INTERNATIONAL TELECOMMUNICATION UNION

ITU-T G.985

TELECOMMUNICATION
STANDARDIZATION SECTOR
OF ITU

(03/2003)

SERIES G: TRANSMISSION SYSTEMS AND MEDIA, DIGITAL SYSTEMS AND NETWORKS

Digital sections and digital line system – Optical line systems for local and access networks

100 Mbit/s point-to-point Ethernet based optical access system

ITU-T Recommendation G.985

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ITU-T Recommendation G.985

100 Mbit/s point-to-point Ethernet based optical access system

Summary

This Recommendation describes the 100 Mbit/s point-to-point Ethernet based optical access system, including ODN (optical distribution network) specification, physical layer specification and the requirements for the OAM (operation, administration and maintenance). This Recommendation is based on 1-fiber WDM bidirectional transmission system.

Source

ITU-T Recommendation G.985 was prepared by ITU-T Study Group 15 (2001-2004) and approved under the WTSA Resolution 1 procedure on 16 March 2003.

FOREWORD

The International Telecommunication Union (ITU) is the United Nations specialized agency in the field of telecommunications. The ITU Telecommunication Standardization Sector (ITU-T) is a permanent organ of ITU. ITU-T is responsible for studying technical, operating and tariff questions and issuing Recommendations on them with a view to standardizing telecommunications on a worldwide basis.

The World Telecommunication Standardization Assembly (WTSA), which meets every four years, establishes the topics for study by the ITU-T study groups which, in turn, produce Recommendations on these topics.

The approval of ITU-T Recommendations is covered by the procedure laid down in WTSA Resolution 1.

In some areas of information technology which fall within ITU-T's purview, the necessary standards are prepared on a collaborative basis with ISO and IEC.

NOTE

In this Recommendation, the expression "Administration" is used for conciseness to indicate both a telecommunication administration and a recognized operating agency.

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CONTENTS

ITU-T Recommendation G.985

100 Mbit/s point-to-point Ethernet based optical access system

1 Scope

This Recommendation describes 100 Mbit/s point-to-point Ethernet based optical access system for the optical access services including ODN (optical distribution network) specification, physical layer specification and the requirements for the OAM (operation, administration and maintenance).

For an effective use of optical fibres, this Recommendation specifies only a single fibre bi-directional transmission system, dual-fibre systems being out of the scope of this Recommendation.

2 References

The following ITU-T Recommendations and other references contain provisions which, through reference in this text, constitute provisions of this Recommendation. At the time of publication, the editions indicated were valid. All Recommendations and other references are subject to revision; users of this Recommendation are therefore encouraged to investigate the possibility of applying the most recent edition of the Recommendations and other references listed below. A list of the currently valid ITU-T Recommendations is regularly published. The reference to a document within this Recommendation does not give it, as a stand-alone document, the status of a Recommendation

[1] ITU-T Recommendation G.957 (1999), *Optical interfaces for equipments and systems relating to the synchronous digital hierarchy.*

[2] ITU-T Recommendation G.982 (1996), *Optical access networks to support services up to the ISDN primary rate or equivalent bit rates.*

[3] ITU-T Recommendation G.983.1 (1998), *Broadband optical access systems based on Passive Optical Networks (PON).*

[4] ITU-T Recommendation G.652 (2003), *Characteristics of a single-mode optical fibre cable.*

[5] IEEE Standard 802.3-2000, *Information technology – LAN/MAN – Part 3: Carrier Sense Multiple Access with Collision Detection (CSMA/CD) Access Method and Physical Layer Specifications.*

3 Definitions

This Recommendation defines the following terms:

3.1 Optical Access Network (OAN): The set of access links sharing the same network-side interfaces and supported by optical access transmission systems.

3.2 Optical Distribution Network (ODN): An ODN provides the optical transmission means from the OLT towards the users, and vice versa. It utilizes passive optical components.

3.3 Optical Line Termination (OLT): An OLT provides the network-side interface of the OAN, and is connected to the ODN.

3.4 Optical Network Termination (ONT): An ONT provides the user-side interface of the OAN, and is connected to the ODN.

3.5 Wavelength Division Multiplexing (WDM): Bidirectional multiplexing using different optical wavelength for up and downstream signals.

4 Abbreviations

This Recommendation uses the following abbreviations:

CRC Cyclic Redundancy Check

FEFI Far End Fault Indication

MII Media Independent Interface

MLM Multi-Longitudinal Mode

NRZI Non Return to Zero Inverted

OAM Operation, Administration and Maintenance

OAN Optical Access Network

ODN Optical Distribution Network

OLT Optical Line Termination

ONT Optical Network Termination

PCS Physical Coding Sub-layer

PMA Physical Medium Attachment

PMD Physical Medium Dependent

RMS Root Mean Square

RS Reconciliation Sub-layer

SLM Single Longitudinal Mode

SMF Single Mode Fibre

SNI Service Network Interface

UNI User Network Interface

UTP Unshielded Twisted Pair cable

WDM Wavelength Division Multiplexing

5 Configuration of an OAN

5.1 System configuration

Figure 1 shows the system configuration of the point-to-point Ethernet based optical access system. In this Recommendation, both UNI and SNI are Ethernet interfaces.

The two directions for optical transmission in the ODN are identified as follows:

– downstream direction for signals travelling from the OLT to the ONT;

– upstream direction for signals travelling from the ONT to the OLT.

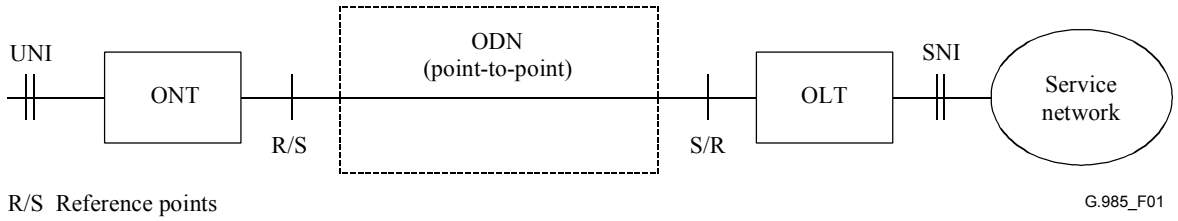

Figure 1/G.985 – System configuration

5.2 Fibre type

Single-mode fibre should be used in accordance with ITU-T Rec. G.652.

5.3 Transmission methodology

Bidirectional transmission is accomplished by use of Wavelength Division Multiplexing (WDM) technique of 1310 nm region and 1550 nm region wavelengths on a single fibre, allowing the connection to be a point-to-point type ODN.

5.4 Wavelength allocation

For downstream, the operating wavelength range should be 1260-1360 nm.

For upstream, the operating wavelength range should be 1480-1580 nm.

These wavelength ranges are compatible with ITU-T Rec. G.982 though it specifies point-to-multipoint configuration.

5.5 ODN model

The ODN provides the optical transmission medium for the physical connection between ONT and OLT.

The ODN for the point-to-point configuration consists of passive optical elements as follows:

– single-mode optical fibres and cables;
– optical fibre ribbons and ribbon cables;
– optical connectors;
– passive optical attenuators;
– splices.

The ODN is defined between the reference points S and R. In analogy with the definitions provided in ITU-T Rec. G.957, S and R are defined as follows:

– S: Point on the optical fibre just after the OLT/ONT optical connection point (i.e., optical connector or optical splice).
– R: Point on the optical fibre just before the OLT/ONT optical connection point (i.e., optical connector or optical splice).

Because of the 1-fibre bidirectional transmission, the point S and R at each end of the ODN are located on the same fibre.

The optical properties of the ODN shall enable the provision of any presently foreseeable service without the need of extensive modifications to the ODN itself. A set of essential items, which have a direct influence on the optical properties of the ODN, are identified as follows:

– Optical wavelength transparency: Devices, which are not intended to perform any wavelength-selective function, shall be able to support transmission of signals at any wavelength in the 1310 nm and 1550 nm regions.
– Reciprocity: Reversal of input and output ports shall not cause significant change of the optical loss through the device.
– Fibre compatibility: All optical components shall be compatible with single-mode fibre as specified in ITU-T Rec. G.652.

If additional connectors or other passive devices are needed for ODN rearrangement, they shall be located between the reference points S and R and their losses shall be taken into account in any optical loss calculation.

5.6 Class for optical path loss

Recommended classes for optical path loss are shown in Table 1.

Table 1/G.985 – Classes for optical path loss

	Class S	Class A	Class B
Minimum loss	0 dB	For further study	For further study
Maximum loss	15 dB	For further study	For further study

Class A and B are for further study. Class A is for the transmission within 20 km of distance and Class B is for the transmission within 30 km of distance.

5.7 Reflectance in ODN

The reflectance of an ODN depends on the return loss characteristics of the individual components along the optical path and on any reflection points existing in the ODN. A reflection model is described in 6.8.

6 Physical layer specification

The optical interface of ONT and OLT should follow the transmission and coding specification in conformance with PMA, PCS, MII, RS of 100 BASE-FX (IEEE Standard 802.3), except for the physical layer specification defined in this Recommendation. Physical layer specification is also specified for each of the following applicable areas.

– Class S: optical path loss 15 dB, Power penalty 1 dB.

– Class A: For further study. The transmission distance is assumed to be within 20 km.

– Class B: For further study. The transmission distance is assumed to be within 30 km.

NOTE – The distance described above is not a standard, but for classification.

This physical layer specification describes PMD sub-layer on the layer structure in Figure 2.

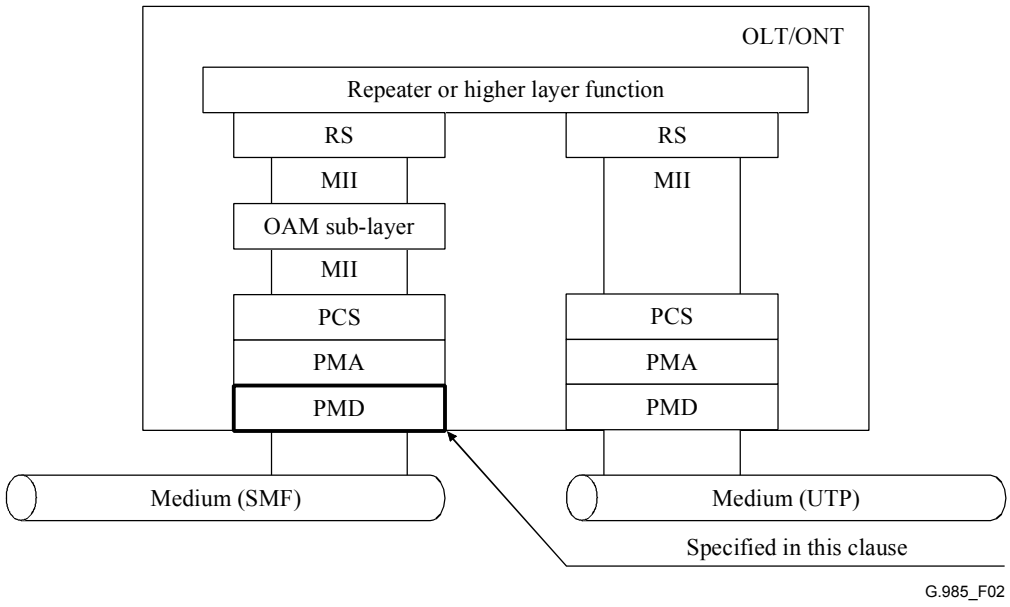

Figure 2/G.985 – Index of clause 6 in the layer structure

All parameters are specified as follows, and should be in accordance with Table 2 for an ONT, and Table 3 for an OLT.

Table 2/G.985 – Physical layer specification for ONT

Items	Unit	Specification		
ODN class		**Class S**	**Class A**	**Class B**
Nominal bit rate	Mbit/s	125		
Transmit wavelength	nm	1260-1360		
Receive wavelength	nm	1480-1580		
Line code	–	NRZI and 4B5B block coding		
Spectral characteristic			For further study	For further study
If MLM laser – Maximum RMS width	nm	7.7		
If SLM laser – Maximum –20 dB width	nm	For further study		
If SLM laser – Minimum side mode suppression ratio	dB	For further study		
Mean launch power MAX	dBm	–8		
Mean launch power MIN	dBm	–14		
Minimum overload	dBm	–8		
Minimum sensitivity	dBm	–30		
Power penalty	dB	1		
Extinction ratio	dB	More than 8.2		
Pulse mask		Conformance with ITU-T Rec. G.957, STM-1		
S/X			For further study	For further study
Optical return loss condition	dB	More than 14		
Bit error ratio		Less than 10^{-10}		
Optical return loss of the interface	dB	More than 14		

Table 3/G.985 – Physical layer specification for OLT

Items	Unit	Specification		
ODN class		**Class S**	**Class A**	**Class B**
Nominal bit rate	Mbit/s	125		
Transmit wavelength	nm	1480-1580		
Receive wavelength	nm	1260-1360		
Line code	–	NRZI and 4B5B block coding		
Spectral characteristic			For further study	For further study
If MLM laser – Maximum RMS width	nm	6		
If SLM laser – Maximum –20 dB width	nm	For further study		
If SLM laser – Minimum side mode suppression ratio	dB	For further study		
Mean launch power MAX	dBm	–8		
Mean launch power MIN	dBm	–14		
Minimum overload	dBm	–8		
Minimum sensitivity	dBm	–30		
Power penalty	dB	1		
Extinction ratio	dB	More than 8.2		
Pulse mask		Conformance with ITU-T Rec. G.957, STM-1		
S/X			For further study	For further study
Optical return loss condition	dB	More than 14		
Bit error ratio		Less than 10^{-10}		
Optical return loss of the interface	dB	More than 14		

6.1 Transmit wavelength/Receive wavelength

Transmit and receive wavelength are described in 5.3 and 5.4.

6.2 Bit rate and line coding

Bit rate of both upstream and downstream is 125 Mbit/s, but its effective bandwidth is 100 Mbit/s because line coding scheme is NRZI and 4B5B block coding specified in IEEE Standard 802.3.

6.3 Spectral characteristics

For MLM lasers, the spectral width is specified by the maximum Root-Mean-Square (RMS) width under standard operating conditions. The RMS width means the standard deviation (σ) of spectral distribution. As to the measurement method for RMS width, all modes should be within 20 dB range from the peak mode.

For SLM lasers, the maximum spectral width is specified by the maximum full width measured at the point of 20 dB lower than the maximum amplitude of the central wavelength under standard operating conditions. Additionally, for control of mode partition noise in SLM systems, a minimum value for the laser side-mode suppression ratio is specified.

In this Recommendation, specification for SLM lasers is for future study.

6.4 Mean launched power

Mean launched power at reference point is the average optical power of a pseudo-random data sequence coupled into the fibre by the transmitter.

6.5 Receiver characteristics

Receiver characteristics are described as minimum overload and minimum sensitivity as the average optical power against pseudo-random data sequence. Sensitivity includes power penalty.

6.6 Extinction ratio

The convention adopted for optical logic level is:

– Emission light for a logical "1";

– No emission light for a logical "0".

The extinction ratio (EX) is defined as:

$$EX = 10\log_{10}(A/B)$$

Where A is the average optical power level for a logical "1" and B is the average optical power level for a logical "0".

6.7 Pulse mask

Pulse mask at reference points is in conformance with ITU-T Rec. G.957, STM-1.

Bessel-Thomson filter of fourth-order or fifth-order with cut-off frequency of 125 MHz × 0.75 shall be used for measuring. Also Bessel-Thomson filter of fourth-order or fifth-order with cut-off frequency of 155.52 MHz × 0.75 might be used.

6.8 S/X

The OLT (or ONT) shall receive both signal and cross-talk light from the ONT (or OLT) because of multiple reflections incurred by discontinuity of reflective index on the optical path. The OLT or ONT must have applicable S/X against reflection from the optical path which satisfies the specification of optical return loss.

Reflection model is assumed to have such a structure that it is connected to two connectors at near end, with optical return loss of 35 dB for one connector and 32 dB for two connectors.

If the total optical return loss of optical signals transmitted from the OLT (or ONT), which reflects on the optical path and/or at the opposite ONT (or OLT), falls on the value described in Tables 2 and 3, the bit error ratio in Tables 2 and 3 can be satisfied within the range of receiver characteristics in this Recommendation.

In Tables 2 and 3, minimum optical return loss of the optical path is assumed to be 14 dB because the reflection from two connectors (32 dB) is small enough compared with that from the ONT or OLT(14 dB).

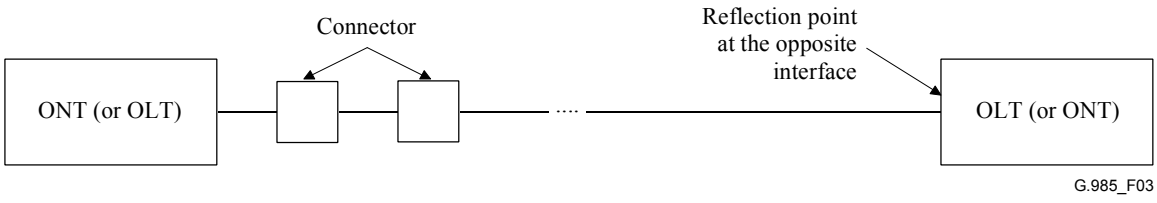

Figure 3/G.985 – Reflection model

6.9 Optical return loss of the interface

The optical return loss of the interface means the ODN reflection of its received light. Therefore, the optical return loss of the interface is defined by the wavelength of 1550 nm band for the ONT, and by the wavelength of 1310 nm band for the OLT.

6.10 Test pattern

Data pattern to be used in measuring wavelength or spectral characteristics is not specified in this Recommendation, but short continuous random test pattern described in IEEE Standard 802.3, Annex 36A.5 may be referred.

6.11 Jitter

Jitter is time distortion of optical signal, incurred through the process of electrical-optical conversion at the transmitter or by the effect of optical path.

Duty distortion shall be specified by pulse mask in this specification, and it is recommended in this clause that the jitter of transmitter excluding duty distortion may be less than 1 ns, and similarly the jitter durability of receiver may be more than 2.5 ns.

At the receiver, the duty distortion specified in pulse mask may be taken into account as well as jitter durability.

6.12 Signal detect

Interruption of communication such as release of optical connecter or power interruption of the opposite side equipment shall be detected to avoid incorrect link up between OLT and ONT.

6.13 Optical connector

The formation and characteristic of optical connector, which is connected to the OLT, the ONT and optical fibre of optical path mechanically, is not specified in this Recommendation.

7 Requirements for the OAM

7.1 General requirements

Ethernet based point-to-point connection is simple to configure, therefore a simple OAM function is required. To provide optical access services using the Ethernet based point-to-point system, the operator should be capable of following actions from the remote side, which are not defined in the Ethernet protocol. To achieve these actions, the OLT should be able to monitor and test the ONT.

– *Identification of the failure point*

  The OLT should identify where the failure point is (e.g., in the optical line, inside the ONT and so on). Optical link signal status and ONT status should be monitored by the OLT in order to identify this. And to know the power-off of the ONT, the ONT should also notify its power status to the OLT.

– *Verification of the line*

  The loop-back test for the optical access line from the OLT is required.

The layer for this OAM function is defined as shown in Figure 4.

Also, performance monitoring items are specified as optional in this Recommendation, which is defined in layer-2 exceptionally.

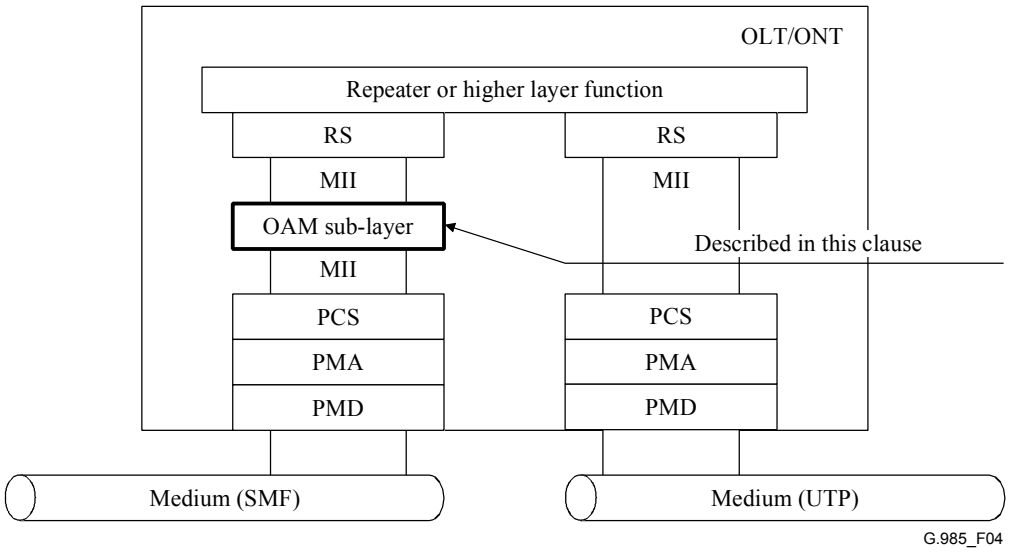

Figure 4/G.985 – Index of clause 7 in the layer structure

7.2 Requirements for the OAM functions

The OAM function is used by OLT to control and monitor the ONT. This protocol allows the OLT to:

– Request status and information to the ONT.

– Receive alarm from the ONT.

– Start and end loop-back test.

In this Recommendation, this function is protocol-independent, but its sequences are shown in 7.4.

7.2.1 Fault management

Fault management provides functions of ONT to notify an alarm to the OLT. The ONT should also notify a recover from these faults to the OLT.

– *Power supply*

This indicates the power supply fault on the ONT or the power-off of ONT by the end user in order to inhibit the link down alarm on the access line detected at the OLT.

– *ONT failure*

This indicates any failure in ONT.

– *Received signal*

This indicates no valid signal received at ONT receiver in downstream. This can be notified by the FEFI defined in 100BASE-FX of IEEE Standard 802.3.

7.2.2 Loop-back test

Loop-back test is used by the OLT to check the transportation of the Ethernet frames over the access line. The OLT controls the start and end of loop-back test. This means that the OLT changes following ONT status.

– *ONT loop-back status*

This indicates the ONT is in the loop-back test mode or in the normal operation mode.

7.2.3 Notification

Notification provides function to request the ONT information. This function includes the following items.

– ONT vender code.

– ONT model number.

7.3 Managed entities

The managed entities are as follows.

7.3.1 Loop-back test status

This managed entity indicates an ONT status which is the loop-back test mode or the normal operation mode.

Attributes:

LoopbackStatusID: This attribute provides the loop-back status of ONT. This includes "during loop-back test" and "normal operation".

7.3.2 ONT product information

This managed entity indicates the information related to the ONT. The ONT sends this managed entity to the OLT with attributes of proper values when the OLT requests.

Attributes:

ONT_VenderCode: This attribute provides the vender code of the ONT.

ONT_ModelNumber: This attribute provides the model number of the ONT.

7.3.3 Power supply

This managed entity indicates the power supply status of the ONT in order to prevent link down alarm on access line from being detected at the OLT. The ONT notifies this managed entity to the OLT with attributes of proper values when its power supply condition changes to the normal status or the power down status.

Attributes:

ONT_PowerSupplyStatusID: This attribute provides the power supply status of the ONT which includes "normal" and "power down".

7.3.4 ONT failure

This managed entity indicates the failure of the ONT. The ONT notifies this managed entity to the OLT with attributes of proper values when failure occurs or when it recovers from failure.

Attributes:

ONT_Failure: This attribute provides the any failure status of the ONT. This includes "normal" and "failure".

7.3.5 Received signal

This managed entity indicates the status of received signals from the OLT. This is the alarm status that downstream signal does not receive by the ONT. The ONT notifies this managed entity to OLT with attributes of proper values when the ONT detects fault of received signals from the OLT or when the ONT detects recovery of those signals.

Attributes:

RecevedSignalStatusID: This attribute provides the received signal status of the ONT. This includes "normal" and "failure".

7.4 Requirements for the OAM signals and sequences

To realize the requirements for the OAM, it is necessary to define the following OAM signals and sequences. The OAM signals are defined to transmit information described above and control-commands on the Ethernet connection. The OAM signal should cover upstream and downstream direction. The sequence means the flow of the OAM signal transmission between ONT and OLT. And the sequences are defined to transmit information described above correctly using the OAM signals.

a) *OAM signals*

   i) OAM signals should support layer-1-only devices (e.g., a repeater, etc.). Therefore, a special frame is required for the OAM signal, easy to handle layer-1-only devices.

   ii) OAM signals should have the error protection such as CRC.

   iii) OAM signals coming from user/service network side and going to a user/service network side should be prohibited.

b) *Sequences*

   i) The OLT sends a request signal to the ONT, and the ONT sends a response signal to the OLT for status notification.

   ii) The ONT sends an alarm indication signal to the OLT for fault management.

   iii) The OLT sends a request signal to the ONT in order to start or end the loop-back test, and the ONT sends a response signal to the OLT.

   iv) The OLT sends loop-back frames after it receives a response signal of loop-back start.

When an OAM signal for loop-back test start or end is lost, the OLT and the ONT should recover to the normal operation mode from loop-back test mode automatically.

For these sequences, the following signals are defined.

a) *Request status and information to the ONT*

   i) Status notification request (from OLT to ONT).

   ii) Status notification response (from ONT to OLT).

b) *Receive alarm from the ONT*

   i) Status notification trap (from ONT to OLT).

c) *Control loop-back test start and end*

   i) Loop-back test start request (from OLT to ONT).

   ii) Loop-back test start response (from ONT to OLT).

   iii) Loop-back test end request (from OLT to ONT).

   iv) Loop-back test end response (from ONT to OLT).

   v) Loop-back test end trap (from ONT to OLT for unexpected loop-back end).

7.5 Requirements for the performance monitor function

In this Recommendation, the performance monitoring function is defined in layer-2 exceptionally because it facilitates traffic monitoring better than if it had been defined in layer-1.

This function is here also specified as optional, and performance monitoring at the ONT is out of scope in this Recommendation.

Monitor items at the OLT are shown in the Table 4.

Table 4/G.985 – Performance monitor items

Item	Description
All Packets received from ONT	This indicates a number of all packets received from ONT.
Unicast Packets received from ONT	This indicates a number of only unicast packets received from ONT.
Non-Unicast Packets received from ONT	This indicates a number of only Non-unicast packets (Multicast or Broadcast packets) received from ONT.
Error Packets received from ONT	This indicates a number of error packets (discarded packets) received from ONT.
All Packets received from SNI	This indicates a number of all packets received from SNI.
Unicast Packets received from SNI	This indicates a number of only unicast packets received from SNI.
Non-Unicast Packets received from SNI	This indicates a number of only Non-unicast packets (Multicast or Broadcast packets) received from SNI.
Error Packets received from SNI	This indicates a number of error packets (discarded packets) received from SNI.

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Geneva, 2003