ISO 9001:2008

GENERIC REQUIREMENT

FTTH/FTTB/FTTC BROADBAND ACCESS APPLICATIONS USING GIGABIT PASSIVE OPTICAL NETWORK (GPON) TECHNOLOGY

TEC/GR/TX/PON-001/03/MAR-17

Release 03

TELECOMMUNICATION ENGINEERING CENTRE
KHURSHID LAL BHAWAN, JANPATH, NEW DELHI-110 001, INDIA

वर्गीय आवश्यकताएँ

सं:टीईसी/जीआर/टीएक्स/पीओएन-००१/०३/मार्च-१७

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No. : TEC/GR/TX/PON-001/03/MAR-17

(Supersedes No. TEC/GR/PON-01/02.APR.2008)

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FTTH/FTTB/FTTC BROADBAND ACCESS APPLICATIONS USING GIGABIT PASSIVE OPTICAL NETWORK (GPON) TECHNOLOGY

दूरसंचार अभियांत्रिकी केंद्र

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FOREWORD

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

- Issue of Generic Requirements (GR), Interface Requirements (IR), Service Requirements (SR) and Standards for Telecom Products and Services
- Field evaluation of products and Systems
- National Fundamental Plans
- Support to DOT on technology issues
- Testing & Certification of Telecom products

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 broadband access network architectures based on Fibre-to-the-Home/Building/Curb/Cab (FTTH/FTTB/ FTTC/FTTCab) commonly called FTTX architectures, using Gigabit-capable Passive Optical Network (GPON) technology, as per ITU-T G.984.x series Recommendations, for use in Indian telecom network. The GR also includes the specifications of various equipment constituents and management system to deploy these architectures.

CONTENTS

HISTORY SHEET

Sl. No.	GR No.	Particulars	Remarks
1.	GR/PON-01/01.SEP.2006	Generic Requirements for FTTH/ FTTB/FTTC Broadband Access Applications using Gigabit Passive Optical Network (GPON) Technology	First release
2.	GR/PON-01/02.APR.2008	- do-	Second release
3	TEC/GR/TX/PON-001/03/MAR-17	- do-	Third release

REFERENCES

S. No.	*Document No.*	*Title/Document Name*
1.	ITU-T Rec.G.652	Characteristics of a Single Mode Optical Fibre and Cable
2.	ITU-T Rec. G.656	Characteristics of a fibre and cable with non-zero dispersion for wideband optical transport
3.	ITU-T Rec.G.984.1	Gigabit-capable Passive Optical Networks (GPON): General Characteristics.
4.	ITU-T Rec.G.984.2	Gigabit-capable Passive Optical Networks (GPON): Physical Media Dependent (PMD) layer specification
5.	ITU-T Rec.G.984.3	Gigabit-capable Passive Optical Networks (GPON): Transmission convergence layer specification.
6.	ITU-T Rec.G.984.4	Gigabit-capable Passive Optical Networks (GPON): ONT management and control interface specification
7.	ITU-T Rec.G.993.2	Very high speed digital subscriber line transceivers 2 (VDSL2)
8.	ITU-T Rec.H.248	Gateway control protocol: User interface elements and actions packages
9.	IEEE 802.3	Ethernet standards
10.	IEEE 802.3ad	Ethernet link aggregation standards
11.	IEEE 802.3ae	Media Access Control (MAC)Parameters, Physical Layers, and Management Parameters for 10 Gb/s Operation
12.	IEEE 802.1d/p/q	Ethernet bridging standards
13.	QM-333	Specification for environmental testing of electronic equipment for transmission and switching use

14.	QM-115	Reliability Methods and Predictions
15.	RFC 2544	Benchmarking Methodology for Network Interconnect Devices
16.	RFC 3046	
17.	IS 8437 (1993)	Guide on the effects of current passing through the human body
18.	IEC 61010	Safety Requirements for Electrical Equipment for Measurement, Control and laboratory use
19.	CISPR-22	Limits and methods of measurement of radio disturbance characteristics of Information Technology Equipment
20.	IEC Publication 61000-4-2	Testing and measurement techniques of Electrostatic discharge immunity test
21.	IEC Publication 61000-4-3	Radiated RF electromagnetic field immunity test
22.	IEC Publication 61000-4-4	Testing and measurement techniques of electrical fast transients/burst immunity test
23.	IEC Publication 61000-4-6	Immunity to conducted disturbances
24.	TEC Standard No. SD/EMI-02/03 MAY 2006 with Amendment No. 1 dated 01.01.2008	Electromagnetic Compatibility Standard for Telecommunication Equipment

Note:

Unless otherwise explicitly stated, the latest approved issue of the standard/GR/IR, with all amendments in force listed in this References Table, on the issuance date of this GR/IR applies"

Generic Requirements for FTTH/FTTB/FTTC Broadband Access Applications using Gigabit Passive Optical Network (GPON) Technology GR No.: GR/TX/PON-001/03/MAR-17

CHAPTER 1 – Technical Requirements

1.0 Introduction.

1.1 This document describes the generic requirements and specifications for broadband access network architectures based on Fibre-to-the-Home/Building/Curb/Cab (FTTH/FTTB/ FTTC/FTTCab) commonly called FTTX architectures, using Gigabit-capable Passive Optical Network (GPON) technology, as per ITU-T G.984.x series Recommendations, for use in Indian telecom network. The GR also includes the specifications of various equipment constituents and management system to deploy these architectures.

1.2 A Passive Optical Network (PON), in general, consists of Optical Line Termination (OLT) system installed generally at the Central Office (CO) and a set of associated Optical Network Units (ONU)/Optical Network Terminations (ONT) installed at various locations in the network (as detailed later) with a passive Optical Distribution Network (ODN) comprised of optical fibres and passive splitters/couplers interconnecting them. The placement of OLT may be centralised or distributed to a Remote Office (RO), building basement etc. In such a manner, the Service providers may extend the PON services beyond the reach possible with existing CO.

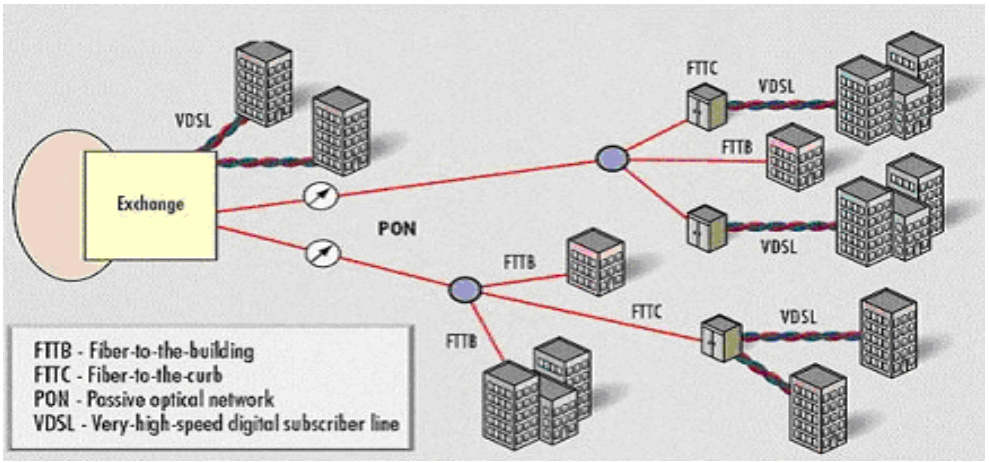


Fig.1: General schematic of passive optical network applications

1.3 The general characteristics and architecture of GPON shall be complaint to ITU-T Rec. G.984.1 as specified in the GR. The transmission convergence (TC) layer specifications for Gigabit-capable Passive Optical Network shall be as per ITU-T Rec. G.984.3 (2004 version including amendment 1 dated July 2005 and amendment 2 dated March 2006). Physical Media Dependent (PMD) layer specifications shall be as per ITU-T Rec. G.984.2 (2004 version including amendment 1 dated February 2006). The ONT management and control interface (OMCI) and other management requirements shall be as per ITU-T Rec. G.984.4 (2004 version including amendment no. 1 dated June 2005 & amendment no. 2 dated March 2006).

1.4 The GR outlines general characteristics of GPON systems including network services, User Network Interfaces (UNI) and Service Node Interfaces (SNI). Also, the GR outlines the basic deployment configurations; however specific implementation shall be subject to networking requirements of the Service Providers.

2.0 An introduction to GPON constituents.

A GPON shall consist of an OLT in Central Office and distributed Optical Network Unit (ONU)/Optical Network Termination (ONT) to terminate customer traffic at various remote locations. The access node in FTTH

architecture for network termination installed within user premises is called as ONT. Whereas the access nodes in FTTB/FTTC/FTTCab architectures, installed at other locations i.e. Curb/Cabinet/MDU (or MTU) basement, are termed as ONU. A single-fibre shall connect OLT to an ONU or ONT in point to multipoint {p2mp} configuration through optical splitter/coupler. Such splitters/couplers shall be installed at various outdoor as well as indoor locations (at Central Office and remote nodes) dependent on the number of customers to be served and consequently on the FTTX architecture chosen for the deployment. Depending upon the customer density and speed requirements in the serving area, single or multi-stage splitting shall be used by Service Providers as shown in Fig.2.

There are also cases where GPON system might be deployed in a point-to-point (p2p) architecture where a separate fibre is terminated for each user. Such a configuration is used to cater to higher customer bandwidth requirements in specific cases, as per requirements. Another application for such point-to-point connectivity is to provide backbone connectivity to the existing infrastructure. Various ONU/ONTs are terminated at OLT.

The GR envisages the use of the industry best practice with reference to optical budgets etc., for 2.488Gb/s downstream and 1.244Gb/s upstream bit rate GPON system.

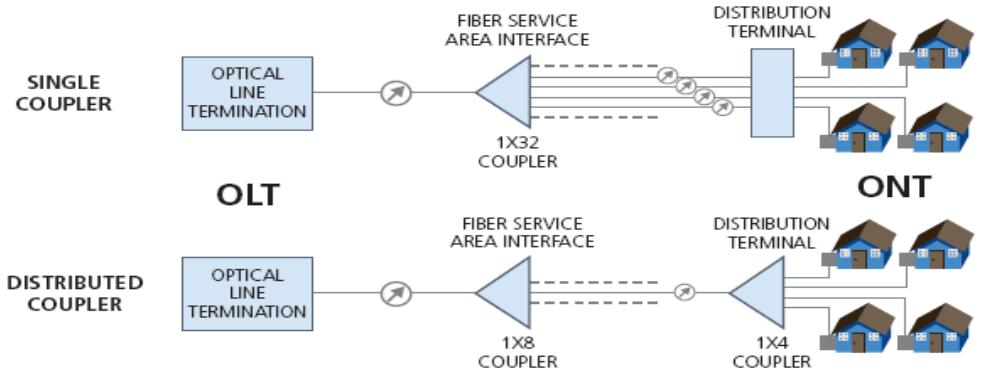


Fig.2: Schematic showing single or multi-stage splitting

2.1 Functional components of GPON:

This GR envisages FTTX deployments using GPON technology. Depending upon the deployed architecture, there shall be variations in placement of various PON constituents, as described in clause 2.3.1 detailing various FTTX architectures.

2.1.1 ONU/ONT

ONU and ONT are the system blocks to provide access to the users. The access node in FTTH architecture for network termination installed within user premises is termed as ONT. Whereas the access nodes in FTTB/FTTC/FTTCab architectures, installed at locations such as Curb/Cabinet/MDU (or MTU) basement, are termed as ONU.

In FTTC/Cab architecture, the users generally need to install additional network termination (NT) device to access the ONU at a typical distance of 500m-1000m. The possible choices of NT for households shall be VDSL2. Whereas, in FTTB scenario, the user can access the ONU installed in the MTU/MDU over Ethernet or VDSL2 interfaces. The VDSL2 card shall be backward compatible with ADSL2+.

The ONU/ONTs shall provide 1) User-interfaces **(UNI)** towards the customers and 2) Uplink **(IF_{PON})** interfaces to uplink local traffic towards an OLT. Adaptation function for specified UNIs shall also be an integral part of the ONU/ONT blocks.

ONTs are deployed in Fibre To The Home (FTTH) and Fibre To The Business (FTTB) architectures, where the fibre termination shall take place at the premises. The UNI are integrated in the ONT box to provide data, voice, RF video (If required by purchaser) and WiFi (in-built) interfaces.

ONUs are deployed in MDU, cabinet and at curb site. ONU shall provide PON interface towards the OLT to connect IP backhaul to the additional

network termination (NT) and UNI interface towards the customer of high density living or working areas and as such it may comprise of two separate devices. Both of them may be provided as an integrated solution or the NT device such as DSLAM (VDSL2) may be implemented as a separate box in case it is a third party item.

Any ONT to be utilised for meeting Type C Protection shall be provided with two PON ports

Note: In the case of ONUs providing separate box solution, the management of different boxes shall be possible through the EMS of the GPON system.

Service support by ONU and ONT:

- High speed data/Internet,
- Voice through in-built VoIP gateway in case of ONT and through in-built/external VoIP gateway as per requirement in the case of ONU for large no. of POTS.
- RF video,
- E1 through TDM over IP External Gateway,
- IP Video.
- In-built WiFi support as per IEEE 802.11g/n/ac *.

  *Note: Exact requirement for WiFi support as per IEEE 802.11g/ IEEE 802.11n/ IEEE 802.11 ac will be specified by the purchaser. However, higher standard shall be backward compatible with lower version of standard).

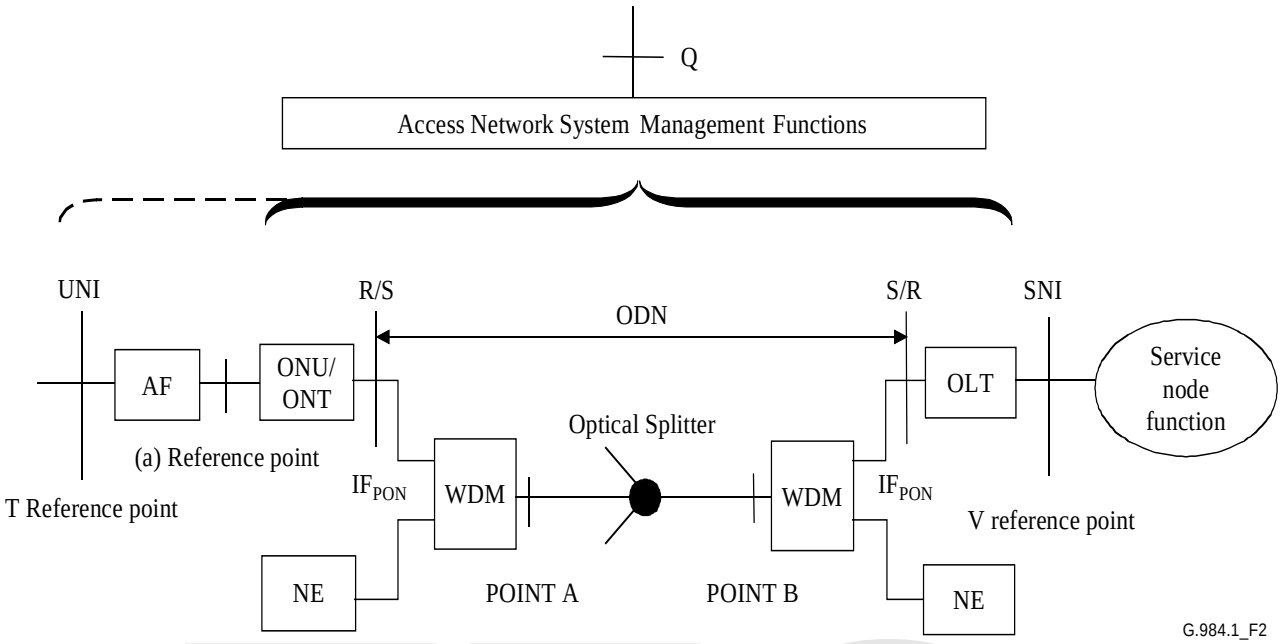
- USB Interface for monitoring#/sharing external devices. (The requirement and application of USB shall be specify by purchaser.)
  (#Note: Application of USB includes inter-alia monitoring of power back-up ONT etc).
- ONU user interface may also have G.Fast (ITU-T rec G.9700 & G.9701) / G.hn(ITU-T rec G.9960 & G.9961) interface. (If required by purchaser)

2.1.2 **OLT:**

An OLT shall provide aggregation and switching functionality between the core network and PON interfaces. It shall offer PON interfaces (towards ONU/ONTs) & Service interfaces (towards core network). The interfaces towards ONU/ONTs are called PON interfaces **(IF_{PON})** and the interfaces towards core network are called Uplink interfaces **(SNI)**.

2.1.3 **Optical splitters.**

Optical splitters capable of providing up-to 1: 128 optical split, on end to end basis, per PON interface on OLT, are envisaged. There shall be various options provided to purchaser such as m:N where m = 1 or 2 and N = 2,4, 8, 16, 32,64 and 128. The purchaser may use a combination of these split options. The purchaser shall communicate the exact requirements.(Note: for further specification on optical splitter, refer generic requirements for optical splitter for passive optical network technology NO. TEC/GR/TX/OPT-001/01/APR-12)



ONU	Optical Network Unit
ONT	Optical Network Terminal
ODN	Optical Distribution Network
OLT	Optical Line Termination
WDM	Wavelength Division Multiplex Module (If WDM is not used, this function is not necessary.)
NE	Network Element which uses the different wavelength from the OLT and the ONU
AF	Adaptation Function (Sometimes, it may be included in the ONU.)
SNI	Service Node Interface
UNI	User Network Interface
S	Point on the optical fibre just after the OLT (Downstream)/ONU (Upstream) optical connection point (i.e., optical connector or optical splice)
R	Point on the optical fibre just before the ONU (Downstream)/OLT (Upstream) optical connection point (i.e., optical connector or optical splice)
(a) Reference point	If AF is included in the ONU, this point is not necessary.
POINT A/B	If WDM is not used, these points are not necessary.

NOTE – Whether or not the AF is an operating object of the Q interface depends on the service.

Figure 3. Configuration for a Passive Optical Network

2.1.4 WDM couplers.

Multiple dedicated wavelengths may be used, as per ITU-T Recs. G.984.x, for various applications e.g. voice, video, internet, data etc., and enabling combined optical transport through a single fibre. For example, two dedicated wavelengths may be used for downstream and upstream (~1490nm & ~1310 nm respectively) for data & voice transport and the other one (~1550nm) may be used for downstream video. The RF video as specified in Table-1 shall be supported by the system; however the implementation shall be an optional item on purchaser' s requirements. If

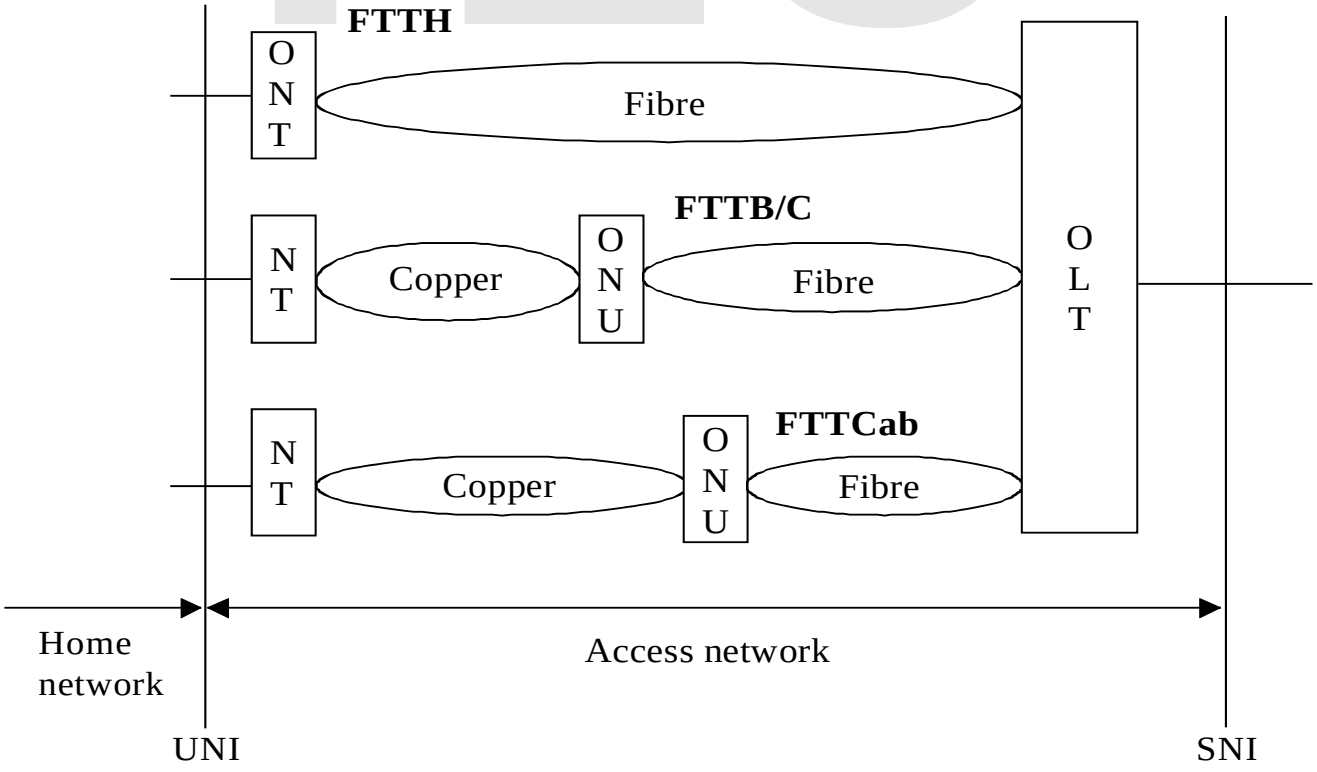
RF video is not used, the WDM coupler may not be necessary unless additional wavelengths (CWDM/WDM) are proposed to be used by purchaser.

Table-1. RF video specifications

RF video ports (physical connectors)	Female F-type connector – no. of connectors shall be indicated by the purchaser.
RF video output bandwidth	52-870MHz
RF output level (nominal @870MHz, 5dBm input power and 3.5% OMI)	14 dBmV
RF output tilt	0 dB

2.1.5 Fibre plant for PON

ITU-T Rec. G.652 fibre shall primarily be used between OLT and ONUs/ONTs. Special access fibre e.g. ITU-T Rec. G.656 fibre may also be used for FTTB/FTTH intra-building, campus etc. applications.



ONU Optical Network Unit
ONT Optical Network Termination
OLT Optical Line Termination
NT Network Termination

Figure 4. Network Architecture

Note: Direct Ethernet access to ONU (upto 100Mb/s) over copper-pairs can be used, if user location within ~100 meter reach of ONU in an MDU/MTU in FTTB architecture. DSL based access may be used for longer distances in FTTB/FTTC/FTTCab architectures.

2.2 **Topological requirements of GPON:**

The optical section of a local access network system shall be passive and its architecture shall be capable of simultaneously supporting a mix of p2p or p2mp applications. Figure 4 shows the architectures for Fibre-to-the-Home (FTTH), Fibre-to-the-Building/Curb (FTTB/FTTC) and also Fibre to the Cabinet (FTTCab). Actual architecture required shall be decided and conveyed by the purchaser. The Optical Access Network (OAN) is common to all architectures as shown in the figure 4.

2.3 **FTTX architectures: An introduction & discussion.**

The ' X' in FTTX stands for a lot of things, often not very different, but for practical purposes they can all be grouped under any of the three basic approaches:

i. **Fibre all the way to residential or business customer by using PON or Ethernet**

These are-

a. Fibre to the Home (FTTH)
b. Fibre to the Building (FTTB).

The distinction is basically between single homes or apartments and business or multi-tenant buildings.

ii. **Fibre all the way to the customer by using PON only**

- Fibre to the Premises (FTTP).

iii. Fibre partial

These all use copper from the partial point to the user:

a. Fibre to the Curb (FTTC)

b. Fibre to the Cabinet (FTTCab).

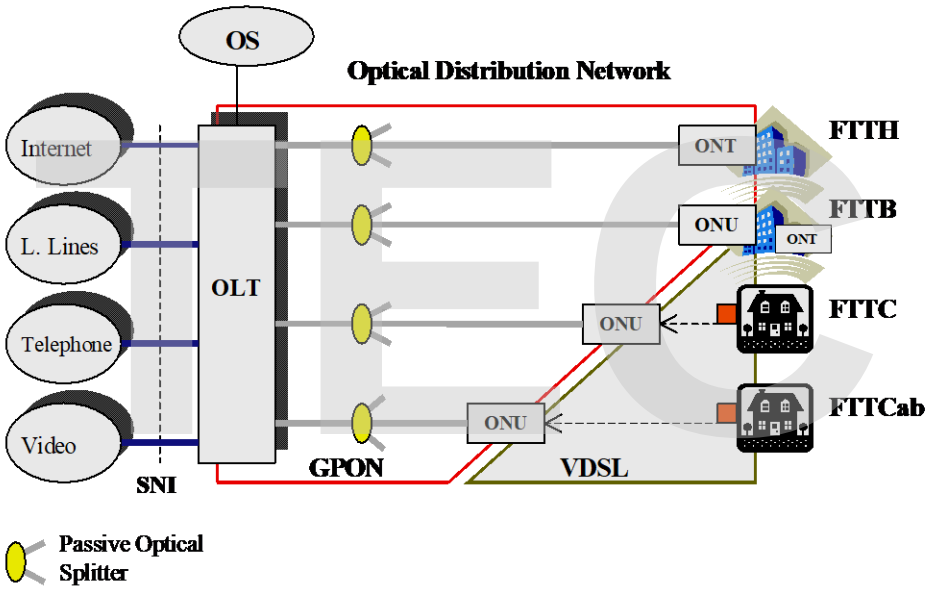


Figure 4a. Schematic showing various FTTX architectures

Fibre partial means that fibre goes to some point near to the customer, and then another mechanism usually copper-pairs supporting VDSL2 takes over for the final link to the customer.

Specific to Indian context, in FTTCab architecture, the fibre is brought upto a point close to the customers, where a cabinet is installed in the existing network (approximately 1000-2000m from users). To a rough approximation, this node may serve ~500-1000 customers or households. Whereas, in FTTC, the fibre is brought even closer, upto a roadside telephone pole in the distance range of 200-400 m from end users. Usually, this architecture may serve ~ 8-32 customer drops (copper).

In FTTH architecture, fibre termination takes place right up to individual home. The user installs an ONT and connects to OLT in CO directly or through cascaded splitter stages.

In FTTB architecture, fibre is extended right upto the building. Based on home and business applications, there are two possible scenarios in this architecture.

i. FTTB for residential applications in MDU.
ii. FTTB for business applications.
iii. A mix of these applications in MDU/MTU.

The main difference for the afore-mentioned scenarios is based on the user access to ONU. The users in Scenario #1 shall mainly access the ONU through use of in-building copper runs, through VDSL2 as per ITU-T Rec. G.993.2 based NTs. Whereas in Scenario #2, users might prefer to avail direct fibre access to ONU over Ethernet interface. To support such flexible options, the ONU shall provide options for direct Ethernet access as well as DSL based access. The ATM encapsulation, if any, shall be terminated right at the ONU.

In FTTC and FTTCab architectures, fibre penetration takes place up to the curb (200-400m) or cabinet (1000-2000m) from user locations. These architectures are suitable for densely populated residential areas comprising of mainly individual households. The access to the users shall be provided mainly through VDSL2 as the NT device over copper pairs. There shall be provision for POTS and VDSL2 interfaces towards users at ONUs.

Note: The VDSL2 specifications shall be as per ITU-T Rec. G.993.2.

2.4 Equipment interfaces and service support:

The GPON equipment shall provide three types of interfaces, namely:

i. User-Network Interface (UNI)
ii. Service-Node Interface (SNI)

iii. PON interface (IF_{PON})

2.4.1 User-network interface (UNI) and service-node interface (SNI).

a. **User-network interface (UNI)**

The ONU/ONT provides various application interfaces towards users, as shown in figure 3, called UNI. UNIs shall be supported for various services as envisaged for different Categories/Types of ONU/ONTs. The possible examples of UNI are described in clause I.2, detailing with examples of UNI in Chapter 4.

b. **Service-node interface (SNI)**

OLT shall support SNI towards core network, as described in Fig.3. SNI depends on the services provided by the service provider. The examples of SNI are described in clause I.3 detailing examples of SNI in Chapter 4.

The SNI at OLT is envisaged to provide various Gigabit Ethernet and/or 10G Ethernet interfaces. The purchaser may convey specific interface requirements as well as quantity of such interfaces.

c. **PON interfaces (IF_{PON})**

The ONUs shall provide (IF_{PON}) interfaces towards OLT for GPON transport. In a similar manner, OLT also provides (IF_{PON}) interfaces towards ONUs for GPON transport. The interfaces are the reference points R/S and S/R respectively in figure 3. They are PON-specific interfaces that shall support all the protocol elements to allow transmission between OLT and ONU/OLT.

2.4.2 A broad overview of services in various FTTX architectures.

The service support for various FTTX deployment architectures are summarized below. The details of the service support are also available in Chapter 4/Clause I.1.

a. **FTTB architecture.**

The scenarios identified in Clause 2.3.1 shall support the following service categories:

FTTB for residential applications.

i. Asymmetric broadband services (e.g., Internet, digital broadcast TV services, Video-on-demand, file download, etc.) over direct Ethernet over copper or through VDSL2.
ii. Symmetric broadband services (e.g., content broadcast, e-mail, file exchange, distance learning, telemedicine, online-gaming, etc.) over direct Ethernet over copper or through VDSL2.
iii. POTS through VoIP.

FTTB for business applications.

i. Asymmetric broadband services (e.g., Internet, digital broadcast TV services, Video-on-demand, file download, etc.) over direct Ethernet over copper or through VDSL2.
ii. Symmetric broadband services (e.g., group software, content broadcast, e-mail, file exchange, etc.) over direct Ethernet over copper or through VDSL2.
iii. POTS through VoIP.
iv. TDMoP services.

b. FTTC and FTTCab applications

In this architecture, the following service categories are envisaged:

i. Asymmetric broadband services (e.g., Internet, digital broadcast TV services, VoD, file download, online-gaming, etc.) over VDSL2.
ii. Symmetric broadband services (e.g., content broadcast, e-mail, file exchange, distance learning, telemedicine, etc.) over VDSL2.
iii. POTS through VoIP.

Note: ATM encapsulation of DSL, if any, shall be terminated in the ONU node in all deployment architectures.

c. **FTTH applications**

In this scenario, the following service categories are envisaged:

i. Asymmetric broadband services (e.g., Internet, digital broadcast TV services, VOD, file download, etc.) over fibre.

ii. Symmetric broadband services (e.g., content broadcast, e-mail, file exchange, distance learning, telemedicine, online-game, etc.) over fibre.

iii. POTS through VoIP.

Note 1. The above service descriptions are indicative of possibilities and not for exact specification. The purchaser shall indicate the requirement of the interfaces.

Note 2. Both IPTV and RF-broadcast modes shall be supported for residential deployments as options to the purchaser.

Note 3. The service interface shall be TDM over packet.

2.5 **TDM lines and voice transport options.**

The layer-2 control protocol between ONU/ONT and OLT shall be Ethernet over GEM. TDM support shall be provided through TDM over Packet (TDMoP) option. TDMoP support shall be relevant to E1 lines.

The OLT shall interface the core network at various Ethernet interfaces, as detailed later in the GR.

Transport of voice services shall be supported as Voice over Packet between ONT/ONU and OLT. The voice traffic shall be terminated at OLT across IP over Ethernet interfaces (with SIP signalling and ITU-T Rec. G.711 framing), thus creating a simple evolution path to an all IP network with soft-switches, as needed. An external SIP/H.248 ↔ Media gateway may be used for interfacing PSTN switches subject to purchaser' s requirements

2.6 **Important parametric definitions & functional requirements of GPON systems.**

a. **Logical reach:** The maximum logical reach is defined as the maximum length between ONU/ONT and OLT that can be achieved for a particular transmission system independently from optical budget. It is measured in km and it is not limited by PMD parameters, but rather TC layer and implementation issues.

The GPON system shall support a logical reach upto 60 km. At least a physical reach of 20 kms shall be demonstrated.

Specific requirements may be suitably planned and conveyed by purchaser.

b. **Maximum differential logical reach:** The differential logical reach is the maximum difference in logical reach among all ONUs. It is measured in km and it is not limited by PMD parameters but rather TC layer and implementation issues. The maximum differential logical reach shall be 20 kms as per GPON standards G.984.x.

2.7 **Bit-rate options**

a. 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.

b. The GPON parameters to be defined are categorized by the downstream and upstream, and nominal bit-rates are as follows-

Table-2

TX-direction	Nominal bit rate	Table in ITU-T Rec. G.984.2
Downstream	2488.32 Mbit/s	Table 2c (downstream, 2.4 Gbit/s)
Upstream	1244.16 Mbit/s	Table 2f-1 (upstream, 1.2 Gbit/s) Table 2f-2 (upstream, 1.2 Gbit/s)

Note:. All parameter values specified are worst-case values, assumed to be met over the range of standard operating conditions (i.e., temperature and

humidity ranges), and they include ageing effects. The parameters are specified relative to an optical section design objective of a Bit Error Ratio (BER) not worse than 1×10^{-10} for the extreme case of optical path attenuation and dispersion conditions.

3.0 Specifications for GPON system constituents for various topologies

3.1 Types of equipments:

On the basis of target applications, there shall be the following types of ONU/ONTs:

Type 1. Home-ONT **(H-ONT)** for FTTH applications.

Type 2. Cabinet/Curb-ONU **(C-ONU)** for FTTCab/FTTC applications.

Type 3. MDU-ONU **(M-ONU)** for FTTB applications in MDU.

Type 4. Business-ONT **(B-ONT)** for FTTH applications.

Type 5: Cell- Site backhauling (M-ONT) for FTTM applications.

Type 6: Optical-ONT (O-ONT) for FTTH applications.

Note: Protection requirements due to fibre cuts:

a. No support for protection (used mainly for residential applications), and
b. For Business as well as high density residential applications, the purchaser may opt for configurable protection as fully-protected, partially-protected or unprotected. This requires separate such ONT/ONUs for each application with diversified fibre routes.

3.2 Physical interface requirements at UNI.

3.2.1 Type 1: H-ONT for residential broadband service delivery.

H-ONT shall provide the following residential broadband services. Service support shall be there for voice, video & data. Purchaser shall indicate the exact requirement of each interface.

i. POTS

ii. 10/100/1000BaseT Ethernet interface (to inter-connect VoIP phones, STB, PC etc., through a home Ethernet bridge).

iii. RF video interface over coaxial ' F' connector (If required by purchaser)

iv. In-built WiFi support as per IEEE 802.11g/n/ac in the home.

v. Dying gasp feature (If required by purchaser).

vi. USB 2.0/3.0 Interface (If required by purchaser)

3.2.2 **Type 2: Residential-ONU (R-ONU) for FTTCab/FTTC applications.**

The ONU for FTTC/FTTCab architectures shall provide VDSL2 interfaces in addition to other interfaces as mentioned below. The number of homes/users to be served shall be high in these deployments. A typical distance from target users may be 500m-1000m. The interface support shall be provided for:

i. Upto 16 POTS through VoIP (purchaser shall specify exact number of ports).

ii. VDSL2

iii. ONU user interface may also have G.Fast (ITU-T rec G.9700 & G.9701) / G.hn(ITU-T rec G.9960 & G.9961) interface. (If required by purchaser)

iv. Dying gasp feature (If required by purchaser).

v. USB 2.0/3.0 Interface (If required by purchaser)

The users shall install an appropriate NT at their premises. Purchaser shall specify exact number of ports required.

3.2.3 **Type 3: MDU-ONU (M-ONU) for FTTB applications in MDU.**

The M-ONU for FTTB architectures shall provide interfaces to cater to residential as well as business requirements in Multi-Dwelling Unit (MDU). M-ONU is usually installed in the basement of the MDU.

Direct Ethernet access to ONU (upto 100Mb/s) over copper-pairs can be used, if user location is within ~100 meter reach of ONU in an MDU/MTU. VDSL2 based access may be used for longer distances.

A typical distance from target users may be 100-150m. The interface support shall be provided for:

i. POTS

ii. 10/100/1000BaseT Ethernet interfaces

iii. RF video interface over coaxial female ' F' connector (If required by purchaser)

iv. In-built WiFi support as per IEEE 802.11g/n/ac.

v. VDSL2 interfaces.

vi. Dying gasp feature (If required by purchaser).

vii. USB 2.0/3.0 Interface (If required by purchaser)

viii. ONU user interface may also have G.Fast (ITU-T rec G.9700 & G.9701) / G.hn(ITU-T rec G.9960 & G.9961) interface. (If required by purchaser)

The users shall install an appropriate NT at their premises. Purchaser shall specify exact number of ports required.

3.2.4 **Type 4: Business-ONT (B-ONT) for FTTH applications.**

i. POTS (purchaser shall specify exact number of ports).

ii. E1 line (for PBX interconnection etc.). The support for E1 shall be meant for transport applications of TDM to OLT.

iii. 10/100/1000BaseT Ethernet interface to inter-connect VoIP phones, STB, PC etc.

iv. RF video interfaces over coaxial female ' F' connector (If required by purchaser)

v. In-built WiFi support as per IEEE 802.11g/n/ac.

vi. Dying gasp feature (If required by purchaser).

vii. USB 2.0/3.0 Interface (If required by purchaser)

3.2.5 **Type 5: Cell- Site backhauling (M-ONT) for FTTM applications.**

i. POTS (purchaser shall specify exact number of ports).

ii. 10/100/1000Ethernet Interface.

iii. PON ports for Uplink- one.

iv. USB 2.0/3.0 Interface (If required by Purchasers)

v. The system shall support 1588v2 protocol for synchronisation.

vi. Dying gasp feature (If required by purchaser).

3.2.6 Type 6: Optical-ONT (O-ONT) for FTTH applications.

i. POTS (purchaser shall specify exact number of ports).

ii. 10/100/1000Ethernet Interface through SFP– Minimum Four Ports. (Optical or Ethernet SFP as options to be mounted)

iii. PON ports for Uplink- one

iv. USB 2.0/3.0 Interface (If required by Purchasers).

v. Dying gasp feature (If required by purchaser).

Note 1 Purchaser shall specify exact number of ports required and also the no. of access to WiFi users.

Note 2 The system shall be designed considering 100Mbps throughput per 10/100BaseX Ethernet UNI port and 400 Mbps up/down for 10/100/1000BaseX Ethernet UNI port.

Note 3 The PON access shall support Set Top Boxes (STB) in the home network offering different video channels of IPTV, on different TV sets.

Note 4: All types of ONTs/ONUs shall support Dual stack IP addresses (IPv4 & IPv6).

Note 5: Any ONT to be utilised for meeting Type C Protection shall be provided with two PON ports.

3.3 ONU & ONT equipment architecture

The equipment architecture of ONU as well as ONT 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 various UNI interfaces on the user side through DSLAM etc. This basic module and the sub modules may be implemented in the same mechanical package or implemented on different box.

3.3.1 Functional requirements of ONU/ONT at UNI

1. Isolation of subscriber traffic to ensure user privacy for ONU.

i. ONU shall have capability to prevent MAC address spoofing. It shall be possible to limit the number of MAC/IP addresses per port and to bind the MAC/IP addresses to a port.

ii. There shall be no layer 2 connectivity between users at ONU. Subscriber (peer to peer-P2P) communication shall be allowed only through OLT.

2. Layer 2 bridging support for various ONU/ONTs.

i. Type 1. Home-ONT (H-ONT) for FTTH applications.
64 MAC addresses, 16 VLAN.

ii. Type 2. Residential-ONU (R-ONU) for FTTCab/FTTC applications.
1K MAC addresses, 4096 VLAN.

iii. Type 3. MDU-ONU (M-ONU) for FTTB applications in MDU.
1K MAC addresses, 4096 VLAN.

iv. Type 4. Business-ONT (B-ONT) for FTTH applications.
256 MAC addresses, 64 VLAN.

v. Type 5: Cell- Site backhauling (M-ONT) for FTTM applications.
64 MAC addresses, 16 VLAN.

vi. Type 6: Optical-ONT (O-ONT) for FTTH applications.
64 MAC addresses, 16 VLAN.

The following capabilities shall be supported at UNI for all ' types' :

a. Flow control per 802.3x
b. IGMPv2 snooping – applicable for ONU only, optional for ONT,
c. IGMP filtering - applicable for ONU only, optional for ONT,
d. 128 multicast groups - applicable for ONU only, optional for ONT.

Note: Flow control shall be supported by both ONU and ONT. The others shall be as per the requirements of the purchaser.

3. **Bandwidth management, congestion control and QoS.**

i. For ONU, there shall be robust and programmable buffer management, congestion control, and traffic scheduling at a per-user flow level. This is required to ensure appropriate levels of service on premium or time-sensitive content. Sufficient buffer capacity shall be as per ITU-T G984.3.

ii. For better quality of service support, the ONT/ ONU is required to support 802.1 p bridging. This function maps 802.1 p priorities into priority queues in the upstream direction.

iii. Different scheduling methods can be applied, e.g. strict priority and weighted round¬-robin. When p-bits are combined with VLAN ID for indicating QoS classes, the network elements should have the ability to queue in function of the VLAN ID.

iv. For ONU, the rate in the downstream and upstream directions at UNI ports shall be controllable through EMS.

4. **Dynamic bandwidth adjustment (DBA).**

i. Piggy-back DBRu report mode 0 shall be supported.

ii. Idle GEM DBA shall be supported

- By ‘ Idle GEM’ support, it is implied that OLT will proactively monitor US frame for these and reassign BW-MAP as needed to other ONT/ONUs reporting back-pressure in its queues via DBRu.

iii. Concurrent support of idle GEM and piggy-back DBRu mode 0 shall be supported

iv. T-CONT Type 1to T-CONT type 4 shall be supported.

5. **Traffic policing functions**

These functions shall include traffic shaping. Policing of upstream traffic shall be done at ONU. To ensure strict QoS guarantees, the ONU shall need to perform bandwidth control at the ingress of the Ethernet network.

Bandwidth control can be done by per-VLAN or per-class policing and shaping at the ingress of the Ethernet network. Stricter guarantees can be provided with policing at the ingress port of each Ethernet switch. The service edge and the ONU must also implement policers and shapers for downstream traffic.

6. Security

i. user name and password based authentication,

ii. Support of 802.1x authenticator functionality (MAC based) for ONU

iii. MAC address limitation per-ONT

iv. >100 ACL support (based on switch port, MAC address, Ether-type) on ONU or OLT.

v. DOS prevention, SSH v1/2 for CLI for ONU.

vi. AES (key-size of 128 bit) support (If required by purchaser) per port-id with operator disable/enable capability for ONU/ONT

vii. Operator disable/enable shall be done in-band PLOAM message (Encrypt Port-Id) and there is only one AES key per ONT/ONU. Also for higher security, ONT/ONU must support run-time regeneration of the AES key and encryption using the new key, while carrying the live traffic.

Note: The above mentioned security capabilities shall be supported by ONT/ONU.

7. ONT Ethernet port shall be configurable to accept the following frames.

i. Customer VLAN tagged frames

ii. Priority tagged frames

iii. Untagged frames

iv. 802.1p mode.

8. ONU shall support DHCP relay agent. ONU shall support DHCP option 82 for DHCP-based broadband access.

9. There shall be support for RS (255,239) FEC with operator enable/disable capability in both upstream and downstream directions.

10. Line testing

In FTTC/FTTCab and FTTB architectures, the ONU shall allow pre-qualification testing of the 2-wire line from the central location through software. The output of the pre-qualification testing shall at least be the maximum downstream and upstream bit rate possible over the line.

11. Local management port

There shall be provision for a local management port at Ethernet interface for local trouble-shooting. This requirement is applicable for ONU only.

3.3.2 ' Triple-play' related requirements for ONU

a. Channel zapping time

The GR envisages distributed channel-change activation at ONU by means of IGMPv2/3 messages. The GR assumes an average 6 seconds time between channel-swapping by a user as a design measure. To achieve the same, the ONU shall be able to scale upto @N*10 swaps/minute (where N = No. of users at ONU). Besides it shall keep the time taken for the multicast join low enough to enable the customer to perceive a channel change time of less than a second.

b. Channel-change activation

Channel change decision shall be taken at ONU to achieve the targets as at sub-clause a) above. Further, ONU shall support two stage of multicasting for Broadcast TV. Normally, the ONU shall be downloading a group of channels commonly seen in the served-area. Other ' niche' channels shall be available in Metro Core. For a ' niche' channel, ONU shall send an IGMP join to OLT, if demanded by at least one user.

c. DHCP option 82 (IETF RFC 3046)

For DHCP based access for entertainment & gaming services, the ONU shall support DHCP option 82 for line identification.

3.4 Functional & technical requirements of OLT:

a. Hardware capability

i. Number of PON interfaces in a chassis:

An OLT shall support PON/IF cards, network side interface cards, switch-fabric cards and controller cards.

ii. Number of PON interfaces supported per shelf (sub-rack):

The OLT shall support 32 PON interfaces per shelf (sub-rack) or more.

iii. Number of interfaces towards the Core network:

iv. An OLT shall have the provision to terminate the following interfaces:

A minimum of 2 x GigE and 2 x 10GE LAN interfaces per shelf shall be supported towards the core network. The purchaser may demand upto 4 nos. of GigE and 4 nos. of 10GE LAN interfaces towards the Core network.

b. Functional and architectural requirements

OLT shall transparently support SIP/H.248 signaling. External SIP/H.248 → Media gateway can be used for connectivity to PSTN switches.

Protection requirements

i. The fibre protection scheme at the individual PON line card granularity shall be optional to purchaser requirements.

ii. 1+1 redundancy is required for uplink card, SW fabric card and also the system controller card. In case the system controller card failure does not affect the traffic, 1+1 redundancy for this card is not required.

iii. The two ports shall reside on two different cards in case of 1+1 redundancy for uplink port.

c. Features and capabilities.

i. The OLT shall have local status monitoring.
ii. The OLT shall supports LED status indication per OLT port.
iii. **Power**: Indicates power on/off status.
iv. **Fail:** Indicates internal device failure status
v. **Alarm:** Indicate alarm status.
vi. OLT shall support the following PON link diagnostics measurement:
    I. Measurement of received optical power per ONT
    II. BER measurement per ONT/ONU (applicable in case of E1 interfaces only).

d. Dynamic Bandwidth Allocation (DBA).

i. Maximum bandwidth limiting
ii. Minimum guaranteed bandwidth
iii. Two or more level (preferred four) classes of classification
iv. Piggy-back DBRu report mode 0
v. Idle GEM DBA
vi. Concurrent support of idle GEM and piggy-back DBRu mode 0 support
vii. T-CONT Type 1 to Type 4.

e. Layer 2 management and QoS support

i. Switch fabric in OLT shall be able to handle full wired speed throughputs.
ii. MAC learning shall be supported at OLT
iii. Port-id-based VLAN shall be supported at OLT
iv. VLAN stacking towards the network at the OLT shall be supported

f. Support for MAC address limiting.

i. The operator shall be able to set the maximum number of MAC addresses from an ONT UNI through OLT. The number shall be operator programmable. When MAC address limit is reached, subsequent MAC addresses from that specific ONT UNI will not be learned.

g. **Supports learning and aging time configuration at OLT.**

The operator shall be able to enable/disable MAC address learning function and configure the MAC learning aging time.

i. VLAN and Port-id mapping:

ii. The OLT shall have a function to store the corresponding relationship of user ID, VLAN tag value and port-id number.

h. **VLAN function.**

The 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.

i. **Filtering functions at OLT.**

i. Filtering by destination MAC address and protocol type
ii. Filtering by destination MAC address
iii. Filtering by source MAC address
iv. Filtering of 802.1x packets (optional, If required by purchaser)
v. Support of ONU Ethernet port authentication

j. **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 OLT chassis should be able to configure up to 4094 (1-4094) VLAN. VLAN 0 and 4095 are reserved and not used in the OLT system.
v. The database of learning should be based on IVL (Independent VLAN Learning)
vi. Support of RSTP
vii. Support of IGMP proxy
viii. 802.1x port based security (If required by purchaser)
ix. DHCP relay and relay agent with option 82 for RADIUS authentication

k. **Security**:

i. >100 ACL support (based on switch port, MAC address, Ether-type)
ii. DOS prevention, SSH v1/2 for CLI

l. **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 OLT.

Note: Number of GEM Port-Id/Alloc.-Id per ONT/ONU to be supported by GPON link shall be communicated by purchaser.

4.0 Network requirements

4.1 Passive optical network

a. The transmission methodology should be bidirectional by the use of wavelength division multiplexing (WDM) technique on a single 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 1260-1360nm shall be used for upstream. There shall be option to purchaser for use of 1550nm for overlay RF video applications.

d 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.

4.1.1 Optical splitter specifications

Passive optical splitter bank must include 1xN, 2xN (with 1 & 2 representing number of input ports and ' N' several output ports). The fibre types used in the manufacturing of Passive Optical Splitter, connectors shall be compliant with ITU-T Rec. G.652. The overall lowest possible maximum insertion loss (dB) for a splitter to be taken from generic requirements for optical splitter for passive optical network technology NO. TEC/GR/TX/OPT-001/01/APR-12)

a) 1xN Symmetrical splitter, 2xN Symmetrical splitter & Connector and adaptor specifications - optical specifications, refer generic

requirements for optical splitter for passive optical network technology NO. TEC/GR/TX/OPT-001/01/APR-12)

4.1.2 Optical WDM coupler specifications

Table 4.1.

S. No.	Parameters	Minimum	Maximum	Unit	Remarks
1	Video band	1539	1565	nm	Lambda 3
2	Data bands	1260 1480	1360 1500	nm nm	Lambda 1 Lambda 2
3	Data isolation	20		db	Port 3-1, worst point over data bands
4	Video isolation	20		db	Port 3-2/port 3-1 Port to port excluding connector loss
5	Insertion loss		1.0	db	Port 3-2/port 3-1 Port to port excluding connector loss
6	Insertion loss		0.8	db	Port 3-2/port 3-1 Port to port excluding connector loss
7	PMD		0.1	ps	All ports over data and video bands
8	PMD		0.1	ps	All ports over data and video bands
9	CD	-1	1	ps/nm	All ports over data and video bands
10	Input power		24	dbm	All ports over data and video bands
11	Directivity	55		db	All ports over data and video bands
12	Return Loss	55		db	All ports over data and video bands

4.1.3 Ethernet user interfaces at SNI of OLT: Specifications

The following Ethernet interface options shall be supported. Actual interface type shall be communicated by purchaser. In the case of p2p application, the SNI interface of the OLT may be GbE as mentioned below and the purchaser shall indicate the exact interface requirement.

i. 1000BaseSX (50µ multi-mode) interface
ii. 1000BaseLX (10µ single-mode @1310nm) interface
iii. 1000Base ZX (10µ single-mode @ 1550) interfaces.

iv. 10GBase LAN interface as per IEEE 802.3ae.

The specifications for these interfaces shall comply with TEC GR No.: GR/EMC-01/01.JUN.2006 on Ethernet Media Converter. The different GbE interfaces and 10GBaseLAN interfaces may be implemented through the use of SFP and XFP/SFP+ respectively.

5.0 Configuration schemes

From the viewpoint of administration of the access network, the protection architecture of GPON 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 following configuration schemes are given as examples for implementation of various protection mechanisms in GPON network such as unprotected, partially protected and fully protected. These protection schemes shall be optional to purchaser' s requirements.

Type B(Duplex GPON system: OLT-only duplex system): The second configuration (Figure 5b) 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.

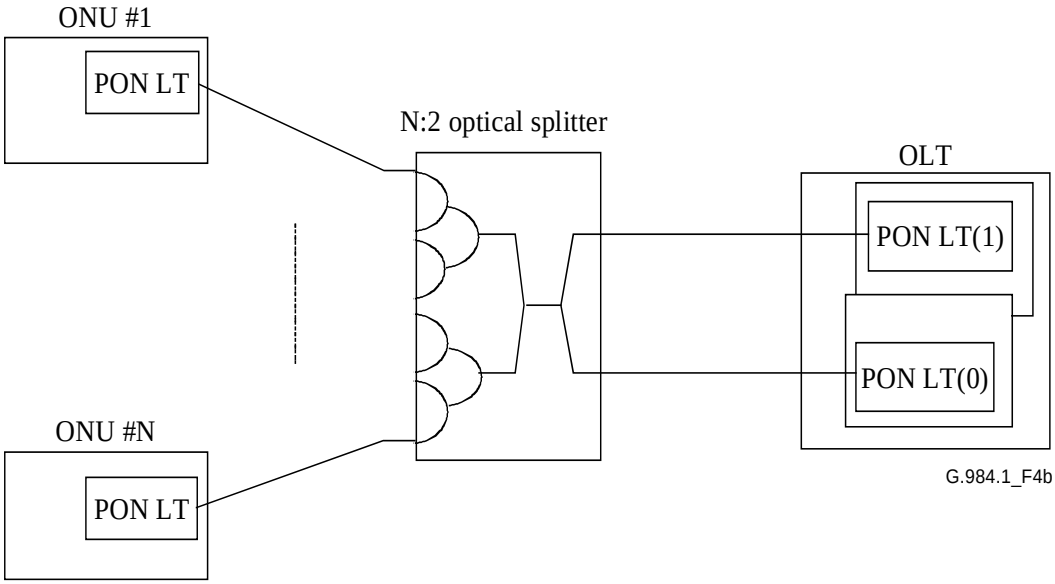


Figure 5b/G.984.1 – Duplex GPON system: OLT-only duplex system

Type C(Duplex GPON system: Full duplex system): The third configuration (Figure 5c) 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.

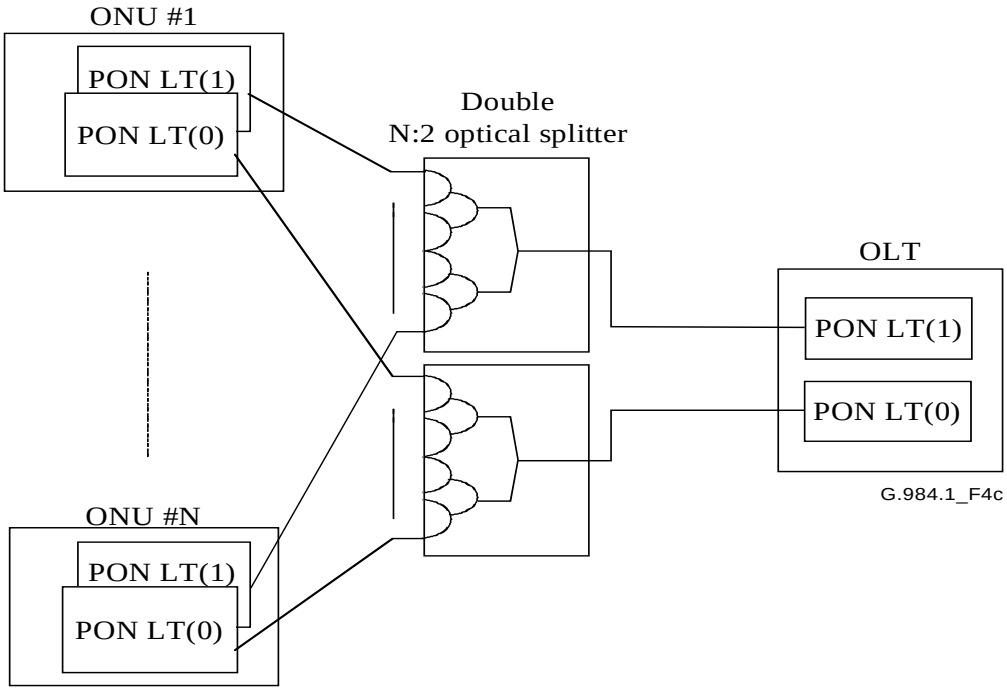


Figure 5c/G.984.1 – Duplex GPON system: Full duplex system

5.1 **Protection on the OLT SNI section**

There shall be support of multiple Ethernet service network interfaces (SNI) from each OLT. For redundancy, the OLT shall support IEEE 802.3ad Ethernet link aggregation and RSTP as per IEEE 802.1w on those interfaces.

5.2 **Possible switching types for PON protection**

In case the purchaser asks for protection in the PON section as detailed in Clause 5.0 (Type-C/D), the following two types of protection switching shall be made available both of which are analogous to those of SDH systems:

i) Automatic switching and

ii) Forced switching.

The first one 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. The second one is activated by administrative events, such as fibre rerouting, fibre replacement, etc. Both types should be possible in the GPON 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.

6.0 Equipment redundancy

The equipment shall provide complete redundancy for:

1. **Control/Processor**

If the Control/Processor unit failure does not affect the working traffic, no redundancy of Control/Processor unit shall be required.

However, if the Control/Processor unit failure does result in traffic failure , then (1+1) hot-standby mode redundancy of Control/Processor shall be provided in the equipment. Immediate upon insertion of a healthy card, the system shall revert to its pre-failure NMS/EMS configuration.

Note. The performance data as envisaged above shall be ensured all clients at UNI/SNI.

2. **Switch/Matrix**

There shall be provision for a parallel hot-standby MAC switch fabric at OLT to take-over traffic during failure of the working card.

The switching-over time from working switch matrix card to standby card shall be completed within 50 ms.

3. **Power supply**

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

Further, there shall be provision for dual-feed arrangement to the chassis power-supply, such that in case of failure of one feed, the system shall be able to function in a healthy manner without traffic interruption.

* The changeover for all redundancy actions shall be completed with in 50ms.

7.0 Performance requirements

The equipment shall be tested for error performance as follows.

In laboratory: 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. IETF RFC 2544 conformance/performance shall be tested for end-to-end Ethernet service.

In field: 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. IETF RFC 2544 conformance/performance shall be tested for end-to-end Ethernet service.

8.0 Synchronization requirements

When OLT and ONU are in their normal operating state, the downstream bit-rate shall be traceable to stratum-1 clock (PRC). When OLT is in free-running mode, the accuracy of downstream signal shall be that of a stratum-4 clock ($3.2x10^{-5}$).

8.1 Synchronization reference

The synchronization timing reference shall be an external timing reference source at 2048 KHz.

8.1.1. Frequency accuracy, hold-over mode accuracy, clock bandwidth and frequency pull-in and pull-out range shall be as per ITU-T Rec. G.984.x series of Recommendations.

8.2 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.

9.0 Maintenance, performance monitoring & supervisory signals

The maintenance signals philosophy shall be as per ITU-T Rec. G.984.x.

9.1 Alarms

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

10.0 Mechanical standards

a. As the ONT is located in customer premises, it should be designed to support wall-mounting - installation.

b. The OLT equipment shall be housed in the standard 19'' racks, 600 mm rack or slim rack with a maximum height of 2750 mm. The ETSI racks shall also be accepted. No mini rack shall be accepted, however **purchaser may specify specific requirements.** The sub-rack shall be fitted with mother-board duly masked to avoid short-circuiting. The PCB' s back and forth movement shall be very smooth without any significant sideways play.

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

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

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

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

g. No side-way opening of the rack shall be allowed.

11.0 Minimum equipment required for Type Approval

Fully loaded pre-wired equipment for specific ' category/type' with input and output ports as specified in this GR shall be offered during the Type Approval testing. EMS and LCT (with minimum configuration of PC/laptop as per GR on " Element Management System" No. TEC/SD/IT/EMT-

001/01/MAR 2016) shall also be offered. All test jigs, test instruments etc., shall be arranged by the manufacturer.

ONT/ONU*	: 4 nos.
OLT	: 1 no.
EMS	: 1 no.
LCT	: 1 no.

***Note: (i)** GPON working with ONT shall be demonstrated during technology testing/Type approval testing.

ii) GPON working with ONU shall also be demonstrated during technology testing/Type approval testing.

11.1 During **Lab test**, split ratio of 1:32 and 2:32 with 20Km fibre length to be used. Support of splitter with highest split ratio of 1:64, 2:64,1:128, 2:128 to be verified in lab.

12.0 Field Trial Testing:

During **field trial**, the equipment shall be subjected to field trial for a minimum period of 4 weeks with working traffic. The equipment shall be loaded with maximum possible live-traffic & the balance may be loaded with simulated traffic to assess the performance of the equipment. The manufacturer/supplier shall ensure that the equipment meets the field requirements of the purchaser. During field trial, the testing shall be done on full system (OLT, ONU/ONT, EMC/LCT along with splitter of any configuration upto 1:32 and 2:32) deployed/ to be deployed in field.

CHAPTER 2 – General Requirements

1.0 Reference documents

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

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

1.3 All references to TEC GRs & 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/NMS.

b) Multiple fans are there in one tray with [n+1] hot-standby redundancy.

c) Fans are DC operated.

d) MTBF is better than 80,000 hours.

2.6 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: QM-333 - " Specification for environmental testing of electronic equipment for transmission and switching use" .

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

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 support Dual stack IP addresses (IPv4 & IPv6).

3.3 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.

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

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

3.6 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.

4.0 Quality requirements

4.1 The manufacturer shall furnish the MTBF/MTTR values. The calculations shall be based on the guidelines as in BSNL-QA document: QM-115 - " Reliability Methods and Predictions" .

4.2 The equipment shall be manufactured in accordance with international quality standards to meet the quality requirement of BSNL-QA wing. A quality plan describing the quality assurance system followed by the manufacturer would be required to be submitted to BSNL-QA.

4.3 The equipment shall conform to the requirements for environment as specified in QM-333 - " Specification for environmental testing of electronic equipment for transmission and switching use" . The applicable tests shall be conducted for respective environmental categories as follows:

Environmental requirements for various GPON constituents.

a. ONU/ONT/OLT

Environmental requirements for various ONUs shall be as follows:

i. Type 1. Home-ONT (H-ONT) for FTTH applications:
   - ✓ QM-333 ' B2' category

ii. Type 2. Cabinet/Curb-ONU (C-ONU) for FTTCab/FTTC applications:
   - ✓ QM-333 ' D' category

iii. Type 3. MDU-ONU (M-ONU) for FTTB applications in MDU:
   - ✓ QM-333 ' B2' category

iv. Type 4. Business-ONT (B-ONT) for FTTH applications:
   - ✓ QM-333 ' B2' category

v. Type 5: Cell- Site backhauling (M-ONT) for FTTM applications.
   - ✓ QM-333 ' B2' category

vi. Type 6: Optical-ONT (O-ONT) for FTTH applications.
   - ✓ QM-333 ' B2' category

vii. OLT shall provide compliance to QM-333 ' B2' category. Purchaser may specify the requirement of OLT to comply to QM-333 ' A' category, if required.

b. 1xN symmetrical splitters

i. At Cabinet: QM-333 ' D' category.
ii. At MDU/MTU: QM-333 ' B2' category
iii. At Central/Remote Office: QM-333 ' B2' category.

c. 2xN symmetrical splitters

i. At Cabinet: QM-333 ' D' category.
ii. At MDU/MTU: QM-333 ' B2' category
iii. At Central/Remote Office: QM-333 ' B2' category.

d. Connectors

i. At Cabinet: QM-333 ‘ D’ category.

ii. At MDU/MTU: QM-333 ‘ B2’ category

iii. At Central/Remote Office: QM-333 ‘ B2’ category.

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 Suitable potential-free contacts (preferably)/or any other suitable method shall be provided for extension of audio/visual alarms.

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

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

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

5.8 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 GPON constituents:

a. Powering requirements: ONT

The primary power source shall be 160-270Vac, 50±2Hz for the following:

I. **Type 1.** Home-ONT **(H-ONT)** for FTTH applications.

II. **Type 4.** Business-ONT **(B-ONT)** for FTTH applications.

III. **Type 3.** MDU-ONU **(M-ONU)** for FTTB applications in MDU.

IV. **Type 2.** Cabinet/Curb-ONU **(C-ONU)** for FTTCab/FTTC applications:

V. **Type 5:** Cell- Site backhauling (M-ONT) for FTTM applications.

VI. **Type 6:** Optical-ONT (O-ONT) for FTTH applications

The ONT 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 conversion shall be provided. The adaptor can be either internal or external to the device.

ii. The power rating shall be clearly marked on the device.

iii. The power backup requirement for ONT is left to the purchaser' s discretion.

b. Powering requirements: Cabinet/Curb ONU (C-ONU) at Remote Office

The nominal power supply shall be – 48V DC with a variation in the range from -40V to -60V for R-ONU for FTTCab applications (when installed at Remote Office e.g. DLC/RSU/RLU locations). 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 power consumption shall be minimal. The actual power rating/ consumption to be furnished by the manufacturer on the equipment.

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

c. Powering requirements: Cabinet/Curb ONU (C-ONU) at Curb (installed at street-cabinets etc.)

The primary power source shall be 160-270Vac, 50+/-5Hz for this case. The ONU 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 conversion shall be provided. The adaptor can be external or internal to the device.

ii. The power rating shall be clearly marked on the device.

iii. The power backup requirement for R-ONU is left to the purchaser' s discretion.

iv. The ONU shall provide external 4-6 hours battery backup (to be specified by purchaser for the exact backup duration) to withstand commercial power outages. This assumes 0.5 average traffic in erlangs for POTS and 4-6 hours average usage time for 10/100/1000Base interface with 30% activity factor.

v. The battery shall have a minimum life of 2 years. The replacement of the battery shall not cause any service interruption. The backup system should have a low voltage cut-off at battery voltage below 10.5V to prevent overdraw.

vi. The system shall be equipped to test, monitor and report (through EMS and LCT) the following:

A. Battery present or not (assessed by voltage of the battery)

B. Battery useful or not (assessed by a short periodic discharge/charge test)

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

d. Powering requirements: OLT and related equipment in CO

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 system shall be provided with at least two power feeds – centralized power supply or distributed on-board power supply as follows:

A. Centralized power supply with 1+1 redundancy, and

B. Distributed on-board power supply

C. under voltage (-42V) alarm and over voltage(-56V) alarm to EMS

7.0 Accessories

7.0 The supplier shall provide complete set of:

i. 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 GR

ii. Software and the arrangement to load the software at site.

Note. The quantity shall be as ordered by purchaser.

iii. 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.

8.0 Documentation

Technical literature in English language only shall be accepted.

A. Installation spares, 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.

B. 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.

9.0 Optical safety requirements

The equipment shall meet the optical safety requirement as per IEC-60825-1 and 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.

If an RF video-overlay is used, there shall be additional safety requirements on the optical transmitters as these are high-power devices, in the range of +17dBm to +20dBm (in comparison, OLT and ONT max TX level is +4dBm).

9.1 Optical access port

The optical access ports should be designed to protect themselves against the entry of dust when they are not occupied by an external fibre-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.

9.2 **Equipment safety requirements**

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

ii. All switches/controls on front panel shall have suitable safeguards against accidental operations.

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

10.0 Operating personnel safety requirements

10.1 The equipment shall conform to IS 13252 part 1:(2010) " information technology Equipment Safety Part 1: General Requirements {equivalent to IEC 60950-1 (2005)} " information technology Equipment-Safety" Part 1: General Requirements and IS 10437(1986) " Safety requirements for radio transmitting equipments" equivalent to IEC 60215.

10.2 The instrument shall conform to the relevant clauses of the document No. IEC 61010-1(2001) with corrigendum-1(2002) and corrigendum-2 (2003) - " Safety Requirements for Electrical Equipment for Measurement, Control and laboratory use".

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

11.0 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 a test agency.

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

Name of EMC Standard: " As per CISPR 22 (2008) - Limits and methods of measurement of radio disturbance characteristics of Information Technology Equipment" for the following

Limits:-

i. To comply with **Class A** of CISPR 22 (2008).

ii. The values of limits shall be as per TEC Standard No. TEC/SD/DD/EMC-221/05/OCT-16.

iii. For Radiated Emission tests, limits below 1 GHz shall be as per Table 4 (a) or 5 (a) for measuring distance of 10m **OR** Table 4 (a1) or 5 (a1) for measuring distance of 3m.

OR

Conducted and radiated emission (applicable to instruments such as power meter, frequency counter etc.):

Name of EMC Standard: "As per CISPR 11 {2015} - Industrial, scientific and medical (ISM) radio- frequency equipment -Electromagnetic disturbance characteristics- Limits and methods of measurement" for the following

Limits :-

i. To comply with the category of Group 1 of Class A of CISPR 11 {2015}

ii. The values of limits shall be as per clause No. 8.5.2 of TEC Standard No. TEC/SD/DD/EMC-221/05/OCT-16.

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;

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.

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;

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) 4.0 kV peak open circuit voltage for line to ground coupling

(d) 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) 4.0 kV peak open circuit voltage for line to ground

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

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.

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.

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/SD/DD/EMC-221/05/OCT-16 and the references mentioned therein unless otherwise specified specifically. Alternatively, corresponding relevant Euro Norms of the above IEC/CISPR standards are also acceptable subject to the condition that frequency range and test level are met as per above mentioned sub clauses (a) to (g). 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

CHAPTER 3

Element Management System Requirements

Part-I:

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).

i. The management system shall comply with the latest ITU G.984.x series Recommendations on GPON.

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

iii. The management menu selections should include the following functionality:

a. Alarm Monitoring
b. Customized functions (To be mentioned by the purchaser)
c. Remote view on ONT/ONU
d. PON Management
e. IP Management
f. Alarm Management
g. Equipment Management
h. Log Management
i. Loopback Management
j. Operational State
k. Profile Management
l. Performance Monitoring
m. User Security

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

LCT and EMS terminal shall be able to display:

a. All alarms and messages of the entire network
b. Color coded graphical fault display.

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

d. 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.

v. The EMS shall provide:

a. Security management (EMS security control, and management privilege control)

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

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

vi. It should be possible to generate 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.

vii. 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.

viii. 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.

ix. 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 shall be provided.

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

xi. 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.

xii. 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.

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

xiv. 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.

xv. 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.

xvi. Messaging system

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

xvii. It is recommended that the response time for query/command on any operator terminal, local or remote shall be 10 seconds or better.

xviii. 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).

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

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

xxi. Installation & commissioning of the EMS shall include supply & installation of cables, distribution frames, electrical switches etc.

xxii. The purchaser shall validate all the components of EMS and features of EMS. All the instruments necessary for carrying out validation test shall be arranged by supplier.

xxiii. The hot-swapping of a card/unit shall not affect working of any other tributaries. Hot-swapping capability shall be provided for all cards/units including standby power supplies. No EMS notification or system setting shall be required for extraction or insertion of any unit/card.

xxiv. The power-supply failure/EMS server break-down/bugs in the software shall not affect the current tributary-connection map. The removal/replacement of any unit shall also not affect the existing connection-map. No reconfiguration shall be called for against this action.

2.0. EMS architecture & server hardware specifications

2.1 Architecture

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

ii. In case of loss of EMS connectivity, the LCT privilege shall remain for monitoring and for local configurations, as privileged by EMS administrator.

iii. The centralized EMS may consist of standalone application server and database 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.

iv. LCT connectivity to EMS for privileged operation shall be through a log-in password.

v. 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.

2.2 Scalability aspects

i. The EMS should be able to support at least 500 OLTs. The EMS application shall also be scaleable to 10000 ONT/ONUs. Any more requirements may be communicated by 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 Pentium IV with 80GB HDD, 17" video display, Ethernet interface (10/100M) with industry standard operating system UNIX/Linux/Windows but having GUI.

iv. The EMS shall provide SNMPv2 (or later), TL1 options for southbound interfaces. The options for northbound interface shall be SOAP, XML, SNMP or CORBA.

2.3 EMS server specifications

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

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.

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

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, 1000BaseT. The operating system shall be Windows 7/8/10, Linux or Unix. The specifications are given in clause 2.7 of chapter 3(Part-I).

2.4 Application server specifications

The EMS application server shall be multi-processor with minimum 4 processor with each processor having at least 8cores,RISC based 64 bit system with at least 1.9GHz clock, 16 GB RAM, 512KB cache memory, 160GB HDD with CD-ROM/DVD-ROM, Ethernet LAN interfaces floppy drive, and shall operate in high availability cluster mode. Exact specifications may be issued by purchaser.

2.5 Database server specifications

The database server shall be multi-processor based each with 4 processors each cores having at least 8 cores, RISC based 64 bit system with at least 1.9 GHz clock, 64 GB RAM and one GB Cache memory. However, the purchaser may choose single server as per network needs. The system disc shall be minimum 500GB with OS and RDBMS mirroring 20/40 GB DAT drives shall be provided as back up devices. The system shall support at least 6X DVD for loading of software and configuration. The system shall have Hard-disk storage implemented on RAID 0, RAID 1, RAID 0+1 and RAID 5 architecture of Disk Storage which shall be site 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.

i. 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.

ii. 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.

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

iv. The database interface shall be open so that a centralized NMS 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.

v. The memory of the Database server shall be sufficient to store the data of 500 full loaded OLTs and 10000 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.

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.: GR/FWS-01. 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.

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. Pentium IV 2 GHz and above
ii. 17" colour monitor (for PC) and LCD/TFT display (for Laptop)
iii. 500GB/4GB RAM
iv. 48X DVD/CD drive
v. 10/100/1000 Ethernet LAN port
vi. Inbuilt V.90 modem (If required by purchaser)
vii. 2 nos. USB ports
viii. Printer port
ix. Mouse port
x. PS-2 Keyboard port
xi. Licensed operating software preloaded/recovery CDs.

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

Note1. No QM-333 environmental tests shall be conducted on the EMS server/LCT PC.

Note 2. Actual server sizing defined should be left to purchasers requirements.

CHAPTER 3

FCAPS requirements for GPON System

Part II

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 ITU-T Rec. G.984.x series for GPON. 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:

i. Configuration management
ii. Fault management
iii. Performance management
iv. Security management
v. Software management
vi. Inventory management.

1.1.1 Configuration management

The equipment EMS shall support configuration and provisioning capabilities as per ITU-T Recs. G.984x series. 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:

i. Network Element creation in the NE management domain.
ii. Programming of a multiple interface units.
iii. Assigning the equipment protection to a unit/interface.
iv. Error detection thresholds.
v. Network Element configuration.
vi. Software download (local & remote).
vii. Protection switching.
viii. Ethernet interface bandwidth.
ix. The layer-2 control protocol between ONU/ONT and OLT shall be Ethernet over GEM. TDM support shall be provided through TDM over Packet (TDMoP) option. The same shall be configurable through EMS/LCT. Such TDMoP support shall be relevant to E1 lines.

1.1.2 Fault management

The equipment management system shall support ' Fault management functions' as described in the ITU-T Rec. G.984.x series. The EMS Network Element shall perform a persistency check on the fault-cause, before it declares a fault causing failure. The time taken to declare the fault shall be as per ITU-T Rec. G.984.x series. Each failure and clearance, thereof, shall be time-stamped. The atomic functions associated with the failure shall be as per ITU-T Rec. G.984.x series.

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:

i. Path alarm notification to be generated and recorded, the alarm notification shall include: type, occurrence, severity, probable cause and clearing.
ii. Path alarm shall be graphically shown by the EMS/LCT.
iii. Alarm and status display.
iv. Fault localization.

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

vi. 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.

vii. FCS errors for Ethernet clients.

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

1.1.3 Performance management

The equipment shall support the ' Performance Management' functions in accordance with ITU-T Rec. G.984.x. 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:

i. Configuration of threshold concerning the error counters.

ii. FCS error check for Ethernet clients

iii. Frame/Packets dropped in case of Ethernet frames

iv. Configuration of threshold concerning the error counters

v. **Performance history (data logging).**

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 -

vi. The collection of the performance counters shall be performed at pre-assigned rate as per ITU-T Rec. G.984.x.

vii. 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:

i. 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.

ii. 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.

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

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

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

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

vi. 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.

vii. 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.

viii. Back up for programs and data.

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

x. **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

i. 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.

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

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

iv. 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.

v. 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.

i. Loading of new system software.

ii. Manage different versions of software.

iii. 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.

iv. Installation of software patches.

v. 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.

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

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

viii. 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.

ix. 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.).

1.1.7 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:

a. Protocol details at all layers of TCP/IP stack.
b. PHY I/F at each layer.
c. Database structures.
d. Number formats.
e. Node addressing system.

f. Complete application software details etc.

g. 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 Element as conforming to ITU-T Rec. G.984.x.

The system shall provide an SNMP version2c [or later interface] with standard MIBs Browzer. It shall be implemented on UDP/IP stack. 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 either TL1, SNMP, TMF 814 CORBA [version 3.0] or XML. And the southbound interface towards NEs shall be SNMPv2c [or later interface] implemented on UDP/IP stack or XML/SOAP. 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 with in 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.**

ONT/ONU requirements.

1.2.1 ONUs and ONTs shall perform following tests/monitor relative to the battery to be reported through EMS and LCT:

a. Battery present or not (assessed by voltage of the battery)
b. Low capacity (means going to shutdown soon).

1.2.2 **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.

1.2.3 **ONT 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 1522 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? Can also be defined as ONT sees off-hook signal from one phone.
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
xvi. Speed. Indicates 10/100/1000M speed selection (as applicable)

The system shall support OMCI as per ITU-T Rec. G.984x GPON standard for all OAM features between ONT/ONU and OLT for interoperability.

1.3. **OLT requirements.**

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

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

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

d. The OLT shall support alarm output and control

   i. Critical alarm output

   ii. Major alarm output

   iii. Minor alarm output

e. Line rate, security, and performance requirements

f. The PON system shall support 2.488Gbps line-rate downstream and 1.244Gbps line-rate upstream.

g. AES (key size of 128 bit) support per port-id with operator disable/enable capability

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

i. Network diagnostic and healthy check:

j. 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.

CHAPTER 4

GPON Service Support

I.1 Examples of services

The examples of services that GPON may support are shown in Table I.1, along with relevant remarks.

Table I.1/G.984.1 – Examples of services and related remarks

Service category (Note 1)	**Service**	**Remarks**
Data service	Ethernet (Note 2)	Standardized in IEEE 802.3. Comply with IEEE 802.1D.
PSTN	POTS	Mean signal transfer delay time between T-V (or (a)-V) should be less than 1.5 ms. If echo cancellation is used in the network, the mean signal transfer delay time between T-V (or (a)-V) on the PON-based system may be longer, provided End-to-End transfer delay requirements are met. Synchronize with the network's 8 kHz clock. Signal on the T reference point and V reference point must be continuous.
Private Line	E1 (Optional)	Bearer rate is 2.048 Mbit/s.
Video	Digital video	Deliver with same quality as class.1 specified in ITU-T I.356 or rt-VBR/CBR specified in ATM-Forum.
NOTE 1 – Service category is merely an index. It is not meaningful in itself, but it is useful in visualizing the services. NOTE 2 – Ethernet service is mainly to transmit the data such as IP, which includes VoIP, video streams coded by MPEG-2 or MPEG-4, and so on.		

I.2 Examples of UNI

In this Chapter, UNI is defined as the interface that includes the following conditions:

a. described by a well-known standard

b. includes a physical layer aspect.

Some UNIs are provided via an AF, so it is not mandatory that the ONU/ONT support those interfaces.

Examples of UNIs, physical interfaces and services that they provide are shown in Table I.2.

Table I.2/G.984.1 – Examples of UNI and services

UNI (Note 1)	Physical interface (Note 2)	Service (Note 3)
10 BASE-T (IEEE802.3)	–	Ethernet
100BASE-TX (IEEE802.3)	–	Ethernet
1000BASE-T (IEEE802.3)	–	Ethernet
ITU-T Rec. G.703	PDH	E1
	-	POTS
ITU-T Rec. G993.2	-	VDSL2
Note-1: There are many other services accommodated in GPON, but those services do not have specified UNIs. Note-2: Each item in the "Physical Interface" column is illustrated by the corresponding entry in the "UNI" column. Note-3: The column labelled "Service" shows which services can be supported by the physical interface.		

I.3 Examples of SNI

In this Chapter, SNI is defined as the interface that includes the following conditions:

a. described by a well-known standard;
b. includes a physical layer aspect.

Examples of SNIs, physical interfaces and services that they provide are shown in Table I.3.

Table I.3/G.984.1 – Examples of SNI and services

SNI (Note 1)	Physical interface (Note 2)	Service (Note 3)
1000BASE- X (IEEE802.3)	–	Ethernet
10GE LAN (802.1ae)	-	Ethernet

NOTE 1 – There are many other services accommodated in GPON, but those services do not have specified SNIs. NOTE 2 – Each item in the "Physical Interface" column is illustrated by the corresponding entry in the "SNI" column. NOTE 3 – The column labelled "Service" shows which services can be supported by the physical interface.

I.4 QoS details for GPON.

a. **Peak Information Rate (PIR).** PIR is the rate of the maximum transmitting bytes of GEM packets. Its unit is " Bytes/s" . This parameter is analogous to Peak Cell Rate in ATM.

b. **Sustained Information Rate (SIR).** SIR is the rate of committed transmitting bytes of GEM packets on the long-term range. Its unit is " Bytes/s" . This parameter is analogous to Sustained Cell Rate (SCR) in ATM.

Per customer, per application CIR/EIR/CIR+EIR policing on all interfaces for packet data

i. per UNI port basis
ii. per UNI port + per customer VLAN
iii. per UNI port + 802.1p bits (If required by purchaser)
iv. per UNI port + per customer VLAN + 802.1p bits.

c. There shall be per-customer service queuing, scheduling, accounting and filtering.

d. There shall be classification of high-speed Internet (HSI) based on source network address or IEEE 802.1p marking that shall allow QoS information to be propagated to upstream or downstream nodes.

e. The ONU nodes shall be capable of scheduling and queuing functions on per-service, per-subscriber basis, in addition to performing packet classification and filtering based on layer 2 fields.

f. Each subscriber interface shall provide at least three dedicated queues. In addition to per-service rate limiting for HSI services, each subscriber' s traffic can be rate-limited as an aggregate using a " bundled" service policy. This shall allow different subscribers to receive different service levels independently and simultaneously. It shall also be necessary for the combined bandwidth of all the services to be scheduled to an overall rate limit to allow multicast traffic to be delivered to subscribers further downstream, and thus avoid further complex queuing and scheduling of traffic in the ONU.

g. Downstream QoS enablement

At ONU end

i. Per-subscriber queuing and PIR/CIR policing/shaping for HSI. HSI service classify on Source IP range.

ii. Per-service prioritization for VoIP and Video. VoIP prioritized over Video. Destination IP and/or DSCP classification. 802.1p marking for prioritization in the access rings and Residential Gateway (RG).

At OLT end

i. VoIP and Video queued and prioritized as per VLAN QoS policy.

ii. HSI content differentiation based on DSCP. Each queue shall have individual CIR/PIR and shaping.

iii. If required by purchaser, overall subscriber rate limiting on VLAN (H-QoS).

h. Upstream QoS enablement

At ONU end

i. Per-subscriber queuing and PIR/CIR policing/shaping for HSI.

ii. Shared queuing for prioritization of real-time traffic over HSI.

iii. Per-subscriber QoS/content classification for content differentiation.

At OLT end

iv. For VoIP and video, policy shall define priority aggregate CIR/PIR.

v. For HSI, QoS policy shall define priority and aggregate CIR/PIR. Content differentiation based on ingress classification. DSCP marked.

i. If required by purchaser OLT shall **optionally** provide DSCP marking and re-marking QoS per packet, per application based on-

i. Port of arrival
ii. TCP/UDP source/destination port
iii. Time of day
iv. Based on service/application
v. Based on MAC (SA/DA) address
vi. Based on S-VLAN tags
vii. Based on Source/Destination IP address
viii. Based on IGMP
ix. Based on ICMP
x. Based on IP-TOS/DSCP bits etc.

CHAPTER 5

Industry Best Practice for 2.488 Gbit/s downstream, 1.244 Gbit/s upstream G-PON (As per amendment 1 to ITU-T Rec. G.984.2: Physical Media Dependent (PMD) layer Specifications)

(Informative: Optional to purchaser' s requirements)

This Chapter establishes the industry best practice optical budgets for the G-PON system operating at 2.488 Gbit/s downstream, 1.244 Gbit/s upstream.

1.0 Introduction

These power budgets are optional extensions of the GR, and reflect the observed practical optimum values for this particular system. Purchaser may specify these requirements if needed.

The notable variations from the loss budgets found elsewhere in ITU-T Rec. G.984.2 include:

a. Overall loss budgets midway between Class B and C
b. Different value of optical path penalties
c. The OLT must support FEC in the downstream

These variations can provide increased capabilities for operation of G-PON systems. Therefore, the budgets contained in this Chapter are recommended over and above all others in this Recommendation for the 2.4/1.2 Gbit/s rate PON.

2.0 System Applications

There are currently two major applications for the G-PON system. The first is a full-service system with a video overlay. The second is a digital-only system without a video overlay. These two applications are diagrammed in Figure III.1.

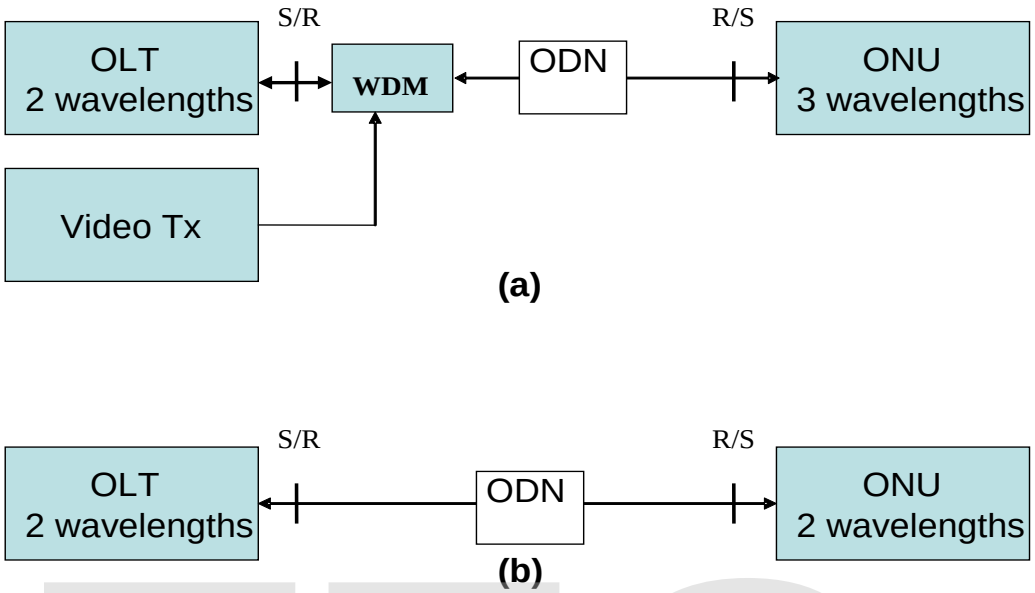


Figure III.1/G.984.2. - G-PON applications: (a) Video overlay, and (b) Digital-only.

3.0 Optical specifications

The optical specifications for the OLT and ONU optics are given in Table III.1. This table refers to power levels measured at the interface points shown in Figure III.1 (both type (a) Video Overlay and type (b) Digital-only systems); specifically, any WDM filters external to the OLT or ONU equipment are considered part of the ODN. These specifications are meant to augment similar specifications found in Table 2 in the main body of the Recommendation. All other specifications found elsewhere in the table still apply.

The ONU sensitivity can be achieved either using an APD without FEC, or a PIN with FEC. The choice is a matter of ONU implementation. The APD solution is seen as an immediately available option, while the PIN with FEC solution is a longer-term option that depends on the introduction of higher performance receiver circuitry. The OLT must support FEC in the downstream by having the capability of calculating and transmitting the

FEC parity bytes in the downstream signal. The OLT equipment must also have the ability to activate or deactivate the downstream FEC feature by operations system command. The ONU can optionally support FEC decoding in the downstream, and in any specific instance the ONU can use the FEC parity at its own discretion.

The optical penalty does not include any Raman impairment in the downstream wavelength. Any penalty due to this effect must be accounted for out of the link budget. However, in any system with appreciable Raman effect will also have a significant length of fibre. Because of the loss differential between 1490 nm and 1310 nm, it is anticipated that the Raman impairment will be compensated by the lower fibre loss at 1490 nm.

Table III.1/G.984.2 - Optical power levels for the 2.4 Gbit/s downstream, 1.2 Gbit/s upstream system

Items	Unit	Single fibre
OLT:		OLT
Mean launched power MIN	dBm	+1.5
Mean launched power MAX	dBm	+5
Minimum sensitivity	dBm	-28
Minimum overload	dBm	-8
Downstream optical penalty	dB	0.5
ONU:		ONU
Mean launched power MIN	dBm	+0.5
Mean launched power MAX	dBm	+5
Minimum sensitivity	dBm	-27
Minimum overload	dBm	-8
Upstream optical penalty	dB	0.5

4.0 Link Budget

The link budget is given in Table III.2. This budget covers all optical components between the OLT and ONU, including non-integrated WDM filters for the multiplex of video overlays and other enhancement band services, and must include any Raman impairment from the overlay signal.

Table III.2/G.984.2 - Loss Budgets for the G-PON system

Items	Unit	Single fibre
Minimum optical loss at 1490 nm	dB	13
Minimum optical loss at 1310 nm	dB	13
Maximum optical loss at 1490 nm	dB	28
Maximum optical loss at 1310 nm	dB	28

In comparison, the B-PON class B+ budgets recommended in G.983.3 amendment 2 are shown in Table III.3/G.984.2. The G-PON budget is similar to the Video Overlay system in that it supports a 13 dB minimum loss, and it is similar to the digital only budget in that it is symmetric and it supports a 28 dB maximum loss. It is theoretically possible that a PON that complies with the B-PON B+ budgets might not comply with the G-PON budget; however, such cases should be very rare in the actual deployed base of PONs. Therefore, the G-PON budget should be compatible with practically all deployed PONs.

Table III.3/G.984.2 - Loss Budgets for the B-PON G.983.3 Amdt. 2 systems

Items	Unit	Single fibre
Video Overlay system (OLT1-ONT)		
Minimum optical loss at 1490 nm	dB	9
Minimum optical loss at 1310 nm	dB	13
Maximum optical loss at 1490 nm	dB	27
Maximum optical loss at 1310 nm	dB	29
Digital-only system (OLT2-ONT)		
Minimum optical loss at 1490 nm	dB	10
Minimum optical loss at 1310 nm	dB	10
Maximum optical loss at 1490 nm	dB	28
Maximum optical loss at 1310 nm	dB	28

CHAPTER 6- Purchase Guidelines

Purchaser should specify the exact requirements against the purchaser guidelines before initiating the procurement process.

Part I: Technical Requirements

2.1.1 Provisioning In-built WiFi support as per IEEE 802.11g/n/ac
USB 2.0/3.0 Interface
ONU user interface may also have G.Fast (ITU-T rec G.9700 & G.9701) / G.hn(ITU-T rec G.9960 & G.9961) interface

2.1.3 & 4.1 Selection of splitters from m:N where m = 1 or 2 and N = 2, 4, 8, 16, 32.

2.2 Requirements of external SIP/H.248 ↔ Media gateway for interfacing PSTN switches to be indicated.

2.3 Selection of architecture which ranging from Fibre-to-the-Home (FTTH), through Fibre-to-the-Building/Curb (FTTB/FTTC) to Fibre to the Cabinet (FTTCab).

2.3.2 Requirements of IPTV and RF-broadcast modes for residential deployment to be indicated.

3.1 Selection of protection as fully-protected, partially-protected or unprotected.

3.2.1 Indicate -
- Selection of POTS

i. Provisioning of 10/100/1000BaseT Ethernet interface
ii. Provisioning of RF video interface
iii. Provisioning In-built WiFi support as per IEEE 802.11g/n/ac
iv. Dying gasp feature
v. USB 2.0/3.0 Interface

3.2.2 - Specify exact number of POTS.

- ONU user interface may also have G.Fast (ITU-T rec G.9700 & G.9701) / G.hn(ITU-T rec G.9960 & G.9961) interface.

-Dying gasp feature

-USB 2.0/3.0 Interface

3.2.3 Indicate -

- Selection of POTS

i. Provisioning of 10/100/1000BaseT Ethernet interfaces
ii. Provisioning of RF video interface
iii. Provisioning of In-built WiFi support as per IEEE 802.11g/n/ac
iv. Provisioning of VDSL2 interfaces.
v. Dying gasp feature
vi. USB 2.0/3.0 Interface

3.2.4 Indicate –

i. POTS
ii. E1 line
iii. 10/100/1000BaseT Ethernet interface
iv. RF video interfaces
v. In-built WiFi support as per IEEE 802.11g/n/ac
vi. Dying gasp feature
vii. USB 2.0/3.0 Interface

3.2.5 Indicate –

i. POTS
ii. 10/100/1000BaseT Ethernet interface
iii. In-built WiFi support as per IEEE 802.11g/n/ac
iv. Dying gasp feature
v. USB 2.0/3.0 Interface

3.2.6 Indicate –

i. POTS

ii. 10/100/1000BaseT Ethernet interface

iii. In-built WiFi support as per IEEE 802.11g/n/ac

iv. Dying gasp feature

v. USB 2.0/3.0 Interface

3.3 a. Indicate the GigE and LAN interfaces in case a higher number of them is required than the stipulated interfaces.

Note:Indicate the number of GEM Port-Id/Alloc.-Id per ONT/ONU to be supported by GPON link.

4.1.2 Indicate the requirements of GbE interfaces.

4.3. Purchaser may specify the requirement of OLT to comply to QM-333 ' A' category, if required.

5.0 Indicate the requirements of protection scheme.

8.2 Specify provision of external clock port

10.0 Specify racks

Part II: General Requirements

2.5 Indicate the use of fans.

5.9 Supply of spares by the vendor.

ABBBREVIATIONS

ACL	Access Control List
AES	Advanced Encryption Standard
ADSL	Asymmetric Digital Subscribers Line
AIS	Alarm Indication Signal
APC	Angle Polished Connector
BITE	Built-In Test Equipment
BSNL	Bharat Sanchar Nigam Limited
CATV	Cable Television
CD	Compact Disc
CISPR	Special International Committee on Radio Interference
CO	Central Office
CORBA	Common Object Request Broker Architecture
CPU	Computer Processing Unit
DBA	Dynamic Bandwidth Allocation
DBRu	Dynamic Bandwidth Report - upstream
DHCP	Dynamic Host Control Protocol
DOS	Denial of Service
DSCP	Differential services code point
DSLAM	Digital Subs Line Access Multiplexer
EEPROM	Electrically Erasable Programmable Read-Only Memory
EMC	Electro Magnetic Compatibility
EMS	Element Management System
FEC	Forward Error Correction
FTTB	Fibre To The Building
FTTC	Fibre To The Curb
FTTCab	Fibre To The Cabinet
FTTH	Fibre To The Home

FWS	Firewall Server
GEM	GPON Encapsulation Method
GPON	Gigabit capable 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 Organization
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
NE	Network Element
NMS	Network Management System
NNI	Network Node Interface
OAN	Optical Access Network
ODN	Optical Distribution Network
OLT	Optical Line Terminal
OMCI	ONT Management and Control Interface
ONU	Optical Network Unit
ONT	Optical Network Termination
OSI	Open System Interconnection

P2P	Point to Point
PBX	Private Branch Exchange
PC	Personal Computer
PCM	Pulse Code Modulation
PLOAM	physical layer operations and maintenance
PMD	Physical Media Dependent
PON	Passive Optical Network
POP	Point of presence
POTS	Plain Old Telephone System
PRC	Primary Reference Clock
PVC	Permanent Virtual Circuit
QA	Quality Assurance
QM	Quality Manual
QoS	Quality of Service
RDBMS	Relational Database Management System
RISC	Reduced Instruction Set Computer
RO	Remote Office
ROM	Read Only Memory
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
SOAP	Simple Object Access Protocol
STB	Set Top Box
TC	Transmission Convergence
T-CONT	Traffic Containers
TCP	Transmission Control Protocol

TDM	Time Division Multiplexing
TDMoP	Time Division Multiplexing over Packet
TMN	Telecommunication Management Network
UNI	User Network Interface
VDSL	Very High-speed Digital Subscriber Line
VLAN	Virtual LAN
VoIP	Voice over Internet Protocol
WiFi	Wireless Fidelity
XML	Extensible Markup Language

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

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No.TEC/FA/GR/Revision/GPON/2016-17 dated 28.06.2017

Subject: Amendment of the GR on GPON (No. TEC/GR/TX/PON-001/03.MAR 2017)

i) Clause 2.1.1: Paragraph no. 4: May be read as under:

"ONTs are deployed in Fibre to The Home (FTTH) and Fibre to The Business (FTTB) architectures, where the fibre termination shall take place at the premises. The UNI are integrated in the ONT box to provide data, voice, RF video (optional to purchaser) and WiFi interfaces (if ordered by purchaser).

ii) Clause 3.2.1: May be read as under:

"Type I: H-ONT for residential broadband service delivery.

H-ONT shall provide the following residential broadband services. Service support shall be there for voice, video &data. Purchaser shall indicate the exact requirement of each interface.

I. POTS
II. 10/100/1000 Base T Ethernet interface (to interconnect VoIP phones, STB, PC etc. through a home Ethernet Bridge)
III. RF video interface over Coaxial "F" connector (if required by purchaser)
IV. In-built Wi-Fi support as per IEEE 802.11g/n/ac in the home. **Purchaser may order Type-I H-ONT with or without Wi-Fi.**
V. Dying gasp feature (if required by purchaser)
VI. USB 2.0/3.0 interface (if required by purchaser)"

iii) Clause 1.3 j (FCAPS Requirements): May be read as under:

"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/towards the OLT."

All the other clauses of the GR remain unchanged.

--Sd--
(Abdul Kayum)
Director (FA), TEC

Copy for information to:

1. CGM, QA and Inspection Circle, Jabalpur
2. DDG(RC), New Delhi/DDG(NR), New Delhi/DDG(WR), Mumbai/DDG(ER), Kolkata /DDG(SR), Bangalore
3. Director (RKT), DoT HQ, Room No. 1004, Sanchar Bhawan, in compliance to Minutes of the meeting issued vide letter No. 05-15/2017 –Policy-1dated18.05.2017
4. Director1(C-DOT), New Delhi