architecture Initiative
ODN	Optical Distribution Network
OLT	Optical Line Terminal
ONU	Optical Network Unit
ONT	Optical Network Termination
OSI	Open System Interconnection
OTL	Optical trunk line
PtP	Point to Point

PCM	Pulse Code Modulation
PON	Passive Optical Network
POP	Point of presence
POTS	Plain Old Telephone System
PRC	Primary Reference Clock
PVC	Permanent Virtual Circuit
QA	Quality Assurance
RN	Remote Node
RO	Remote Office
RSTP	Rapid Spanning Tree Protocol
SDH	Synchronous Digital Hierarchy
SFP	Small Form Factor Pluggable Transceiver
SIP	Session Initiation Protocol
SNI	Service Network Interface
SNMP	Simple Network Management Protocol
TCP	Transmission Control Protocol
TEC	Telecommunication Engineering Centre
TMN	Telecommunication Management Network
UNI	User Network Interface
VDSL	Very High-speed Digital Subscriber Line
VLAN	Virtual LAN
VoIP	Voice over Internet Protocol
WBF	Wavelength Blocking Filters
Wi-Fi	Wireless Fidelity
WDM	Wavelength Division Multiplexing
XG-PON	10Gigabit-capable -Passive Optical Network
XGS-PON	10Gigabit-capable Symmetric-Passive Optical Network
XML	Extensible Markup Language

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