

TR-309

XG-PON1 TC Layer Interoperability Test Plan

Issue: 1
Issue Date: September 2013

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Issue History

Issue Number	Issue Date	Publication Date	Issue Editor	Changes
1	9 September 2013	1 October 2013	Lincoln Lavoie, Vincent Buchoux, Hugues Le Bras	Original

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Table of Contents

EXECUTIVE SUMMARY.....8

1 PURPOSE AND SCOPE9

1.1 PURPOSE.....9

1.2 SCOPE.....9

2 REFERENCES AND TERMINOLOGY10

2.1 CONVENTIONS10

2.2 REFERENCES10

2.3 DEFINITIONS.....11

2.4 ABBREVIATIONS.....12

3 TECHNICAL REPORT IMPACT15

3.1 ENERGY EFFICIENCY15

3.2 IPV615

3.3 SECURITY15

3.4 PRIVACY.....15

4 TEST CONFIGURATION AND EQUIPMENT16

4.1 GENERAL.....16

4.2 BASIC TC LAYER TEST SETUP16

4.3 ETHERNET TRAFFIC TEST SETUP17

4.4 MULTIPLE ONU TEST SETUP18

4.5 PMD PARAMETERS FOR TC LAYER TESTS.....18

4.5.1 *Strict Parameter Set*19

4.5.2 *Relaxed Parameter Set*19

4.6 EQUIPMENT REQUIREMENTS19

4.7 BASIC TRACING AND TROUBLESHOOTING FACILITIES.....20

5 TEST CASE SUMMARY.....21

5.1 PMD LAYER TESTS.....21

5.2 BASIC TC LAYER TESTS.....21

5.3 COMPREHENSIVE TC LAYER TESTS22

6 PMD LAYER TESTS24

6.1 GENERAL.....24

7 BASIC TC LAYER TESTS.....25

7.1 ONU START-UP25

7.1.1 *ONU Discovery - Single ONU (cold OLT, cold ONU)*25

7.1.2 *ONU Activation*27

7.1.3 *ONU Discovery – Multiple ONUs (warm PON)*.....29

7.1.4 *ONU Activation – Multiple ONUs without Data Transmission*.....31

7.1.5 *ONU Discovery – Multiple ONUs (cold OLT, cold ONUs)*.....32

7.1.6 *ONU Discovery and Activation during Data Transmission*.....33

7.1.7 *DD40 Differential Reach Operation*.....35

7.2	BANDWIDTH ALLOCATION	37
7.2.1	<i>Single Allocation</i>	37
7.2.2	<i>Repetitive Allocation</i>	40
7.2.3	<i>Burst Series</i>	42
7.2.4	<i>Maximal Allocation</i>	44
7.2.5	<i>Adjacent Allocations to Different ONUs</i>	46
7.3	EMBEDDED OAM OPERATION	48
7.3.1	<i>PON-ID</i>	48
7.3.2	<i>Dying Gasp</i>	49
7.3.3	<i>PLOAM Queue Status</i>	50
7.3.4	<i>Dynamic Bandwidth Reporting</i>	51
7.4	PLOAM CHANNEL OPERATION	53
7.4.1	<i>Multiple PLOAM Messages per Frame</i>	53
7.4.2	<i>Burst Profile Version Changes</i>	55
7.4.3	<i>ONU Deactivation and Disable SN</i>	57
7.4.4	<i>Alloc-ID Allocation and De-allocation</i>	59
7.4.5	<i>Encryption Key Exchange</i>	61
7.5	FORWARD ERROR CORRECTION	63
7.5.1	<i>Downstream FEC Operation</i>	63
7.5.2	<i>Upstream FEC Operation – Integral Multiple of Codeword Size</i>	64
7.5.3	<i>Upstream FEC Operation – Non-Integral Multiple of Codeword Size</i>	66
7.5.4	<i>Upstream FEC Operation – Burst Series with Shared Parity Words</i>	68
7.5.5	<i>Upstream FEC Operation – Mixed FEC and No-FEC Accesses – Multiple ONUs</i>	70
7.6	DATA TRANSMISSION	72
7.6.1	<i>OMCI Channel Establishment</i>	72
7.6.2	<i>OMCI Channel Establishment – Multiple ONUs</i>	74
7.6.3	<i>Downstream Encryption Operation</i>	76
7.6.4	<i>Upstream Encryption Operation</i>	78
7.6.5	<i>Downstream Ethernet Traffic Transmission</i>	80
7.6.6	<i>Upstream Ethernet Traffic Transmission</i>	81
7.6.7	<i>Bidirectional Ethernet Traffic Transmission</i>	83
7.6.8	<i>Multiple Port-ID/Alloc-ID Data Transmission – Single ONU</i>	85
7.6.9	<i>Bidirectional Ethernet Traffic Transmission – Multiple ONUs</i>	87
8	COMPREHENSIVE TC LAYER TESTS	89
8.1	AUTHENTICATION AND ENCRYPTION	89
8.1.1	<i>Registration-ID Based Authentication</i>	89
8.1.2	<i>Automatic Encryption Key Exchange and Traffic Transmission</i>	91
8.1.3	<i>Encrypted Ethernet Transmission</i>	94
8.1.4	<i>Multicast Encryption Operation</i>	96
8.1.5	<i>ONU Re-Activation After Fiber Disconnection with Registration-ID Based Authentication</i>	97
8.1.6	<i>Automatic Encryption Key Exchange during Traffic</i>	100
8.1.7	<i>Secure Mutual Authentication – OMCI Based</i>	102
8.1.8	<i>Secure Mutual Authentication – 802.1x</i>	104
8.1.9	<i>ONU Re-Activation after Fiber Disconnection with Secure Mutual Authentication</i> ...	107
8.1.10	<i>Request Registration after Secure Mutual Authentication</i>	110

8.2	ONU POWER MANAGEMENT MODES	113
8.2.1	<i>Doze Mode</i>	113
8.2.2	<i>Doze Mode (ONU Wakeup)</i>	116
8.2.3	<i>Cyclic Sleep</i>	118
8.2.4	<i>Cyclic Sleep (ONU Wakeup)</i>	121
8.3	DYNAMIC BANDWIDTH ALLOCATION.....	123
8.3.1	<i>DBA Operation - Single ONU</i>	123
8.3.2	<i>DBA Operation - Multiple ONUs</i>	125
8.3.3	<i>DBA Operation under Different Traffic Loads - Multiple ONUs</i>	127
8.4	DRIFT CONTROL AND COMPENSATION	129
8.4.1	<i>Acceptable Transmission Drift Boundary</i>	129
8.4.2	<i>Adjustable Transmission Drift Boundary (DOW)</i>	131
8.4.3	<i>Unacceptable Transmission Drift Boundary (TIW)</i>	133
8.5	TIME OF DAY DISTRIBUTION OVER XG-PON1	135
8.5.1	<i>Time of Day Distribution – Fixed Equalization Delay, Single ONU</i>	135
8.5.2	<i>Time of Day Distribution – Equalization Delay Adjustments, Single ONU</i>	137
8.5.3	<i>Time of Day Synchronization - Multiple ONUs</i>	139
8.6	PROTECTION SWITCHING.....	141
8.6.1	<i>Intermittent LODS</i>	141

List of Figures

Figure 1 – Basic TC Layer Test Setup 16
 Figure 2 – Ethernet Traffic Test Setup 17
 Figure 3 – Multiple ONU Test Setup with Ethernet Traffic 18
 Figure 4 – Test Setup for DD40 Differential Reach Test 35
 Figure 5 – Test Setup for Intermittent LODS 141

List of Tables

Table 7-1 – Bandwidth Allocation Parameters For Single Allocation..... 38
 Table 7-2 – Bandwidth Allocation Parameters For Burst Series 42
 Table 7-3 – Bandwidth Allocation Map #1 68
 Table 7-4 – Bandwidth Allocation Map #2..... 68
 Table 7-5 – Bandwidth Allocation Parameters For Upstream FEC Operation..... 70

Executive Summary

Broadband Forum, after extending the GPON conformance and interoperability test plans for service architecture to XG-PON1 (TR-247 and TR-255), completes the document suite on ITU-T PON technologies with a XG-PON1 physical layer interoperability test plan.

The scope of TR-309 is the verification of XG-PON1 OLT and ONU interoperability with respect to the Physical Media Dependent (PMD) sub-layer (ITU-T G.987.2 [5]) and the Transmission Convergence (TC) sub-layer (ITU-T G.987.3 [6]). Note, in this version, much of the PMD layer testing is performed indirectly, as a result of testing the TC layer. Other PMD layer test cases are for future study and will be considered in next revisions of TR-309.

TR-309 has been contributed by the Full Service Access Network to the Broadband Forum as a first draft of this document.

1 Purpose and Scope

1.1 Purpose

TR-309 defines a set of test cases whose purpose is to verify interoperability between an XG-PON1 OLT and a BBF.247 certified ONU. These test cases address the Physical Media Dependent (PMD) sub-layer (G.987.2 [5]) and the Transmission Convergence (TC) sub-layer (G.987.3 [6]). Executing these test cases as part of a multi-supplier test event will help OLT and ONU's implementation of the specifications operate as a functional system.

Successfully completing these tests requires that any configurations required will be accomplished through documented EMS interfaces that are typically accessible to provisioning and operations staff and through standards based OLT/ONU communications (i.e., PLOAM, OMCI).

The tests are partitioned to three categories:

1. PMD layer tests – which focus on low level PMD layer functions (for future study)
2. Basic TC layer tests - which focus on the frame structure and isolated TC layer functions
3. Comprehensive TC layer tests - which are oriented towards a more comprehensive TC layer behavior

1.2 Scope

The test cases specified in TR-309 are focused on exploring multi-supplier interoperability at the XG-PON1 PMD and TC sub-layer level of XG-PON1 systems or XG-PON1 test platforms. The test cases are written to allow for the participation of prototype XG-PON1 implementations, which may not have complete G.987.x functionality. The test cases provided in the body of TR-309 provide a minimum set of XG-PON1 PMD and TC sub-layer interoperability tests and are not an exhaustive set of XG-PON1 PMD and TC sub-layer test cases. Other supplemental test cases may optionally be executed as part of any interoperability test event. The focus of the tests provided in TR-309 are on interoperability and not conformance, i.e. checking the operation of multiple vendor equipment with each other from PMD and TC layer perspective rather than exhaustive functional test of the behavior of the equipment, as is, or connected to some “golden” opponent device.

TR-309 contains test cases for features and capabilities that are optional according to G.987.x. Test status of such cases is labeled as “conditional”. Only features and capabilities claimed to be supported by both the OLT and the ONU are to be tested.

2 References and Terminology

2.1 Conventions

In this Technical Report, several words are used to signify the requirements of the specification. These words are always capitalized. More information can be found in RFC 2119 [9].

MUST	This word, or the term “REQUIRED”, means that the definition is an absolute requirement of the specification.
MUST NOT	This phrase means that the definition is an absolute prohibition of the specification.
SHOULD	This word, or the term “RECOMMENDED”, means that there could exist valid reasons in particular circumstances to ignore this item, but the full implications need to be understood and carefully weighed before choosing a different course.
SHOULD NOT	This phrase, or the phrase "NOT RECOMMENDED" means that there could exist valid reasons in particular circumstances when the particular behavior is acceptable or even useful, but the full implications need to be understood and the case carefully weighed before implementing any behavior described with this label.
MAY	This word, or the term “OPTIONAL”, means that this item is one of an allowed set of alternatives. An implementation that does not include this option MUST be prepared to inter-operate with another implementation that does include the option.

2.2 References

The following references are of relevance to this Technical Report. At the time of publication, the editions indicated were valid. All references are subject to revision; users of this Technical Report are therefore encouraged to investigate the possibility of applying the most recent edition of the references listed below.

A list of currently valid Broadband Forum Technical Reports is published at www.broadband-forum.org.

Document	Title	Source	Year
[1] OD-247/IR-247	<i>G-PON ONU Conformance Test Plan</i>	BBF	2011
[2] TR-255	<i>G-PON Interoperability Test Plan</i>	BBF	2011
[3] G.987	<i>10-Gigabit-capable passive optical network (XG-PON) systems: Definitions, abbreviations and acronyms</i>	ITU-T	2010

[4] G.987.1	<i>10-Gigabit-capable passive optical networks (XG-PON): General requirements (01/10)</i>	ITU-T	2010
[5] G.987.2	<i>10-Gigabit-capable passive optical networks (XG-PON): Physical media dependent (PMD) layer specification (10/10)</i>	ITU-T	2010
[6] G.987.3	<i>10-Gigabit-capable passive optical networks (XG-PON): Transmission convergence (TC) layer specification (10/10)</i>	ITU-T	2010
[7] G.987.3 Amd.1	<i>Recommendation G.987.3 (2010) Amendment 1 (06/12)</i>	ITU-T	2012
[8] G.988	<i>ONU Management and Control Interface Specification (OMCI)</i>	ITU-T	2010
[9] RFC 2119	<i>Key words for use in RFCs to Indicate Requirement Levels</i>	IETF	1997

2.3 Definitions

The following terminology is used throughout this Technical Report.

Ethernet Traffic Generator	A device that generates and captures well formed Ethernet frames as defined by test personnel.
Alloc-ID	14-bit number field that indicates the recipient of the bandwidth allocation, i.e. a particular T-CONT or an upstream OMCC within an ONU.
Optical Distribution Network (ODN)	Optical Distribution Network including the fibers, splitters and connectors.
Optical Line Termination (OLT)	A device that terminates the common (root) endpoint of an ODN, implements a PON protocol, such as that defined by G.987, and adapts PON PDUs for uplink communications over the provider service interface. The OLT provides management and maintenance functions for the subtended ODN and ONUs.
Optical Network Unit (ONU)	Optical Network Unit (ONU): A generic term denoting a device that terminates any one of the distributed (leaf) endpoints of an ODN, implements a PON protocol, and adapts PON PDUs to subscriber service interfaces.
ONU-ID	ONU-ID is a 10-bit identifier that the OLT assigns to an ONU during the ONU's activation using the PLOAM messaging channel. The ONU-ID is unique across the PON.
Port-ID	See <i>XGEM Port-ID</i>

PON-TAG	An 8-byte static identity of the OLT PON port that is chosen by the Operator. PON-TAG is recommended to be unique within the operator's domain and fixed for the lifetime of the system.
Optical test equipment	An external device, which may be included in a non-intrusive manner, between the R/S and S/R-interfaces to capture and/or analyze the signals and the traffic present in the ODN
Traffic Flow	A sequence of frames or packets traversing a particular reference point within a network that share a specific frame/packet header pattern. For example, an Ethernet traffic flow can be identified by any combination of specific source MAC address, destination MAC, VLAN ID, 802.1p bits, etc.
Vendor-ID	ONU Vendor-ID code, a four-character combination discovered at SN acquisition.
XGEM	A data frame transport scheme used in XG-PON systems that is connection-oriented and that supports fragmentation of user data frames into variable sized transmission fragments.
XGEM Port	An abstraction on the XGTC adaptation sublayer representing a logical connection associated with a specific client traffic flow.
XGEM Port-ID	A 16-bit number that is assigned by the OLT to an individual logical connections transported over the XG-PON1 interface and which is carried in the header of all the XGEM frames associated with the given logical connection.
XG-PON Network	An XG-PON OLT connected using an Optical Distribution Network (ODN) to one or more XG-PON ONUs or ONTs. A XG-PON network is a subset of the Access Network. A XG-PON system supports nominal transmission rates on the order of 10 Gbit/s in at least one direction, and implements the suite of protocols specified in the ITU-T G.987.x series Recommendations. XG-PON is a subclass of NG-PON1. A XG-PON1 system operates at a nominal line rate of 10 Gbit/s downstream and 2.5 Gbit/s upstream.
XGTC	The XGTC adaptation sublayer is a sublayer of the XG-PON Transmission Convergence (XGTC) layer that supports the functions of user data fragmentation and de-fragmentation, XGEM encapsulation, XGEM frame delineation, and XGEM Port-ID filtering.

2.4 Abbreviations

This Technical Report uses the following abbreviations:

ADSL	Asymmetric Digital Subscriber Line
AES	Advanced Encryption Standard
AN	Access Node
ASP	Application Service Provider

ATM	Asynchronous Transfer Mode
BTS	Base Transceiver Station
CB	Cellular Backhaul
CPE	Customer Premises Equipment
CPN	Customer Premises Network
DSCP	DiffServ Code Point
DBA	Dynamic Bandwidth Assignment
DBR	Dynamic Bandwidth Report
DOW _i	Drift of Window for ONU <i>i</i>
DSL	Digital Subscriber Line
FEC	Forward Error Correction
FE	Fast Ethernet (100Mbps)
FITH	Fiber into the Home
FTTC	Fiber to the Curb
FTTH	Fiber to the Home
FTTO	Fiber to the Office
FTTP	Fiber to the Premises, including buildings
FWI	Forced Wakeup Indication
GE	Gigabit Ethernet (1000Mbps)
HEC	Hybrid Error Correction
KEK	Key Encryption Key
L2-OCM	Layer 2 OMCI Common Model
LoDS	Loss of Downstream Synchronization
MAC	Media Access Control
MDU	Multi-Dwelling Unit
ME	Managed Entity
MIC	Message Integrity Check
MSK	Master Session Key
MTU	Multi-Tenant Unit – or Maximum Transmission Unit
NSP	Network Service Provider
OAM	Operations, Administration and Maintenance
ODN	Optical Distribution Network – as defined in G.987.1 [4]

OLT	Optical Line Termination – as defined in G.987.1
OMCI	ONU Management and Control Interface – as defined in G.988
OMCC	ONU Management and Control Channel
ONT	Optical Network Termination – as defined in G.987.1
ONU	Optical Network Unit – as defined in G.987.1
PLOAM	Physical Layer OAM
PLI	Payload Length Indication
PMD	Physical Media Dependant Layer
POTS	Plain Old Telephone Service
RBN	Regional Broadband Network
RG	Residential Gateway
RNC	Radio Network Controller
SFU	Single Family Unit – a type of residence
TDM	Time-Division Multiplexing
TLS	Transparent LAN Service – a common synonym for Business Ethernet Services
TR	Technical Report
TIWi	Transmission Interference Warning for ONU <i>i</i>
ToD	Time of Day
VDSL	Very high speed Digital Subscriber Line
VSSN	Vendor Specific Serial Number
WG	Working Group
WT	Working Text
xDSL	Any variety of DSL
XGEM	XG-PON Encapsulation Method
XG-PON1	10-Gigabit-capable Passive Optical Network, ITU-T G.987.x-series
XGTC	XG-PON Transmission Convergence (protocol layer) – as defined in G.987.3[6]

3 Technical Report Impact

3.1 Energy Efficiency

TR-309 has no impact on energy efficiency.

3.2 IPv6

TR-309 has no impact on IPv6.

3.3 Security

TR-309 has no impact on security.

3.4 Privacy

Any issues regarding privacy are not affected by TR-309.

4 Test Configuration and Equipment

4.1 General

This section specifies baseline test setup and parameters, common to all test cases except where noted otherwise.

At early interoperability test stage, verification of MIC for PLOAM and OMCI messages and HEC should be optionally disabled by receivers. Correct values should still be generated by transmitters, if possible.

4.2 Basic TC Layer Test Setup

The following setup is used for single ONU tests:

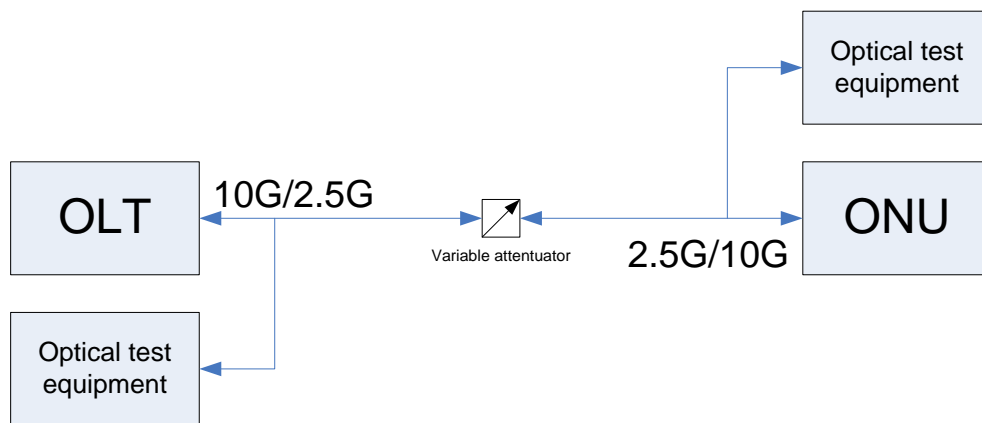


Figure 1 – Basic TC Layer Test Setup

A spool of fiber of 20km shall be added between the OLT and ONU.

4.3 Ethernet Traffic Test Setup

The following setup is used for single ONU tests requiring Ethernet traffic:

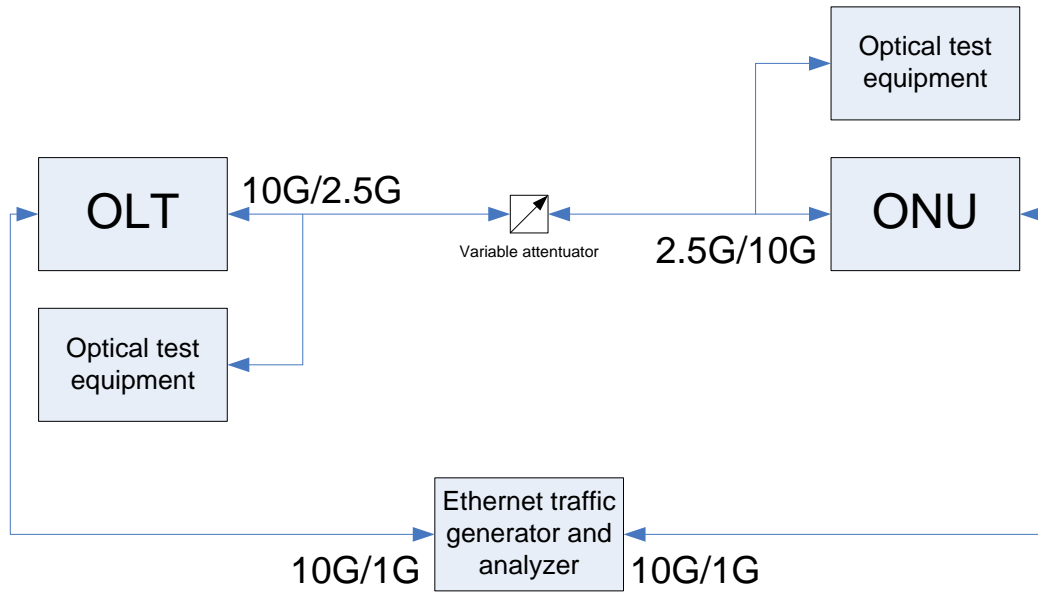


Figure 2 – Ethernet Traffic Test Setup

Exact configuration of the Ethernet interfaces should be coordinated before a specific test event. Ethernet packets must have VLAN tags.

4.4 Multiple ONU Test Setup

This setup is geared to more advanced tests. It is suggested that the basic configuration includes one ONU supplied by the OLT vendor, and another ONU supplied by another vendor. Complex configuration can include several ONUs, possibly at various distances.

During these tests, a spool of fiber of 20km shall be used in front of one ONU and none shall be used in front of the other ONU.

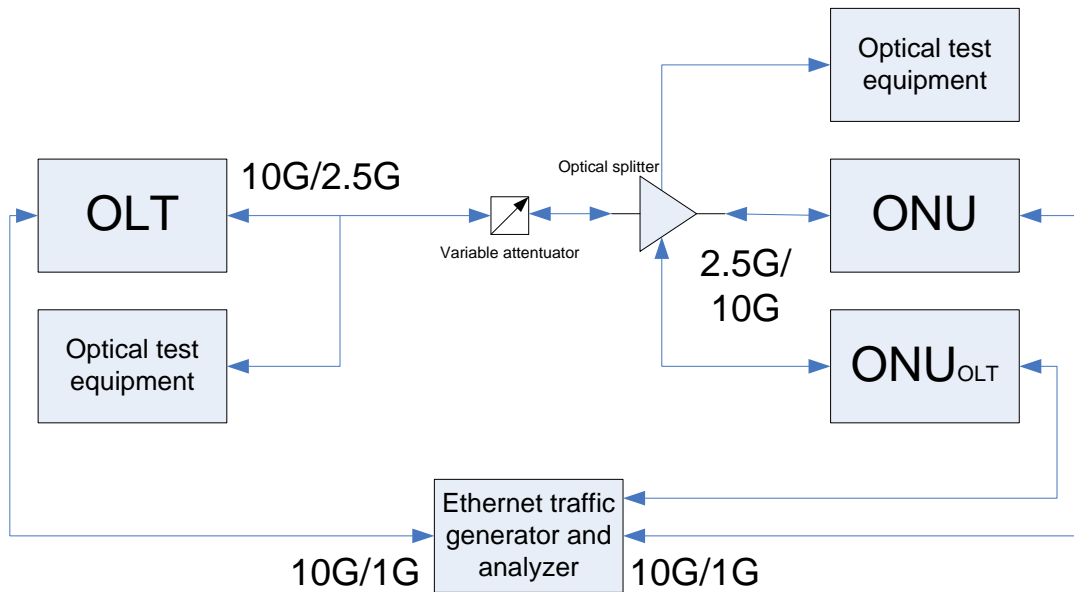


Figure 3 – Multiple ONU Test Setup with Ethernet Traffic

4.5 PMD Parameters for TC Layer Tests

The focus of TR-309 is the TC layer and the main role of the PMD layer is to enable TC layer tests. Transmission power should be within the limits defined in G.987.2 and receiver sensitivity can be anywhere within the defined range.

For TC layer tests, the minimal parameters that are required from the PMD layer to maintain interoperability shall be implemented. For instance, transceivers must meet the wavelength plans so to be able to work with each other. Minimal optical budget, extinction ratio and jitter budget to qualify each one of the setups described in this section are required.

For all TC layer tests, the optics should be adjusted via the variable attenuators so that they are in the middle of their operating range.

4.5.1 Strict Parameter Set

This is a stricter set of parameters, intended to reduce overheads and allow better utilization of upstream bandwidth. These parameters are limited by system components such as optical modules, and are at the discretion of the OLT vendor.

4.5.2 Relaxed Parameter Set

This is a set of relaxed parameters, so it would not be stressful for any OLT or ONU to meet. It might be used at initial interoperability test events. The following values are recommended, but can be changed if required by the OLT or the ONU:

Parameters for upstream FEC off:

- Profile index: 0
- Delimiter length: 8 octets
- Delimiter value: 0xCE99 CE5E 5028 B41F
- Preamble length: 8 octets
- Preamble repeat count: 16
- Preamble value: 0xAAAA AAAA AAAA AAAA

Those parameters are set by the OLT using “profile” PLOAM message and referred within TR-309 as burst profile number 0.

Parameters for upstream FEC on:

- Profile index: 1
- Delimiter length: 8 octets
- Delimiter value: 0xB3BD D310 B2C5 0FA1
- Preamble length: 8 octets
- Preamble repeat count: 16
- Preamble value: 0xAAAA AAAA AAAA AAAA

Those parameters are set by the OLT using “profile” PLOAM message and referred within TR-309 as burst profile number 1.

4.6 Equipment Requirements

The following equipment is required for executing the test cases in this plan:

- At least one variable attenuator per ODN. The variable attenuators should cover the range of 0-40 dB
- Optical test equipment, including at least one power meter per OLT/ONU
- Ethernet generator and analyzer containing at least two data interfaces

Additional equipment might be included in the test setup:

- 20km & 40km spools of fiber
- XG-PON analyzer
- Optical splitter

4.7 Basic Tracing and Troubleshooting Facilities

In order to aid troubleshooting and help efficient testing, it is recommended that the OLT and ONU provide basic tracing information. Examples of such information are:

- OLT and ONU state
- Sent and received PLOAM messages: ONU-ID and contents in hexadecimal format. Ideally, also a parsed version of the message.
- Received XGEM frames: Port-ID and PLI
- Number of sent and received bandwidth allocations
- Number of sent and received XGEM frames and bytes
- Number of sent and received FEC frames and FEC errors
- Number of HEC errors in XGTC header
- Number of HEC errors in bandwidth allocation structures
- Number of HEC errors in XGEM header
- Time of day timestamps
- Count and content of sent and received OMCI messages
- Count and type of errors found in the received stream

5 Test Case Summary

5.1 PMD Layer Tests

This section intentionally left blank (for further study).

5.2 Basic TC Layer Tests

Test Name	Test Type
ONU start-up	(test section)
ONU Discovery - Single ONU (cold OLT, cold ONU)	Mandatory
ONU Activation	Mandatory
ONU Discovery – Multiple ONUs (warm PON)	Mandatory
ONU Activation – Multiple ONUs without Data Transmission	Mandatory
ONU Discovery – Multiple ONUs (cold OLT, cold ONUs)	Mandatory
ONU Discovery and Activation during Data Transmission	Mandatory
DD40 Differential Reach Operation	Mandatory
Bandwidth Allocation	(test section)
Single Allocation	Mandatory
Repetitive Allocation	Mandatory
Burst Series	Mandatory
Maximal Allocation	Mandatory
Adjacent Allocations to Different ONUs	Mandatory
Embedded OAM Operation	(test section)
PON-ID	Mandatory
Dying Gasp	Mandatory
PLOAM Queue Status	Mandatory
Dynamic Bandwidth Reporting	Mandatory
PLOAM Channel Operation	(test section)
Multiple PLOAM Messages per Frame	Conditionally Mandatory for OLT, mandatory for ONU
Burst Profile Version Changes	Mandatory
ONU Deactivation and Disable SN	Mandatory
Alloc-ID Allocation and De-allocation	Mandatory
Encryption Key Exchange	Mandatory
Forward error correction	Mandatory
Downstream FEC Operation	Mandatory

Upstream FEC Operation – Integral Multiple of Codeword Size	Mandatory
Upstream FEC Operation – Non-Integral Multiple of Codeword Size	Mandatory
Upstream FEC Operation – Burst Series with Shared Parity Words	Mandatory
Upstream FEC Operation – Mixed FEC and No-FEC Accesses – Multiple ONUs	Mandatory
Data transmission	(test section)
OMCI Channel Establishment	Mandatory
OMCI Channel Establishment – Multiple ONUs	Mandatory
Downstream Encryption Operation	Mandatory
Upstream Encryption Operation	Mandatory
Downstream Ethernet Traffic Transmission	Mandatory
Upstream Ethernet Traffic Transmission	Mandatory
Bidirectional Ethernet Traffic Transmission	Mandatory
Multiple Port-ID/Alloc-ID Data Transmission – Single ONU	Mandatory
Bidirectional Ethernet Traffic Transmission – Multiple ONUs	Mandatory

5.3 Comprehensive TC Layer Tests

Test Name	Test Type
Authentication and Encryption	(test section)
Registration-ID Based Authentication	Mandatory
Automatic Encryption Key Exchange and Traffic Transmission	Mandatory
Encrypted Ethernet Transmission	Mandatory
Multicast Encryption Operation	Mandatory
ONU Re-Activation After Fiber Disconnection with Registration-ID Based Authentication	Mandatory
Automatic Encryption Key Exchange during Traffic	Mandatory
Secure Mutual Authentication – OMCI Based	Conditionally Mandatory
Secure Mutual Authentication – 802.1x	Conditionally Mandatory
ONU Re-Activation after Fiber Disconnection with Secure Mutual Authentication	Conditionally Mandatory
Request Registration after Secure Mutual Authentication	Conditionally Mandatory
ONU Power Management Modes	(test section)
Doze Mode	Mandatory
Doze Mode (ONU Wakeup)	Mandatory

Cyclic Sleep	Conditionally Mandatory
Cyclic Sleep (ONU Wakeup)	Conditionally Mandatory
Dynamic Bandwidth Allocation	(test section)
DBA Operation - Single ONU	Mandatory
DBA Operation - Multiple ONUs	Mandatory
DBA Operation under Different Traffic Loads - Multiple ONUs	Mandatory
Drift Control and Compensation	(test section)
Acceptable Transmission Drift Boundary	Mandatory
Adjustable Transmission Drift Boundary (DOW)	Mandatory
Unacceptable Transmission Drift Boundary (TIW)	Mandatory
Time of Day Distribution over XG-PON1	(test section)
Time of Day Distribution – Fixed Equalization Delay, Single ONU	Mandatory
Time of Day Distribution – Equalization Delay Adjustments, Single ONU	Mandatory
Time of Day Synchronization - Multiple ONUs	Mandatory
Protection Switching	(test section)
Intermittent LODS	Mandatory

6 PMD Layer Tests

6.1 General

This section intentionally left blank (for further study).

7 Basic TC Layer Tests

7.1 ONU start-up

7.1.1 ONU Discovery - Single ONU (cold OLT, cold ONU)

Test Status: Mandatory

Reference Documents:

- ITU-T G.987.3 [6], Sections 6, 8, 10, 11 and 12.

Test Objective:

Verify that the OLT is able to detect ONU. Verify XG-PON framing, synchronization and serial number acquisition.

Test Setup:

- As shown in Section 4

Pretest Conditions:

1. The OLT and ONU are powered and connected according to the test setup.

Test Configuration:

Parameters for profile message #1:

- ONU-ID: 0x3FF (broadcast ONU-ID)
- Version: 0
- Profile index: 0
- Upstream FEC: off
- PON-TAG: 0x4f 0x4c 0x54 0x23 0x30 0x30 0x30 0x30 (“OLT#0000”)
- Other parameters specified in Section 4.5 for burst profile 0

Parameters for profile message #2:

- ONU-ID: 0x3FF (broadcast ONU-ID)
- Version: 0
- Profile index: 1
- Upstream FEC: on
- PON-TAG: 0x4f 0x4c 0x54 0x23 0x30 0x30 0x30 0x30 (“OLT#0000”)
- Other parameters specified in Section 4.5 for burst profile 1

Parameters for serial number grant:

- Alloc-ID: 0x03FF
- Flags: 1 (DBRu=0, PLOAMu=1)
- Start time: at the discretion of the OLT. Suggested value: 0x100
- Grant size: 0
- FWI: 0
- Burst profile: 0

Parameters for serial number ONU message:

- ONU-ID: 0x3FF (unassigned ONU-ID)
- Sequence number: 0
- Vendor ID: at the discretion of the ONU. Suggested value: 0x41 0x42 0x43 0x44 (“ABCD”)
- VSSN: at the discretion of the ONU. Suggested value: 0x31 0x32 0x33 0x34 (“1234”)

Test Procedure and message timeline:

1. ONU is at state O1 until downstream frame synchronization is attained. It then transitions to state O2-3.
2. OLT transmits the profile messages. Each message is sent at least twice.
3. OLT sends a serial number grant.
4. ONU responds with a serial number ONU message.
5. OLT prints the received serial number.

Pass/Fail Criteria:

1. Serial number detected by the OLT is correct.
2. ONU has entered serial number state (O2-3).

Remarks:

- PON-TAG can be chosen to a different value at the discretion of the OLT, but must be the same for the two profiles.
- Other profile parameters should be chosen according to Section 4.5.
- Only a single ONU should be connected to the ODN for this test. If additional ONUs are connected, they should be not answer the serial number grant.

7.1.2 ONU Activation

Test Status: **Mandatory**

Reference Documents:

- ITU-T G.987.3 [6], Sections 6, 8, 11 and 12.

Test Objective:

Verify that the OLT is able to detect and activate the ONU and the ranging process. This test follows the ONU discovery test.

Test Setup:

- As shown in Section 4

Pretest Conditions:

1. The OLT and ONU are powered and connected according to the test setup.
2. The OLT learned the serial number of the ONU.
3. The ONU is in serial number state (O2-3).

Test Configuration:

Profiles from the ONU discovery test (6.1.1) are used in this test.

Parameters for assign ONU-ID message:

- Destination ONU-ID: 0x3FF (broadcast ONU-ID)
- Sequence number: broadcast PLOAM sequence number
- Set ONU-ID: 1
- Vendor ID and VSSN: as learned in the ONU discovery test

Parameters for ranging grant:

- Alloc-ID: 1
- Flags: 1 (DBRu=0, PLOAMu=1)
- Start time: at the discretion of the OLT. Suggested value: 0x100
- Grant size: 0
- FWI: 0
- Burst profile: 0

Parameters for registration message:

- ONU-ID: 1
- Sequence number: 0
- Registration ID: at the discretion of the ONU. Suggested value: 36 octets of 0x00

Parameters for ranging time message:

- ONU-ID: 1
- Sequence number: 1
- Equalization delay parsing method (octet 5): 0x01 (absolute)
- MIC is calculated using the new derived PLOAM-IK (see comment at 2.1)

Parameters for acknowledge message:

- ONU-ID: 1
- Sequence number: same as ranging time message
- Completion code: 0 (ok)
- MIC is calculated using the new derived PLOAM-IK (see comment at 2.1)

Test Procedure and message timeline:

1. OLT sends an assign ONU-ID message.
2. ONU sets up the default Alloc-ID (1) and default OMCC XGEM Port-ID (1) and transitions to state O4.
3. OLT sends a ranging grant.
4. ONU responds with a registration message.
5. OLT sends a ranging time message. It then provides an allocation with PLOAMu enabled.
6. ONU updates its equalization delay, transitions to state O5 and sends an acknowledge message.

Pass/Fail Criteria:

1. ONU received ONU-ID(1) and entered state O4
2. OLT reports an ONU with the expected serial number has been correctly ranged.
3. ONU has entered regular operational state (O5).
4. OLT received the acknowledge message.

Remarks:

- OLT should count the number of answered allocations and ONU should count the number of granted allocations.

7.1.3 ONU Discovery – Multiple ONUs (warm PON)

Test Status: Mandatory

Reference Documents:

- ITU-T G.987.3 [6], Sections 6, 8, 10, 11 and 12.

Test Objective:

Verify that the OLT is able to detect additional ONUs, one at a time. This test follows the ONU activation test of the first ONU.

Test Setup:

- As shown in Section 4

Pretest Conditions:

1. The OLT and ONUs are powered and connected according to the test setup.
2. First ONU is in operational state (O5).
3. Other ONUs are reset to their initial state (see remarks).

Test Configuration:

Profiles from the ONU discovery test (6.1.1) are used in this test.

Parameters for serial number grant:

- Alloc-ID: 0x03FF
- Flags: 1 (DBRu=0, PLOAMu=1)
- Start time: at the discretion of the OLT. Suggested value: 0x100
- Grant size: 0
- FWI: 0
- Burst profile: 0

Parameters for serial number ONU message:

- ONU-ID: 0x3FF (unassigned ONU-ID)
- Sequence number: 0
- Vendor ID: at the discretion of the ONU.
- VSSN: at the discretion of the ONU, coordinated between participants so serial numbers are unique

Test Procedure and message timeline:

1. ONU(except first ONU) to be detected is at state O1 until downstream frame synchronization is attained. Each ONU (except first ONU) then transitions to state O2-3.
2. OLT transmits the profile messages. Each message is sent at least twice.
3. OLT sends a serial number grant.
4. ONU(except first ONU) responds with a serial number ONU message.
5. OLT prints the received serial number.
6. Steps 1-5 are repeated until all of the serial numbers are learned.

Pass/Fail Criteria:

1. Serial numbers detected by the OLT are correct.
2. First ONU stays at operational state (O5).
3. All additional ONUs have entered serial number state (O2-3).

Remarks:

- Interoperability between three or more vendors should also be tested. The roles of “first ONU” and “other ONUs” should be rotated.

7.1.4 ONU Activation – Multiple ONUs without Data Transmission

Test Status: Mandatory

Reference Documents:

- ITU-T G.987.3 [6], Sections 6, 8, 11 and 12.

Test Objective:

Verify that the OLT is able to activate additional ONUs. This test follows the ONU discovery – multiple ONUs test.

Test Setup:

- As shown in Section 4

Pretest Conditions:

1. The OLT and ONUs are powered and connected according to the test setup.
2. First ONU is in operational state (O5).
3. The OLT learned the serial number of the other ONUs.
4. Other ONUs are in serial number state (O2-3).

Test Configuration:

Profiles from the ONU discovery test (6.1.1) are used in this test. Parameters for other messages are defined in test ONU activation – single ONU test (6.1.2). ONU-IDs are at the discretion of the OLT.

Test Procedure and message timeline:

1. OLT sends an assign ONU-ID message to an inactive ONU.
2. ONU sets up the default Alloc-ID and default OMCC XGEM Port-ID and transitions to state O4.
3. OLT sends a ranging grant to the ONU.
4. ONU responds with a registration message.
5. OLT sends a ranging time message. It then provides an allocation with PLOAMu enabled.
6. ONU updates its equalization delay, transitions to state O5 and sends an acknowledge message.
7. OLT repeats the procedure for each additional ONU.

Pass/Fail Criteria:

1. All ONUs(except first ONU) received ONU-ID and entered state O4.
2. OLT reports that all ONUs with the expected serial numbers have been correctly ranged.
3. All ONUs have entered regular operational state (O5).
4. OLT received acknowledge messages.

Remarks:

- OLT should count the number of answered allocations and ONU should count the number of granted allocations.
- Interoperability between three or more vendors should also be tested. Order of activation should be rotated.

7.1.5 ONU Discovery – Multiple ONUs (cold OLT, cold ONUs)

Test Status: Mandatory

Reference Documents:

- ITU-T G.987.3 [6], Sections 6, 8, 10, 11 and 12.

Test Objective:

Verify that the OLT is able to detect multiple ONUs simultaneously.

Test Setup:

- As shown in Section 4

Pretest Conditions:

1. The OLT and ONUs are powered and connected according to the test setup.
2. All units are in their initial reset state.

Test Configuration:

Profiles from the ONU discovery test (6.1.1) are used in this test.

Test Procedure and message timeline:

1. ONUs are at state O1 until downstream frame synchronization is attained. Each ONU then transitions to state O2-3.
2. OLT transmits the profile messages. Each message is sent at least twice.
3. OLT sends a serial number grant.
4. ONUs respond with a serial number ONU message.
5. OLT prints the received serial numbers.
6. Steps 3-5 are repeated until all of the serial numbers are learned.

Pass/Fail Criteria:

1. Serial numbers detected by the OLT are correct.
2. All ONUs have entered serial number state (O2-3).

Remarks:

- None

7.1.6 ONU Discovery and Activation during Data Transmission

Test Status: Mandatory

Reference Documents:

- ITU-T G.987.3 [6], Sections 6, 8, 9, 11 and 12.

Test Objective:

Verify that the OLT is able to discover and activate additional ONUs while data transmission is taking place. Verify that data transmission to the first ONU is not interrupted.

Test Setup:

- As shown in Section 4
- If the specified Port-ID and/or Alloc-ID cannot be provisioned manually, automatic provisioning is allowed. In such case, these parameters will be coordinated after pairing.

Pretest Conditions:

1. The OLT and ONUs are powered and connected according to the test setup.
2. First ONU is in operational state (O5).
3. Port-ID 1024 is provisioned on both downstream and upstream and assigned to Alloc-ID 1024 for first ONU.
4. Other ONUs are reset to their initial state.

Test Configuration:

Profiles from the ONU discovery test (6.1.1) are used in this test. Parameters for other messages are defined in test ONU activation – single ONU test (6.1.2). ONU-IDs are at the discretion of the OLT. Additional parameters (e.g. VLAN tag mapping, order of generator and analyzer enable) are to be coordinated after pairing.

Parameters for bandwidth allocation structures:

- Alloc-ID: 1024
- Start time: at the discretion of the OLT
- Grant size: at the discretion of the OLT
- FWI: 0
- Burst profile: 0

Test Procedure and message timeline:

1. Traffic generators are enabled for downstream and upstream traffic.
2. Received data is tested by the Ethernet traffic analyzer for both downstream and upstream.
3. Other ONUs are at state O1 until downstream frame synchronization is attained. Each ONU then transitions to state O2-3.
4. OLT transmits the profile messages. Each message is sent at least twice.
5. OLT sends a serial number grant.
6. ONUs respond with a serial number ONU message.
7. OLT prints the received serial number.
8. OLT sends an assign ONU-ID message to the newly detected ONU.

9. ONU sets up the default Alloc-ID and default OMCC XGEM Port-ID and transitions to state O4.
10. OLT sends a ranging grant to an inactive ONU.
11. The ONU responds with a registration message.
12. OLT sends a ranging time message. It then provides an allocation with PLOAMu enabled.
13. ONU updates its equalization delay, transitions to state O5 and sends an acknowledge message.
14. OLT repeats the procedure for each additional ONU.

Pass/Fail Criteria:

1. Serial numbers detected by the OLT are correct.
2. OLT reports that all ONUs with the expected serial numbers have been correctly ranged.
3. All ONUs have entered regular operational state (O5).
4. OLT received acknowledge messages.
5. No errors are detected in downstream and upstream traffic during the whole duration of the test.

Remarks:

- OLT should count the number of answered allocations and ONU should count the number of granted allocations.
- Interoperability between three or more vendors should also be tested.

7.1.7 DD40 Differential Reach Operation

Test Status: Mandatory

Reference Documents:

- ITU-T G.987.3 [6], Sections 6, 8, 10, 11 and 12.

Test Objective:

Verify that the OLT is able to detect two ONUs with a differential distance of 40km.

Test Setup:

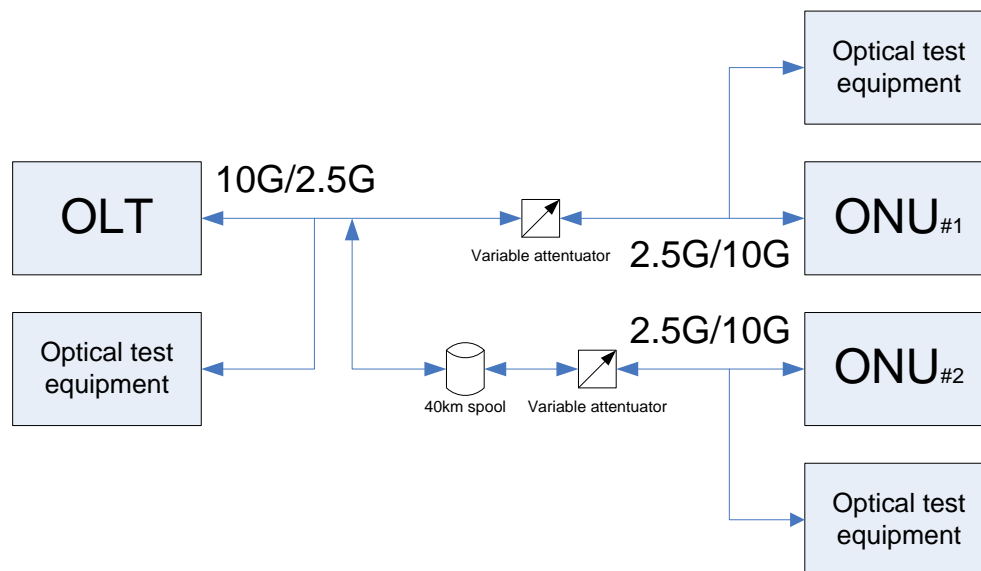


Figure 4 – Test Setup for DD40 Differential Reach Test

Pretest Conditions:

1. The OLT and ONUs are powered and connected according to the test setup.
2. All units are in their initial reset state.

Test Configuration:

Profiles from the ONU discovery test (6.1.1) are used in this test.

Test Procedure and message timeline:

1. ONUs are at state O1 until downstream frame synchronization is attained. Each ONU then transitions to state O2-3.
2. OLT transmits the profile messages. Each message is sent at least twice.
3. OLT sends a serial number grant.
4. ONUs respond with a serial number ONU message.
5. OLT prints the received serial numbers.
6. OLT sends an assign ONU-ID message to the detected ONU.

7. ONU sets up the default Alloc-ID and default OMCC XGEM Port-ID and transitions to state O4.
8. OLT sends a ranging grant.
9. ONU responds with a registration message.
10. OLT sends a ranging time message. It then provides an allocation with PLOAMu enabled.
11. ONU updates its equalization delay, transitions to state O5 and sends an acknowledge message.
12. Steps 3-11 are repeated for the second ONU.

Pass/Fail Criteria:

1. - "PASS (DD40)" when the test is PASS with a spool of 40km
2. - "PASS (DD20)" when the test is PASS with a spool of 20km and FAIL with a 40km spool
3. - "FAIL" otherwise

Remarks:

- If this test fails, a differential distance of 20km can be tested.

7.2 Bandwidth Allocation

7.2.1 Single Allocation

Test Status: Mandatory

Reference Documents:

- ITU-T G.987.3 [6], Section 8.1.2.

Test Objective:

Verify correct generation and parsing of bandwidth allocation structures.

Test Setup:

- As shown in Section 4

Pretest Conditions:

1. The OLT and ONU are powered and connected according to the test setup.
2. The ONU has been ranged and activated by the OLT.

Test Configuration:

Profiles from the ONU discovery test (6.1.1) are used in this test.

Downstream FEC parity bytes can be ignored (error-free reception is assumed).

Parameters for bandwidth allocation structures:

Table 7-1 – Bandwidth Allocation Parameters For Single Allocation

Alloc-ID	Start time	Grant size	PLOAMu	DBRu	Notes
1	100*	256	0	0	
1	0	256	0	0	Minimal Start time
1	9719	256	0	0	Maximal Start time
1	100*	4	0	0	Minimal XGEM section
1	100*	9718	0	0	Maximal allocation size
1	100*	1	0	1	DBRu only grant
1	100*	1	1	1	PLOAM + DBRu only
1	100*	5	0	1	Minimal XGEM + DBRu
1	100*	5	1	1	Minimal XGEM + PLOAM + DBRu

Start time for bandwidth allocation structures marked with (*) are recommended values, and can be changed at the discretion of the OLT as long as grant size is kept as specified. Where not specified, exact start time is mandatory.

Common parameters:

- FWI: 0
- Burst profile: 0

Test Procedure:

1. After ranging succeeds, OLT sends bandwidth allocation structures with one of the bandwidth allocation structures described above once and idle downstream traffic. Bandwidth allocation structures are sent one at a time, at separate XGTC frames. Test results are recorded separately for each scenario.
2. Upon getting bandwidth grants, ONU responds appropriately and at the correct time:
 - a. XGTC header section: headers and acknowledge PLOAM if PLOAMu is 1, or header alone if PLOAMu is 0.
 - b. Allocation overhead: any valid DBR structure if DBRu is 1 or not present if DBRu is 0.
 - c. XGTC payload section: idle XGEMs.
3. OLT verifies that idle traffic is received from ONU at the XGTC payload section.
4. Steps 1-3 are repeated for each additional bandwidth map.

Pass/Fail Criteria:

1. OLT detects idle traffic from ONU in the expected windows for each of the scenarios.
2. OLT should count the number of answered allocations and ONU should count the number of granted allocations.

Remarks:

- None

7.2.2 Repetitive Allocation

Test Status: Mandatory

Reference Documents:

- ITU-T G.987.3 [6], Section 8.1.2.

Test Objective:

Verify correct generation and parsing of bandwidth allocation structures.

Test Setup:

- As shown in Section 4

Pretest Conditions:

1. The OLT and ONU are powered and connected according to the test setup.
2. The ONU has been ranged and activated by the OLT.

Test Configuration:

Profiles from the ONU discovery test (6.1.1) are used in this test.

Downstream FEC parity bytes can be ignored (error-free reception is assumed).

Parameters for bandwidth allocation structures:

- Alloc-ID: 1
- Flags: 0
- Start time: at the discretion of the OLT. Recommended value: 100
- Grant size: 256
- FWI: 0
- Burst profile: 0

Test Procedure:

1. After ranging succeeds, OLT sends the bandwidth map described above continuously, one bandwidth map at each XGTC frame.
2. Upon getting bandwidth grants, ONU responds with the XGEM idle upstream traffic at the correct time.
3. OLT verifies that correct traffic is received from ONU.

Pass/Fail Criteria:

1. OLT detects idle traffic from ONU in the expected windows.

2. OLT should count the number of answered allocations and ONU should count the number of granted allocations.

Remarks:

- None

7.2.3 Burst Series

Test Status: Mandatory

Reference Documents:

- ITU-T G.987.3 [6], Section 8.1.2.

Test Objective:

Verify correct generation and parsing of bandwidth maps containing burst series allocation structures.

Test Setup:

- As shown in Section 4

Pretest Conditions:

1. This test can be performed only after the Alloc-ID allocation and de-allocation test has been performed successfully.
2. The OLT and ONU are powered and connected according to the test setup.
3. The ONU has been ranged and activated by the OLT.
4. Alloc-ID 1024 is assigned to the ONU, using assign Alloc-ID PLOAM message. The PLOAM message is acknowledged.

Test Configuration:

Profiles from the ONU discovery test (6.1.1) are used in this test.

Downstream FEC parity bytes can be ignored (error-free reception is assumed).

Parameters for bandwidth allocation structures:

Table 7-2 – Bandwidth Allocation Parameters For Burst Series

Access #	Alloc-ID	Start time	Grant size
1	1	100	256
2	1024 (0x400)	65535 (0xFFFF)	256

Common parameters:

- PLOAMu: 0
- DBRu: 0
- FWI: 0
- Burst profile: 0

Test Procedure:

1. After ranging succeeds, OLT sends the bandwidth map described above and idle downstream traffic.
2. Upon getting bandwidth grants, ONU responds with the XGEM idle upstream traffic at the correct time.
3. OLT verifies that correct traffic is received from ONU.

Pass/Fail Criteria:

1. OLT detects idle traffic from ONU in the expected windows.
2. OLT should count the number of answered allocations and ONU should count the number of granted allocations.

Remarks:

- Start time value for the first access is a recommended value only, and can be changed at the discretion of the OLT.

7.2.4 Maximal Allocation

Test Status: Mandatory

Reference Documents:

- ITU-T G.987.3 [6], Section 8.1.2.

Test Objective:

Verify correct generation and parsing of bandwidth maps containing bandwidth allocation structures with maximal grant sizes.

Test Setup:

- As shown in Section 4

Pretest Conditions:

1. The OLT and ONU are powered and connected according to the test setup.
2. The ONU has been ranged and activated by the OLT.

Test Configuration:

Profiles from the ONU discovery test (6.1.1) are used in this test.

Downstream FEC parity bytes can be ignored (error-free reception is assumed).

Parameters for bandwidth allocation structures:

- Alloc-ID: 1
- Flags: 0
- Start time: at the discretion of the OLT.
- Grant size: set to maximum possible, considering overheads such as PSBu, XGTC header and XGTC trailer.
- FWI: 0
- Burst profile: 0

Test Procedure:

1. After ranging succeeds, OLT sends the bandwidth map described above 10 times and idle downstream traffic.
2. Upon getting bandwidth grants, ONU responds with the XGEM idle upstream traffic at the correct time.
3. OLT verifies that correct traffic is received from ONU.

Pass/Fail Criteria:

1. OLT detects idle traffic from ONU in the expected windows.
2. OLT should count the number of answered allocations and ONU should count the number of granted allocations.

Remarks:

- None

7.2.5 Adjacent Allocations to Different ONUs

Test Status: Mandatory

Reference Documents:

- ITU-T G.987.3 [6], Section 8.1.2.

Test Objective:

Verify correct system behavior with bandwidth maps containing allocation structures with adjacent bursts.

Test Setup:

- As shown in Section 4

Pretest Conditions:

1. The OLT and ONUs are powered and connected according to the test setup.
2. The ONUs have been ranged and activated by the OLT.

Test Configuration:

Profiles from the ONU discovery test (6.1.1) are used in this test.

Downstream FEC parity bytes can be ignored (error-free reception is assumed).

Parameters for bandwidth allocation structures:

- Alloc-ID: 1, 2
- Flags: 0
- Start time: at the discretion of the OLT.
- Grant size: set to maximum possible, considering overheads such as guard time, PSBu, XGTC header and trailer.
- FWI: 0
- Burst profile: 0

Test Procedure:

1. After ranging succeeds, OLT sends the bandwidth allocation structures described above and idle downstream traffic.
2. Upon getting bandwidth grants, an ONU responds with the XGEM idle upstream traffic at the correct time.
3. OLT verifies that correct traffic is received from ONU.

Pass/Fail Criteria:

1. OLT detects idle traffic from an ONU in the expected windows.
2. OLT should count the number of answered allocations and ONU should count the number of granted allocations.

Remarks:

- None

7.3 Embedded OAM Operation

7.3.1 PON-ID

Test Status: Mandatory

Reference Documents:

- ITU-T G.987.3 [6], Section 10.1.1.

Test Objective:

- Verify that the OLT can generate and the ONU can properly process the PON-ID structure in the PSBd.

Test Setup:

- As shown in Section 4

Pretest Conditions:

1. The OLT and ONU are powered and connected according to the test setup.
2. Value of PON-ID is set at the OLT.
3. The ONU has been ranged and activated by the OLT.

Test Configuration:

Profiles from the ONU discovery test (6.1.1) are used in this test.
Value of PON-ID is at the discretion of the OLT.

Test Procedure:

1. ONU reports the received PON-ID value. This value is compared with the value set at the OLT.

Pass/Fail Criteria:

1. PON-ID value recognized by the ONU is identical to the value set by the OLT.

Remarks:

- None

7.3.2 Dying Gasp

Test Status: Mandatory

Reference Documents:

- ITU-T G.987.3 [6], Section 8.2.1.2.

Test Objective:

Verify that the ONU can generate and the OLT can properly process the following upstream embedded OAM indication:

- Dying gasp

Test Setup:

- As shown in Section 4

Pretest Conditions:

1. The OLT and ONU are powered and connected according to the test setup.
2. The ONU has been ranged and activated by the OLT.

Test Configuration:

Profiles from the ONU discovery test (6.1.1) are used in this test. Downstream FEC parity bytes can be ignored (error-free reception is assumed). Parameters of the bandwidth grants are at the discretion of the OLT.

Test Procedure:

1. ONU is manually configured to send dying gasp indications.
2. OLT sends bandwidth grants.
3. ONU responds to the grants.
4. Cause ONU to send Dying Gasp by removing power to the ONU.

Pass/Fail Criteria:

1. Dying gasp indication is recognized by OLT.

Remarks:

- None

7.3.3 PLOAM Queue Status

Test Status: Mandatory

Reference Documents:

- ITU-T G.987.3 [6], Section 8.2.1.2.

Test Objective:

Verify that the ONU can generate and the OLT can properly process the following upstream embedded OAM indication:

- PLOAM queue status

Test Setup:

- As shown in Section 4

Pretest Conditions:

1. The OLT and ONU are powered and connected according to the test setup.
2. The ONU has been ranged and activated by the OLT.

Test Configuration:

Profiles from the ONU discovery test (6.1.1) are used in this test.

Downstream FEC parity bytes can be ignored (error-free reception is assumed).

Parameters of the bandwidth grants are at the discretion of the OLT.

Test Procedure:

1. OLT sends two directed profile updates with increasing version numbers. No bandwidth grants are sent.
2. OLT waits at least 10ms and then sends a single bandwidth grant without PLOAMu.
3. ONU responds with PLOAM queue status bit asserted.
4. OLT sends a single bandwidth grant with PLOAMu.
5. ONU responds with an acknowledge message and PLOAM queue status bit asserted.
6. OLT sends a single bandwidth grant with PLOAMu.
7. ONU responds with an acknowledge message and PLOAM queue status bit negated.

Pass/Fail Criteria:

1. PLOAM status queue bit is correct.

Remarks:

- None

7.3.4 Dynamic Bandwidth Reporting

Test Status: Mandatory

Reference Documents:

- ITU-T G.987.3 [6], Section 8.2.2.

Test Objective:

Verify that the OLT can request and the ONU can generate DBR reports.

Test Setup:

- As shown in Section 4

Pretest Conditions:

1. This test can be performed only after the Alloc-ID allocation and de-allocation test has been performed successfully.
2. The OLT and ONU are powered and connected according to the test setup.
3. The ONU has been ranged and activated by the OLT.
4. Alloc-ID 1024 is assigned to the ONU, using assign_Alloc_ID PLOAM message. The PLOAM message is acknowledged.

Test Configuration:

Profiles from the ONU discovery test (6.1.1) are used in this test.

Downstream FEC parity bytes can be ignored (error-free reception is assumed).

Parameters for bandwidth allocation structures:

- Alloc-ID: 1024
- Flags: 2 (DBRu=1, PLOAMu=0)
- Start time: at the discretion of the OLT. Recommended value: 100
- Grant size: 1
- FWI: 0
- Burst profile: 0

Test Procedure:

1. After ranging succeeds, OLT sends the bandwidth allocation structures described above.
2. Upon getting bandwidth grants, ONU responds with a DBRu structure.
3. OLT tests the CRC field of the DBRu.

Pass/Fail Criteria:

1. OLT detects a DBRu header with correct CRC field.

Remarks:

- None.

7.4 PLOAM Channel Operation

7.4.1 Multiple PLOAM Messages per Frame

Test Status: Conditional for OLT, mandatory for ONU

Reference Documents:

- ITU-T G.987.3 [6], Sections 8.1.1, 8.1.4 and 11.

Test Objective:

Verify that the ONU is able to detect and process a broadcast PLOAM message and a unicast PLOAM message transmitted in the same XGTC frame.

Test Setup:

- As shown in Section 4

Pretest Conditions:

1. The OLT and ONU are powered and connected according to the test setup.
2. The ONU has been ranged and activated by the OLT. The ONU is assigned with ONU-ID=1.

Test Configuration:

Downstream FEC parity bytes can be ignored (error-free reception is assumed).

Parameters for broadcast profile message:

- ONU-ID: 0x3FF (broadcast ONU-ID)
- Version: 0
- Profile index: 2
- Delimiter value: at the discretion of the OLT. Recommended value 0xCE99 CE5E 5028 B41F
- All other parameters are the same as the burst profile number 0 described in Section 4.5

Parameters for registration request message:

- ONU-ID: 1
- MIC is calculated using the default PLOAM integrity key (see comment at 2.1)

Test Procedure and message timeline:

1. After ranging succeeds, OLT sends the broadcast profile message and the registration request message in a single XGTC frame. Transmission is done only once.
2. ONU detects, reports and counts both messages.

Pass/Fail Criteria:

1. ONU successfully reports and counts both messages.

Remarks:

- Generation of this test case by OLT can be non-trivial, as precise timing of PLOAM message transmission might not be easily controllable due to layering. Hence, this test is conditional for OLT. An ONU, however, must support such XGTC frame and the test is mandatory for ONU.

7.4.2 Burst Profile Version Changes

Test Status: Mandatory

Reference Documents:

- ITU-T G.987.3 [6], Section 11.3.3.1.

Test Objective:

Verify that the OLT can generate and the ONU can properly process the following downstream PLOAM message:

- Burst profile version changes

Test Setup:

- As shown in Section 4

Pretest Conditions:

1. The OLT and ONU are powered and connected according to the test setup.
2. The ONU has been ranged and activated by the OLT. The ONU is assigned with ONU-ID=1.

Test Configuration:

Downstream FEC parity bytes can be ignored (error-free reception is assumed).

Parameters for broadcast profile message:

- ONU-ID: 0x3FF (broadcast ONU-ID)
- Version: 0
- Profile index: 2
- Delimiter value: at the discretion of the OLT. Recommended value 0xCE99 CE5E 5028 B41F
- All other parameters are the same as the burst profile number 0 described in Section 4.5

Parameters for directed profile message:

- ONU-ID: 1
- Version: 1
- Profile index: 2
- Delimiter value: at the discretion of the OLT, but different than the broadcast profile message. Recommended value 0xB752 1F06 48AD E879
- All other parameters are the same as the burst profile number 0 described in Section 4.5

Parameters for bandwidth allocation structures are at the discretion of the OLT. Profile index 2 should be used.

Test Procedure and message timeline:

1. After ranging succeeds, OLT sends the broadcast profile message at least twice.
2. OLT sends bandwidth allocation structures with profile index 2.
3. Upon getting bandwidth grants, ONU responds with idle XGEM frames.
4. OLT detects idle traffic from ONU in the expected windows.
5. OLT stops sending bandwidth grants. It sends the directed profile message as described above, and is configured for the second set of parameters. It then resumes sending bandwidth grants, with PLOAMu allowed at regular intervals.
6. ONU updates to the new profile and responds with the XGEM frame described above for the granted bandwidth. When PLOAMu is granted, ONU acknowledges the profile update.
7. OLT detects idle traffic from ONU in the expected windows.

Pass/Fail Criteria:

1. ONU reports a successful profile update.
2. OLT detects idle traffic from ONU in the expected windows.
3. OLT should count the number of answered allocations and ONU should count the number of granted allocations.

Remarks:

- None

7.4.3 ONU Deactivation and Disable SN

Test Status: Mandatory

Reference Documents:

- ITU-T G.987.3 [6], Sections 11.3.3.4, 11.3.3.5.

Test Objective:

Verify that the OLT can generate and the ONU can properly process the following downstream PLOAM messages:

- ONU deactivation
- Disable serial number

Test Setup:

- As shown in Section 4

Pretest Conditions:

1. The OLT and ONU are powered and connected according to the test setup.
2. The ONU has been ranged and activated by the OLT. The ONU is assigned with ONU-ID=1.

Test Configuration:

Profiles from the ONU discovery test (6.1.1) are used in this test.

Downstream FEC parity bytes can be ignored (error-free reception is assumed).

Parameters for bandwidth allocation structures are at the discretion of the OLT.

Parameters for Deactivate_ONU-ID message:

- ONU-ID: 1
- SeqNo: unicast PLOAM sequence number
- MIC is calculated using the default PLOAM integrity key

Parameters for disable serial number message:

- ONU-ID: 0x03FF
- Disable: 0xFF for disable, 0x00 for enable
- Vendor ID, VSSN: as learned in the ONU discovery test

Test Procedure and message timeline:

1. After ranging succeeds, OLT sends bandwidth allocation structures with grants to the ONU.
2. Upon getting bandwidth grants, ONU responds with idle XGEM frames.
3. OLT detects idle traffic from ONU in the expected windows.
4. OLT sends a deactivate ONU-ID message. It then sends bandwidth grants.
5. ONU transitions to state O1 then transitions to state O2-3 and does not respond to the grants.
6. OLT ranges and activates the ONU.
7. After ranging succeeds, OLT sends bandwidth allocation structures with grants to the ONU. ONU responds with idle XGEM frames and OLT detects idle traffic from ONU in the expected windows.
8. OLT sends a disable serial number message with the disable setting. It then continues to send bandwidth grants to the ONU.
9. ONU transitions to state O7 and does not respond to the grants.
10. OLT sends a disable serial number message with the enable setting.
11. ONU transitions to state O1.
12. OLT ranges and activates the ONU.
13. After ranging succeeds, OLT sends bandwidth allocation structures with grants to the ONU. ONU responds with idle XGEM frames and OLT detects idle traffic from ONU in the expected windows.

Pass/Fail Criteria:

1. Bandwidth grants sent for a deactivated or disabled ONU are not responded.
2. ONU transitions to state O1 then transitions to state O2-3 when receiving deactivate ONU-ID (step 5), to state O7 when receiving disable serial number (step 9) and to state O1 when receiving enable serial number (step 11).
3. ONU returns to regular operational state (O5) after each ranging and correctly responds to bandwidth grants.

Remarks:

- None

7.4.4 Alloc-ID Allocation and De-allocation

Test Status: Mandatory

Reference Documents:

- ITU-T G.987.3 [6], Section 11.3.3.7.

Test Objective:

Verify that the OLT can generate and the ONU can properly process the “assign Alloc-ID” downstream PLOAM message, with “Alloc-ID-type”:

- 1 – XGEM encapsulated payload
- 255 – de-allocate Alloc-ID

Test Setup:

- As shown in Section 4

Pretest Conditions:

1. The OLT and ONU are powered and connected according to the test setup.
2. The ONU has been ranged and activated by the OLT.

Test Configuration:

Profiles from the ONU discovery test (6.1.1) are used in this test.

Downstream FEC parity bytes can be ignored (error-free reception is assumed).

Parameters for bandwidth allocation structures:

- Alloc-ID: 1, 2, 1024, 1025
- Start time: at the discretion of the OLT
- Grant size: 256
- FWI: 0
- Burst profile: 0

Parameters for assign Alloc-ID message:

- ONU-ID: 1
- Alloc-ID value: 1024
- Alloc-ID type: 1 or 255, as described below

Test Procedure and message timeline:

1. After ranging succeeds and ONU-ID 1 is activated, OLT sends the bandwidth allocation structures with grants to all four specified Alloc-IDs.
2. Upon getting bandwidth grants, ONU responds with idle XGEM frames only to Alloc-ID 1.
3. OLT detects idle traffic from ONU in the expected windows. Only grants to Alloc-ID 1 are responded.
4. OLT sends an assign Alloc-ID with type 1 and Alloc-ID 1024 to ONU-ID 1. It then sends a grant with PLOAMu to Alloc-ID 1
5. ONU acknowledges the message.
6. OLT sends bandwidth allocation structures with grants to all four specified Alloc-IDs. Only grants to Alloc-IDs 1 and 1024 are responded.
7. OLT sends an assign Alloc-ID with type 255 and Alloc-ID 1024 to ONU-ID 1. It then sends a grant with PLOAMu to Alloc-ID 1.
8. ONU acknowledges the message.
9. OLT sends bandwidth allocation structures with grants to all four specified Alloc-IDs. Only grants to Alloc-ID 1 are responded.

Pass/Fail Criteria:

1. OLT detects idle traffic from ONU in the expected windows. Only bandwidth allocation structures to assigned Alloc-IDs are responded - when other Alloc-IDs are granted, there is no reply from ONU.
2. OLT should count the number of answered allocations and ONU should count the number of granted allocations.
3. ONU correctly acknowledges the assign Alloc-ID messages when granted.

Remarks:

- None

7.4.5 Encryption Key Exchange

Test Status: Mandatory

Reference Documents:

- ITU-T G.987.3/Amd.1 [7], Section 15.5.3.

Test Objective:

Verify that the OLT and ONU can correctly perform encryption key exchange. This test is focused on the PLOAM message format and not on the encryption of the data.

Test Setup:

- As shown in Section 4

Pretest Conditions:

1. The OLT and ONU are powered and connected according to the test setup.
2. The ONU has been ranged and activated by the OLT.
3. The OLT and ONU are in states KL0 and KN0, respectively (no keys valid).

Test Configuration:

Profiles from the ONU discovery test (6.1.1) are used in this test.

Downstream FEC parity bytes can be ignored (error-free reception is assumed).

Parameters for key control message:

- ONU-ID: 1
- Control: 0 (generate a new key) / 1 (confirm existing key)
- Key index: 01
- Key length: 16 bytes

Parameters for key report message for the new key:

- ONU-ID: 1
- Report type: 0 (new key)
- Key index: 01
- Fragment number: 0

Parameters for key report message for confirmation:

- ONU-ID: 1
- Report type: 1 (existing key)

- Key index: 01
- Fragment number: 0

Test Procedure and message timeline:

1. OLT sends a key control message for a new key.
2. OLT provides a grant with PLOAMu and ONU responses with key report message for the new key.
3. OLT prints the received key fragment (KEK encrypted key) and sends a key control message to confirm the key. It then provides a grant with PLOAMu.
4. ONU sends a key report for the existing key.
5. OLT prints the received key fragment (key name).

Pass/Fail Criteria:

1. Key fragments are correctly printed by OLT.

Remarks:

- Recommended value of actual encryption key:
0x112233445566778899AABBCCDDEEFF00
- Timers TK1-TK5 might have to be relaxed for preliminary implementations

7.5 Forward error correction

7.5.1 Downstream FEC Operation

Test Status: Mandatory

Reference Documents:

- ITU-T G.987.3 [6], Section 10.3.

Test Objective:

Verify that the OLT and ONU can correctly generate and decode FEC parity bytes on the downstream side and perform error-free data transmission.

Test Setup:

- As shown in Section 4
- Attenuation should be set to keep the ONU in the correctable range.

Pretest Conditions:

1. The OLT and ONU are powered and connected according to the test setup.
2. The ONU has been ranged and activated by the OLT.

Test Configuration:

Profiles from the ONU discovery test (6.1.1) are used in this test. Downstream FEC parity bytes are processed.

Test Procedure:

1. After ranging succeeds, OLT sends idle XGEM frames.
2. ONU tests the received data.
3. Variable attenuator is changed to make FEC correction evident.
4. ONU tests the received data.

Pass/Fail Criteria:

1. ONU detects idle traffic under both conditions.
2. Number of bit errors on ONU is zero when ONU operates under optimal conditions.

Remarks:

- None.

7.5.2 Upstream FEC Operation – Integral Multiple of Codeword Size

Test Status: Mandatory

Reference Documents:

- ITU-T G.987.3 [6], Section 10.3.

Test Objective:

Verify that the OLT and ONU can correctly generate and decode FEC parity bytes on the upstream side and perform error-free data transmission.

Test Setup:

- As shown in Section 4
- Attenuation should be set to keep the OLT in the correctable range.

Pretest Conditions:

1. The OLT and ONU are powered and connected according to the test setup.
2. The ONU has been ranged and activated by the OLT.

Test Configuration:

Profiles from the ONU discovery test (6.1.1) are used in this test.

Parameters for bandwidth allocation structures:

- Alloc-ID: 1
- Flags: 0
- Start time: at the discretion of the OLT. Recommended value: 100
- Grant size: 288
- FWI: 0
- Burst profile: 1

Test Procedure:

1. After ranging succeeds, OLT sends the bandwidth allocation structures described above.
2. Upon getting bandwidth grants, ONU responds with the XGEM idle upstream traffic at the correct time.
3. OLT verifies that correct traffic is received from ONU.
4. Variable attenuator is changed to make FEC correction evident.
5. OLT tests the received data.

Pass/Fail Criteria:

1. OLT detects idle traffic from ONU in the expected windows under both conditions.
2. Number of bit errors on OLT is zero when OLT operates under optimal conditions.
3. OLT should count the number of answered allocations and ONU should count the number of granted allocations.

Remarks:

- None.

7.5.3 Upstream FEC Operation – Non-Integral Multiple of Codeword Size

Test Status: Mandatory

Reference Documents:

- ITU-T G.987.3 [6], Section 10.3.

Test Objective:

Verify that the OLT and ONU can correctly generate and decode FEC parity bytes on the upstream side and perform error-free data transmission.

Test Setup:

- As shown in Section 4
- Attenuation should be set to keep the OLT in the correctable range.

Pretest Conditions:

1. The OLT and ONU are powered and connected according to the test setup.
2. The ONU has been ranged and activated by the OLT.

Test Configuration:

Profiles from the ONU discovery test (6.1.1) are used in this test.

Parameters for bandwidth allocation structures:

- Alloc-ID: 1
- Flags: PLOAMu=0 or PLOAMu=1
- Start time: at the discretion of the OLT. Recommended value: 100
- Grant size: 289
- FWI: 0
- Burst profile: 1

Test Procedure:

1. After ranging succeeds, OLT sends the bandwidth allocation structures described above, one at a time.
2. Upon getting bandwidth grants, ONU responds with the XGEM idle upstream traffic at the correct time.
3. OLT verifies that correct traffic is received from ONU.
4. Variable attenuator is changed to make FEC correction evident.
5. OLT tests the received data.

Pass/Fail Criteria:

1. OLT detects idle traffic from ONU in the expected windows under both conditions.
2. Number of bit errors on OLT is zero when OLT operates under optimal conditions.
3. OLT should count the number of answered allocations and ONU should count the number of granted allocations.

Remarks:

- None.

7.5.4 Upstream FEC Operation – Burst Series with Shared Parity Words

Test Status: Mandatory

Reference Documents:

- ITU-T G.987.3 [6], Section 10.3.

Test Objective:

Verify that the OLT and ONU can correctly generate and decode FEC parity bytes on the upstream side and perform error-free data transmission.

Test Setup:

- As shown in Section 4
- Attenuation should be set to keep the OLT in the correctable range.

Pretest Conditions:

1. The OLT and ONU are powered and connected according to the test setup.
2. The ONU has been ranged and activated by the OLT, the assigned ONU-ID is 1.
3. Alloc-ID 1024 is assigned to the ONU.

Test Configuration:

Profiles from the ONU discovery test (6.1.1) are used in this test.

Parameters for bandwidth allocation structures:

Table 7-3 – Bandwidth Allocation Map #1

Access #	Alloc-ID	Start time	Grant size	PLOAMu	DBRu	FWI	Burst Profile
1	1	100	32	0	0	0	1
2	1024 (0x400)	65535 (0xFFFF)	256	0	0	0	1

Table 7-4 – Bandwidth Allocation Map #2

Access #	Alloc-ID	Start time	Grant size	PLOAMu	DBRu	FWI	Burst Profile
1	1	100	32	1	0	0	1
2	1024 (0x400)	65535 (0xFFFF)	256	0	0	0	1

Test Procedure:

1. After ranging succeeds, OLT sends the bandwidth maps described above, one after the other as a burst allocation series. Two burst allocation series are defined for this test, one with PLOAMu=0 and one with PLOAMu=1 that are sent in different XGTC frames.
2. Upon getting bandwidth grants, ONU responds with the XGEM idle upstream traffic at the correct time.
3. OLT verifies that correct traffic is received from ONU.

Pass/Fail Criteria:

1. Number of bit errors on OLT is zero.
2. OLT detects idle traffic from ONU in the expected windows.
3. OLT should count the number of answered allocations and ONU should count the number of granted allocations.
4. Variable attenuator is changed to make FEC correction evident.
5. OLT tests the received data.

Pass/Fail Criteria:

1. OLT detects idle traffic from ONU in the expected windows under both conditions.
2. Number of bit errors on OLT is zero when OLT operates under optimal conditions.
3. OLT should count the number of answered allocations and ONU should count the number of granted allocations.

Remarks:

- Start time value for the first allocation structure in each bandwidth map described above is a recommended value only, and can be changed at the discretion of the OLT.

7.5.5 Upstream FEC Operation – Mixed FEC and No-FEC Accesses – Multiple ONUs

Test Status: Mandatory

Reference Documents:

- ITU-T G.987.3 [6], Section 10.3.

Test Objective:

Verify that the OLT and ONU can correctly generate and decode FEC parity bytes on the upstream side and perform error-free data transmission.

Test Setup:

- As shown in Section 4
- Attenuation should be set for error-free operation.

Pretest Conditions:

1. The OLT and ONUs are powered and connected according to the test setup.
2. The ONUs have been ranged and activated by the OLT, the assigned ONU-IDs are 1 and 2.

Test Configuration:

Profiles from the ONU discovery test (6.1.1) are used in this test.

Parameters for bandwidth allocation structures:

Table 7-5 – Bandwidth Allocation Parameters For Upstream FEC Operation

Access #	Alloc-ID	Start time	Grant size	PLOAMu	DBRu	FWI	Burst Profile
1	1	100	256	0	0	0	1
2	2	1000	256	0	0	0	0

Test Procedure:

1. After ranging succeeds, OLT sends the bandwidth maps described above within the same XGTC frame.
2. Upon getting bandwidth grants, each ONU responds with the XGEM idle upstream traffic at the correct time.
3. OLT verifies that correct traffic is received from ONUs.

Pass/Fail Criteria:

1. Number of bit errors on OLT is zero.
2. OLT detects idle traffic from ONUs in the expected windows.

3. OLT should count the number of answered allocations and each ONU should count the number of granted allocations.

Remarks:

- None.

7.6 Data transmission

7.6.1 OMCI Channel Establishment

Test Status: Mandatory

Reference Documents:

- ITU-T G.987.3 [6], Section 9.
- ITU-T G.988 [8], Section 11.2.

Test Objective:

- Verify that the OLT can properly detect a data pattern inserted by the ONU into a baseline (48-byte) OMCI SDU.
- Verify that the ONU can properly detect a data pattern inserted by the OLT into a baseline (48-byte) OMCI SDU.

Test Setup:

- As shown in Section 4

Pretest Conditions:

1. The OLT and ONU are powered and connected according to the test setup.
2. The ONU has been ranged and activated by the OLT.
3. Default Port-ID 1 is provisioned on both downstream and upstream and assigned to Alloc-ID 1.

Test Configuration:

Profiles from the ONU discovery test (6.1.1) are used in this test.

Parameters for bandwidth allocation structures:

- Alloc-ID: 1
- Flags: 0
- Start time: at the discretion of the OLT
- Grant size: 14
- FWI: 0
- Burst profile: 0

XGEM header parameters for downstream and upstream OMCI messages:

- PLI: 48
- Key index: 0
- Port-ID: 1
- Options: 0
- Last fragment: 1

OMCI message contents:

- Transaction correlation identifier: 0x00 0x00
- Message type: 0x00
- Device identifier: 0x00
- Managed entity identifier: 0x00 0x00 0x00 0x00
- Message contents: 0x01 0x02 .. 0x24

Test Procedure:

1. After ranging succeeds, OLT sends the bandwidth allocation structures and downstream XGEM frames described above. Only one OMCI XGEM frame should be sent in an XG-PON frame.
2. Upon getting bandwidth grants, ONU responds with the upstream XGEM frame described above or with idle XGEM frames. ONU should respond at least once with the described frame.
3. Both OLT and ONU display the received data.

Pass/Fail Criteria:

1. Correct OMCI message detected in both OLT and ONU at least once.

Remarks:

- None.

7.6.2 OMCI Channel Establishment – Multiple ONUs

Test Status: Mandatory

Reference Documents:

- ITU-T G.987.3 [6], Section 9.
- ITU-T G.988 [8], Section 11.2.

Test Objective:

- Verify that the OLT can properly detect a data pattern inserted by the ONU into a baseline (48-byte) OMCI SDU.
- Verify that each ONU can properly detect a data pattern inserted by the OLT into a baseline (48-byte) OMCI SDU.

Test Setup:

- As shown in Section 4 (without Ethernet traffic generator and analyzer).

Pretest Conditions:

1. The OLT and ONUs are powered and connected according to the test setup.
2. The ONUs have been ranged and activated by the OLT, with assigned ONU-IDs of 1 and 2.
3. Default Port-ID 1 is provisioned on both downstream and upstream and assigned to Alloc-ID 1 on ONU1.
4. Default Port-ID 2 is provisioned on both downstream and upstream and assigned to Alloc-ID 2 on ONU2.

Test Configuration:

Profiles from the ONU discovery test (6.1.1) are used in this test.

Parameters for bandwidth allocation structures, XGEM header and OMCI message are the same as the OMCI channel establishment test for a single ONU, with the relevant Alloc-IDs.

Test Procedure:

1. After ranging succeeds, OLT sends the bandwidth allocation structures and XGEM frames described above.
2. Upon getting bandwidth grants, an ONU responds with the XGEM frame described above or with idle XGEM frames. Each ONU should respond at least once with the described frame.
3. OLT and both ONUs display the received data.

Pass/Fail Criteria:

1. Correct OMCI message detected in OLT and both ONUs at least once.

Remarks:

- None.

7.6.3 Downstream Encryption Operation

Test Status: Mandatory

Reference Documents:

- ITU-T G.987.3 [6], Section 15.4.

Test Objective:

Verify that the OLT can correctly transmit encrypted data to the ONU.

Test Setup:

- As shown in Section 4

Pretest Conditions:

1. The OLT and ONU are powered and connected according to the test setup.
2. The ONU has been ranged and activated by the OLT.
3. Default Port-ID 1 is provisioned on downstream.

Test Configuration:

Profiles from the ONU discovery test (6.1.1) are used in this test.
Encryption key: 0x112233445566778899AABBCCDDEEFF00

Downstream XGEM header parameters:

- PLI: 48
- Key index: 1
- Port-ID: 1
- Options: 0
- Last fragment: 1

OMCI message contents:

- Transaction correlation identifier: 0x00 0x00
- Message type: 0x00
- Device identifier: 0x00
- Managed entity identifier: 0x00 0x00 0x00 0x00
- Message contents: 0x01 0x02 .. 0x24

Test Procedure:

1. After ranging succeeds, OLT and ONU are manually configured with the key above as the first key, and that key is made valid.
2. OLT sends at least two downstream XGEM frames per XG-PON frame.
3. ONU tests and displays the received data.

Pass/Fail Criteria:

1. Correct downstream OMCI messages detected in ONU at least twice. No wrong messages are detected.

Remarks:

- None.

7.6.4 Upstream Encryption Operation

Test Status: Mandatory

Reference Documents:

- ITU-T G.987.3 [6], Section 15.4.

Test Objective:

Verify that the ONU can correctly transmit encrypted data to the OLT.

Test Setup:

- As shown in Section 4

Pretest Conditions:

1. The OLT and ONU are powered and connected according to the test setup.
2. The ONU has been ranged and activated by the OLT.
3. Default Port-ID 1 is provisioned on upstream and assigned to Alloc-ID 1.

Test Configuration:

Profiles from the ONU discovery test (6.1.1) are used in this test.

Encryption key: 0x112233445566778899AABBCCDDEEFF00

Parameters for bandwidth allocation structures:

- Alloc-ID: 1
- Flags: 0
- Start time: at the discretion of the OLT. Recommended value: 100
- Grant size: 28
- FWI: 0
- Burst profile: 0

Upstream XGEM header parameters:

- PLI: 48
- Key index: 1
- Port-ID: 1
- Options: 0
- Last fragment: 1

OMCI message contents:

- Transaction correlation identifier: 0x00 0x00
- Message type: 0x00
- Device identifier: 0x00
- Managed entity identifier: 0x00 0x00 0x00 0x00
- Message contents: 0x01 0x02 .. 0x24

Test Procedure:

1. After ranging succeeds, OLT and ONU are manually configured with the key above as the first key, and that key is made valid.
2. OLT sends the bandwidth allocation structures described above.
3. Upon getting bandwidth grants, ONU responds with two upstream XGEM frames as described above.
4. OLT tests and displays the received data.

Pass/Fail Criteria:

1. Correct upstream OMCI messages detected in OLT. No wrong messages are detected.

Remarks:

- None.

7.6.5 Downstream Ethernet Traffic Transmission

Test Status: Mandatory

Reference Documents:

- ITU-T G.987.3 [6], Section 9.

Test Objective:

Verify that the OLT can send and the ONU can properly receive Ethernet frames.

Test Setup:

- As shown in Section 4
- If the specified Port-ID cannot be provisioned manually, automatic provisioning is allowed. In such case, exact Port-ID value will be coordinated after pairing.

Pretest Conditions:

1. The OLT and ONU are powered and connected according to the test setup.
2. The ONU has been ranged and activated by the OLT.
3. Port-ID 1024 is provisioned on downstream.

Test Configuration:

Profiles from the ONU discovery test (6.1.1) are used in this test.

Traffic is not encrypted.

Additional parameters (e.g. VLAN tag mapping, order of generator and analyzer enable) are to be coordinated after pairing.

Test Procedure:

1. After ranging succeeds, Port-ID 1024 is manually provisioned.
2. Traffic generators are enabled for downstream traffic.
3. Received data is tested by the Ethernet traffic analyzer.

Pass/Fail Criteria:

1. Correct downstream data detected in ONU.

Remarks:

- None.

7.6.6 Upstream Ethernet Traffic Transmission

Test Status: Mandatory

Reference Documents:

- ITU-T G.987.3 [6], Section 9.

Test Objective:

Verify that the ONU can send and the OLT can properly receive Ethernet frames.

Test Setup:

- As shown in Section 4
- If the specified Port-ID and/or Alloc-ID cannot be provisioned manually, automatic provisioning is allowed. In such case, these parameters will be coordinated after pairing.

Pretest Conditions:

1. The OLT and ONU are powered and connected according to the test setup.
2. The ONU has been ranged and activated by the OLT.
3. Port-ID 1024 is provisioned on upstream and assigned to Alloc-ID 1024.

Test Configuration:

Profiles from the ONU discovery test (6.1.1) are used in this test.

Additional parameters (e.g. VLAN tag mapping, order of generator and analyzer enable) are to be coordinated after pairing.

Parameters for bandwidth allocation structures:

- Alloc-ID: 1024
- Start time: at the discretion of the OLT. Recommended value: 100
- Grant size: 8192
- FWI: 0
- Burst profile: 0

Test Procedure:

1. After ranging succeeds, Port-ID 1024 is manually provisioned.
2. Traffic generators are enabled for upstream traffic.
3. Received data is tested by the Ethernet traffic analyzer.

Pass/Fail Criteria:

1. Correct upstream data detected in OLT.

Remarks:

- None.

7.6.7 Bidirectional Ethernet Traffic Transmission

Test Status: Mandatory

Reference Documents:

- ITU-T G.987.3 [6], Section 9.

Test Objective:

Verify that the OLT and ONU can properly transfer Ethernet frames.

Test Setup:

- As shown in Section 4
- If the specified Port-ID and/or Alloc-ID cannot be provisioned manually, automatic provisioning is allowed. In such case, these parameters will be coordinated after pairing.

Pretest Conditions:

1. The OLT and ONU are powered and connected according to the test setup.
2. The ONU has been ranged and activated by the OLT.
3. Port-ID 1024 is provisioned on both downstream and upstream and assigned to Alloc-ID 1024.

Test Configuration:

Profiles from the ONU discovery test (6.1.1) are used in this test.

Additional parameters (e.g. VLAN tag mapping, order of generator and analyzer enable) are to be coordinated after pairing.

Parameters for bandwidth allocation structures:

- Alloc-ID: 1024
- Start time: at the discretion of the OLT
- Grant size: at the discretion of the OLT
- FWI: 0
- Burst profile: 0

Test Procedure:

1. After ranging succeeds, Port-ID 1024 is manually provisioned.
2. Traffic generators are enabled for downstream and upstream traffic.
3. Received data is tested by the Ethernet traffic analyzer.

Pass/Fail Criteria:

1. Correct data detected in both OLT and ONU.

Remarks:

- None.

7.6.8 Multiple Port-ID/Alloc-ID Data Transmission – Single ONU

Test Status: Mandatory

Reference Documents:

- ITU-T G.987.3 [6], Section 9.

Test Objective:

Verify that the OLT and ONU can properly transfer Ethernet frames using multiple Port-IDs and Alloc-IDs.

Test Setup:

- As shown in Section 4
- If the specified Port-IDs and/or Alloc-IDs cannot be provisioned manually, automatic provisioning is allowed. In such case, these parameters will be coordinated after pairing.

Pretest Conditions:

1. The OLT and ONU are powered and connected according to the test setup.
2. The ONU has been ranged and activated by the OLT.
3. Port-IDs 1024 and 1025 are provisioned on both downstream and upstream and assigned to Alloc-IDs 1024 and 1025, correspondingly.

Test Configuration:

Profiles from the ONU discovery test (6.1.1) are used in this test.

Additional parameters (e.g. VLAN tag mapping, order of generator and analyzer enable) are to be coordinated after pairing.

Parameters for bandwidth allocation structures:

- Alloc-ID: 1024, 1025
- Start time: at the discretion of the OLT
- Grant size: at the discretion of the OLT
- FWI: 0
- Burst profile: 0

Test Procedure:

1. After ranging succeeds, Port-IDs are provisioned manually or automatically, as applicable.
2. Traffic generators are enabled for downstream and upstream traffic.
3. Received data is tested by the Ethernet traffic analyzer.

Pass/Fail Criteria:

1. Correct data detected in both OLT and ONU.

Remarks:

- None.

7.6.9 Bidirectional Ethernet Traffic Transmission – Multiple ONUs

Test Status: Mandatory

Reference Documents:

- ITU-T G.987.3 [6], Section 9.

Test Objective:

Verify that the OLT and multiple ONUs can properly transfer Ethernet frames.

Test Setup:

- As shown in Section 4
- If the specified Port-IDs and/or Alloc-IDs cannot be provisioned manually, automatic provisioning is allowed. In such case, these parameters will be coordinated after pairing.

Pretest Conditions:

1. The OLT and ONUs are powered and connected according to the test setup.
2. The ONUs have been ranged and activated by the OLT.
3. Port-ID 1024 is provisioned on both downstream and upstream and assigned to Alloc-ID 1024 on ONU1.
4. Port-ID 1025 is provisioned on both downstream and upstream and assigned to Alloc-ID 1025 on ONU2.

Test Configuration:

Profiles from the ONU discovery test (6.1.1) are used in this test.

Additional parameters (e.g. VLAN tag mapping, order of generator and analyzer enable) are to be coordinated after pairing.

Parameters for bandwidth allocation structures:

- Alloc-ID: 1024, 1025
- Start time: at the discretion of the OLT
- Grant size: at the discretion of the OLT
- FWI: 0
- Burst profile: 0

Test Procedure:

1. After ranging succeeds, Port-IDs 1024 and 1025 are manually provisioned in ONU1 and ONU2, respectively.
2. Traffic generators are enabled for downstream and upstream traffic.

3. Received data is tested by the Ethernet traffic analyzer.

Pass/Fail Criteria:

1. Correct data detected in OLT and the ONUs.

Remarks:

- Additional ONUs can be connected to the test setup.

8 Comprehensive TC Layer Tests

8.1 Authentication and Encryption

8.1.1 Registration-ID Based Authentication

Test Status: Mandatory

Reference Documents:

- ITU-T G.987.3 [6], Sections 11.3.3.6, 11.3.4.2.

Test Objective:

Verify that the OLT can generate and the ONU can properly process the following downstream and upstream PLOAM messages:

- Request registration
- Registration (during state O5)

Test Setup:

- As shown in Section 4

Pretest Conditions:

1. The OLT and ONU are powered and connected according to the test setup.
2. The ONU has been ranged and activated by the OLT.

Test Configuration:

Profiles from the ONU discovery test (6.1.1) are used in this test.

Parameters for registration request message:

- ONU-ID: 1
- MIC is calculated using the default PLOAM integrity key

Parameters for registration message:

- ONU-ID: 1
- Registration ID: At the discretion of the ONU. Suggested value: 36 octets of 0x00
- MIC is calculated using the default PLOAM integrity key

Test Procedure and message timeline:

1. After ranging succeeds, OLT sends the registration request message. It then sends a grant with PLOAMu.
2. Upon getting the bandwidth grant, ONU responds with the registration message.
3. OLT detects the registration message and displays the registration ID.

Pass/Fail Criteria:

1. OLT detects the registration message from ONU.

Remarks:

- None

8.1.2 Automatic Encryption Key Exchange and Traffic Transmission

Test Status: Mandatory

Reference Documents:

- ITU-T G.987.3/Amd.1 [7], Sections 15.4, 15.5.3.

Test Objective:

Verify that the OLT and ONU can correctly perform automatic key exchange and encrypted data transmission.

Test Setup:

- As shown in Section 4

Pretest Conditions:

1. The OLT and ONU are powered and connected according to the test setup.
2. The ONU has been ranged and activated by the OLT.
3. The OLT and ONU are in states KL0 and KN0, respectively (no keys valid).

Test Configuration:

Profiles from the ONU discovery test (6.1.1) are used in this test.

Parameters for key control message:

- ONU-ID: 1
- Control: 0 (generate a new key) / 1 (confirm existing key)
- Key index: 01
- Key length: 16 bytes

Parameters for key report message:

- ONU-ID: 1
- Report type: 0 (new key) / 1 (existing key)
- Key index: 01
- Fragment number: 0
- Key fragment: at the discretion of the ONU

Parameters for bandwidth allocation structures:

- Alloc-ID: 1
- Flags: 0

- Start time: at the discretion of the OLT. Recommended value: 100
- Grant size: 28
- FWI: 0
- Burst profile: 0

XGEM header parameters for downstream and upstream messages:

- PLI: 48
- Key index: 1
- Port-ID: 1
- Options: 0
- Last fragment: 1

OMCI message contents:

- Transaction correlation identifier: 0x00 0x00
- Message type: 0x00
- Device identifier: 0x00
- Managed entity identifier: 0x00 0x00 0x00 0x00
- Message contents: 0x01 0x02 .. 0x24

Test Procedure and message timeline:

1. OLT transitions to state KL1 and sends a key control message for a new key.
2. ONU transitions to KN1, generates a new key and then to KN2. Key values before and after KEK encryption are printed.
3. OLT provides a grant with PLOAMu and ONU responds with key report message for the new key (KEK encrypted key).
4. OLT transitions to KL2, prints the received key fragment (KEK encrypted key) and its decryption, transitions to KL3 and sends a key control message to confirm the key. It then provides a grant with PLOAMu.
5. ONU transitions to KN3 and sends a key report for the existing key. It then transitions to KN4.
6. OLT prints the received key fragment (key name), verifies it and transitions to KL4.
7. OLT sends the bandwidth allocation structures described above, and two downstream XGEM frames per XG-PON frame, as described above. Those messages are to the default XGEM port-ID of the ONU (i.e. 1) and are encrypted.
8. Upon getting bandwidth grants, ONU responds with two upstream XGEM frames as described above. I.e. encrypted messages with the OMCI payload.

9. Both OLT and ONU test and display the received data.

Pass/Fail Criteria:

1. Keys are correctly printed by OLT at steps 4 and 6. Key decryption and verification succeeds.
2. OLT and ONU in states KL4 and KN4, respectively.
3. Correct OMCI messages detected in both OLT and ONU at least twice. No wrong messages are detected.

Remarks:

- None

8.1.3 Encrypted Ethernet Transmission

Test Status: Mandatory

Reference Documents:

- ITU-T G.987.3/Amd.1 [7], Sections 9, 15.4, 15.5.3.

Test Objective:

Verify that the OLT and ONU can correctly perform encrypted Ethernet transmission.

Test Setup:

- As shown in Section 4
- If the specified Port-IDs and/or Alloc-IDs cannot be provisioned manually, automatic provisioning is allowed. In such case, these parameters will be coordinated after pairing.

Pretest Conditions:

1. The OLT and ONU are powered and connected according to the test setup.
2. The ONU has been ranged and activated by the OLT.
3. Port-ID 1024 is provisioned on both downstream and upstream and assigned to Alloc-ID 1024.

Test Configuration:

Profiles from the ONU discovery test (6.1.1) are used in this test.

Additional parameters (e.g. VLAN tag mapping, order of generator and analyzer enable) are to be coordinated after pairing.

Parameters for bandwidth allocation structures:

- Alloc-ID: 1024
- Start time: at the discretion of the OLT
- Grant size : should be set small enough to cause the encrypted data to require two grants to carry.
- FWI: 0
- Burst profile: 0

Test Procedure:

1. After ranging succeeds, Port-ID 1024 is manually provisioned.
2. Key exchange process is done.
3. Traffic generators are enabled for downstream and upstream traffic. Cause ethernet traffic to be generated across a range of frame sizes.

4. Received data is tested by the Ethernet traffic analyzer.

Pass/Fail Criteria:

1. Correct data detected in both OLT and ONU.

Remarks:

- None.

8.1.4 Multicast Encryption Operation

Test Status: Mandatory

Reference Documents:

- ITU-T G.987.3 [6], Section 15.4.

Test Objective:

Verify that the OLT can correctly transmit multicast encrypted data to multiple ONUs. Additional parameters (e.g. VLAN tag mapping, order of generator and analyzer enable) are to be coordinated after pairing.

Test Setup:

- As shown in Section 4

Pretest Conditions:

1. The OLT and ONUs are powered and connected according to the test setup.
2. The ONUs have been ranged and activated by the OLT.
3. Port-ID 1028 is provisioned on downstream as a broadcast Port-ID.

Test Configuration:

Profiles from the ONU discovery test (6.1.1) are used in this test.
Encryption key: 0x112233445566778899AABBCCDDEEFF00

Test Procedure:

1. After ranging succeeds, Port-ID 1028 is manually provisioned as a broadcast Port-ID in the OLT and ONUs.
2. OLT and ONUs are manually configured with the key above as the first broadcast key, and that key is made valid.
3. Traffic generators are enabled for downstream and upstream traffic. Cause ethernet traffic to be generated across a range of frame sizes.
4. Received data is tested by the Ethernet traffic analyzer.

Pass/Fail Criteria:

1. Correct data is detected in all ONUs.

Remarks:

- If the specified Port-ID cannot be provisioned manually, automatic provisioning is allowed. In such case, these parameters will be coordinated after pairing.

8.1.5 ONU Re-Activation After Fiber Disconnection with Registration-ID Based Authentication

Test Status: Mandatory

Reference Documents:

- ITU-T G.987.3 [6], Section 9.
- ITU-T G.987.3/Amd.1 [7], Sections 15.2, 15.3 and 15.7.
- ITU-T G.988 [8], Section 11.2.

Test Objective:

- Verify that the OLT can successfully re-activate the ONU after fiber disconnection.
- Verify that session keys are initialized correctly following a re-activation.

Test Setup:

- As shown in Section 4

Pretest Conditions:

1. The OLT and ONU are powered and connected according to the test setup.
2. The ONU has been ranged and activated by the OLT.
3. Default Port-ID 1 is provisioned on both downstream and upstream and assigned to Alloc-ID 1.

Test Configuration:

Profiles from the ONU discovery test (6.1.1) are used in this test. Other parameters for the ranging process are as defined in tests 6.1.1 and 6.1.2.

Parameters for bandwidth allocation structures:

- Alloc-ID: 1
- Flags: 0
- Start time: at the discretion of the OLT
- Grant size: 14
- FWI: 0
- Burst profile: 0

XGEM header parameters for downstream and upstream OMCI messages:

- PLI: 48
- Key index: 0

- Port-ID: 1
- Options: 0
- Last fragment: 1

OMCI message contents:

- Transaction correlation identifier: 0x00 0x00
- Message type: 0x00
- Device identifier: 0x00
- Managed entity identifier: 0x00 0x00 0x00 0x00
- Message contents: 0x01 0x02 .. 0x24
- MIC: correct

Test Procedure:

1. After ranging succeeds, OLT sends the bandwidth allocation structures and downstream XGEM frames described above. Only one OMCI XGEM frame should be sent in an XG-PON frame.
2. Upon getting bandwidth grants, ONU responds with the upstream XGEM frame described above or with idle upstream XGEM frames. ONU should respond at least once with the described frame.
3. Both OLT and ONU display the received data and verify that the OMCI MIC is correct.
4. Fiber is disconnected. ONU transitions to state O1.
5. Master session key (MSK) for the ONU and all the derived keys are discarded.
6. Fiber is reconnected. ONU transitions to state O2-3.
7. Ranging process is performed as described in tests 6.1.1, 6.1.2.
8. ONU transitions to state O5. MIC results for the ranging time and acknowledge messages are correct. Default Port-ID 1 is provisioned on both downstream and upstream and assigned to Alloc-ID 1.
9. After ranging succeeds, OLT sends the bandwidth allocation structures and downstream XGEM frames described above. Only one downstream OMCI XGEM frame should be sent in an XG-PON frame.
10. Upon getting bandwidth grants, ONU responds with the upstream XGEM frame described above or with idle XGEM frames. ONU should respond at least once with the described frame.
11. Both OLT and ONU display the received data and verify that the OMCI MIC is correct.

Pass/Fail Criteria:

1. Correct OMCI message with correct MIC detected in both OLT and ONU at least once before fiber disconnection (step 3).
2. ONU has entered regular operational state (O5) after fiber reconnection (step 8).
3. Correct MIC is detected for ranging time and acknowledge messages (step 8).
4. Correct OMCI message with correct MIC detected in both OLT and ONU at least once after fiber disconnection (step 11).

Remarks:

- None.

8.1.6 Automatic Encryption Key Exchange during Traffic

Test Status: Mandatory

Reference Documents:

- ITU-T G.987.3/Amd.1 [7], Sections 15.4, 15.5.3.

Test Objective:

Verify that the OLT and ONU can correctly perform automatic key exchange and encrypted data transmission.

Test Setup:

- As shown in Section 4

Pretest Conditions:

1. The OLT and ONU are powered and connected according to the test setup.
2. The ONU has been ranged and activated by the OLT.
3. The OLT and ONU are in states KL4 and KN4, respectively.

Test Configuration:

Profiles from the ONU discovery test (6.1.1) are used in this test.

Parameters for key control message:

- ONU-ID: 1
- Key length: 16 bytes

Parameters for key report message:

- ONU-ID: 1
- Fragment number: 0
- Key fragment: at the discretion of the ONU

OMCI message contents:

- Transaction correlation identifier: 0x00 0x00
- Message type: 0x00
- Device identifier: 0x00
- Managed entity identifier: 0x00 0x00 0x00 0x00
- Message contents: 0x01 0x02 .. 0x24

Test Procedure and message timeline:

1. OLT continuously sends the bandwidth allocation structures with bandwidth allocated to the ONU, and two encrypted downstream XGEM frames per XG-PON frame.
2. Upon getting bandwidth grants, ONU responds with two encrypted upstream XGEM frames as described above and idle XGEMs.
3. Both OLT and ONU test and display the received data.
4. A new key exchange is initiated by the OLT: OLT transitions to state KL1 and sends a key control message for a new key. Downstream and upstream data is not stopped.
5. ONU transitions to KN1, generates a new key and then to KN2. Key values before and after KEK encryption are printed.
6. OLT provides a grant with PLOAMu and ONU responses with key report message for the new key (KEK encrypted key).
7. OLT transitions to KL2, prints the received key fragment (KEK encrypted key) and its decryption, transitions to KL3 and sends a key control message to confirm the key. It then provides a grant with PLOAMu.
8. ONU transitions to KN3 and sends a key report for the existing key. It then transitions to KN4.
9. OLT prints the received key fragment (key name), verifies it and transitions to KL4.
10. Both OLT and ONU continue to test and display the received data.

Pass/Fail Criteria:

1. Keys are correctly printed by OLT at steps 7 and 9. Key decryption and verification succeeds.
2. At the end of the test, OLT and ONU return to states KL4 and KN4, respectively.
3. Correct OMCI messages detected in both OLT and ONU during the whole test. No wrong messages are detected.

Remarks:

- None

8.1.7 Secure Mutual Authentication – OMCI Based

Test Status: Conditionally mandatory if Secure Mutual Authentication based on OMCI is supported by the devices.

Reference Documents:

- ITU-T G.987.3 [6], Section 9.
- ITU-T G.987.3/Amd.1 [7], Sections 15.2, 15.3 and 15.7.
- ITU-T G.987.3 [6], Annex C.
- ITU-T G.988 [8], Section 9.13.11.

Test Objective:

- Verify that session keys are initialized correctly following a secure mutual authentication and re-activation.

Test Setup:

- As shown in Section 4

Pretest Conditions:

1. The OLT and ONU are powered and connected according to the test setup.
2. The ONU has been ranged and activated by the OLT.
3. Default Port-ID 1 is provisioned on both downstream and upstream and assigned to Alloc-ID 1.

Test Configuration:

Profiles from the ONU discovery test (6.1.1) are used in this test.

Parameters for bandwidth allocation structures:

- Alloc-ID: 1
- Flags: 0
- Start time: at the discretion of the OLT
- Grant size: 14
- FWI: 0
- Burst profile: 0

XGEM header parameters for downstream and upstream messages:

- PLI: 48

- Key index: 0
- Port-ID: 1
- Options: 0
- Last fragment: 1

OMCI message contents:

- Transaction correlation identifier: 0x00 0x00
- Message type: 0x00
- Device identifier: 0x00
- Managed entity identifier: 0x00 0x00 0x00 0x00
- Message contents: 0x01 0x02 .. 0x24
- MIC: correct

Test Procedure:

1. After ranging succeeds, OMCI based secure mutual authentication takes place.
2. MSK is updated, based on the results of the secure mutual authentication.
3. Key derivation takes place.
4. OLT sends the bandwidth allocation structures and downstream XGEM frames described above. Only one OMCI XGEM frame should be sent in an XG-PON frame.
5. Upon getting bandwidth grants, ONU responds with the upstream XGEM frame described above or with idle upstream XGEM frames. ONU should respond at least once with the described frame.
6. Both OLT and ONU display the received data and verify that the OMCI MIC is correct. OMCI MIC is calculated using the keys derived after the secure mutual authentication process.

Pass/Fail Criteria:

1. Correct OMCI message with correct MIC detected in both OLT and ONU at least once at steps 1 and 6. OMCI MIC at step 6 is calculated using the keys derived from secure mutual authentication process.

Remarks:

- None

8.1.8 Secure Mutual Authentication – 802.1x

Test Status: Conditionally mandatory if Secure Mutual Authentication based on IEEE 802.1X is supported by the devices.

Reference Documents:

- ITU-T G.987.3 [6], Section 9.
- ITU-T G.987.3/Amd.1 [7], Sections 15.2, 15.3 and 15.7.
- ITU-T G.987.3 [6], Annex D.

Test Objective:

- Verify that session keys are initialized correctly following a secure mutual authentication and re-activation.

Test Setup:

- As shown in Section 4
- If the specified Port-ID and/or Alloc-ID cannot be provisioned manually, automatic provisioning is allowed. In such case, these parameters will be coordinated after pairing.

Pretest Conditions:

1. The OLT and ONU are powered and connected according to the test setup.
2. The ONU has been ranged and activated by the OLT.
3. Default Port-ID 1 is provisioned on both downstream and upstream and assigned to Alloc-ID 1.
4. Port-ID 1024 is provisioned on both downstream and upstream and assigned to Alloc-ID 1024.

Test Configuration:

Profiles from the ONU discovery test (6.1.1) are used in this test.

Parameters for bandwidth allocation structures:

- Alloc-ID: 1
- Flags: 0
- Start time: at the discretion of the OLT
- Grant size: 14
- FWI: 0
- Burst profile: 0

XGEM header parameters for downstream and upstream messages:

- PLI: 48
- Key index: 0
- Port-ID: 1
- Options: 0
- Last fragment: 1

OMCI message contents:

- Transaction correlation identifier: 0x00 0x00
- Message type: 0x00
- Device identifier: 0x00
- Managed entity identifier: 0x00 0x00 0x00 0x00
- Message contents: 0x01 0x02 .. 0x24
- MIC: correct

Test Procedure:

1. After ranging succeeds, 802.1x based secure mutual authentication takes place. Port-ID 1024 is provisioned for XGEM frames carrying 802.1x packets on downstream and upstream. OLT should provide appropriate bandwidth grants to Alloc-ID 1024 for 802.1x responses from ONU.
2. MSK is updated, based on the results of the secure mutual authentication.
3. Key derivation takes place.
4. OLT sends the bandwidth allocation structures and downstream XGEM frames described in the test configuration. Only one downstream OMCI XGEM frame should be sent in an XG-PON frame.
5. Upon getting bandwidth grants, ONU responds with the upstream XGEM frame described above or with idle upstream XGEM frames. ONU should respond at least once with the described frame.
6. Both OLT and ONU display the received data and verify that the OMCI MIC is correct. OMCI MIC is calculated using the keys derived after the secure mutual authentication process.

Pass/Fail Criteria:

1. Correct OMCI message with correct MIC detected in both OLT and ONU at least once at steps 1 and 6. OMCI MIC at step 6 is calculated using the keys derived from registration ID based authentication.

Remarks:

- None.

8.1.9 ONU Re-Activation after Fiber Disconnection with Secure Mutual Authentication

Test Status: Conditionally mandatory if Secure Mutual Authentication based on IEEE 802.1X is supported by the devices.

Reference Documents:

- ITU-T G.987.3 [6], Section 9.
- ITU-T G.987.3/Amd.1 [7], Sections 15.2, 15.3 and 15.7.
- ITU-T G.987.3 [6], Annexes C and D.

Test Objective:

- Verify that session keys are initialized correctly following a secure mutual authentication and re-activation.

Test Setup:

- As shown in Section 4

Pretest Conditions:

1. The OLT and ONU are powered and connected according to the test setup.
2. The ONU has been ranged and activated by the OLT.
3. Default Port-ID 1 is provisioned on both downstream and upstream and assigned to Alloc-ID 1.

Test Configuration:

Profiles from the ONU discovery test (6.1.1) are used in this test. Other parameters for the ranging process are as defined in tests 6.1.1 and 6.1.2.

Parameters for bandwidth allocation structures:

- Alloc-ID: 1
- Flags: 0
- Start time: at the discretion of the OLT
- Grant size: 14
- FWI: 0
- Burst profile: 0

XGEM header parameters for downstream and upstream messages:

- PLI: 48

- Key index: 0
- Port-ID: 1
- Options: 0
- Last fragment: 1

OMCI message contents:

- Transaction correlation identifier: 0x00 0x00
- Message type: 0x00
- Device identifier: 0x00
- Managed entity identifier: 0x00 0x00 0x00 0x00
- Message contents: 0x01 0x02 .. 0x24

Test Procedure:

1. After ranging succeeds, OMCI or 802.1x based secure mutual authentication takes place.
2. MSK is updated, based on the results of the secure mutual authentication.
3. Key derivation takes place.
4. OLT sends the bandwidth allocation structures and downstream XGEM frames described above. Only one downstream OMCI XGEM frame should be sent in an XG-PON frame.
5. Upon getting bandwidth grants, ONU responds with the upstream XGEM frame described above or with idle upstream XGEM frames. ONU should respond at least once with the described frame.
6. Both OLT and ONU display the received data and verify that the OMCI MIC is correct. OMCI MIC is calculated using the keys derived after the secure mutual authentication process.
7. Fiber is disconnected. ONU transitions to state O1.
8. Master session key (MSK) for the ONU and all the derived keys are discarded.
9. Fiber is reconnected. ONU transitions to state O2-3.
10. Ranging process is performed as described in tests 6.1.1, 6.1.2. A new key derivation takes place, based on the registration ID.
11. ONU transitions to state O5. MIC results for the ranging time and acknowledge messages are correct. Default Port-ID 1 is provisioned on both downstream and upstream and assigned to Alloc-ID 1.
12. After ranging succeeds, OLT sends the bandwidth allocation structures and XGEM frames described above. Only one OMCI XGEM frame should be sent in an XG-PON frame.
13. Upon getting bandwidth grants, ONU responds with the upstream XGEM frame described above or with idle upstream XGEM frames. ONU should respond at least once with the described frame.

14. Both OLT and ONU display the received data and verify that the OMCI MIC is correct.

Pass/Fail Criteria:

1. Correct OMCI message with correct MIC detected in both OLT and ONU at least once before fiber disconnection (step 6). OMCI MIC is calculated using the keys derived after the secure mutual authentication process.
2. ONU has entered regular operational state (O5) after fiber reconnection at step 11.
3. Correct MIC is detected for ranging time and acknowledge messages. PLOAM MIC is calculated using the keys derived from registration ID based authentication (step 11).
4. Correct OMCI message with correct MIC detected in both OLT and ONU at least once after fiber disconnection (step 14). OMCI MIC is calculated using the keys derived from registration ID based authentication.

Remarks:

- None

8.1.10 Request Registration after Secure Mutual Authentication

Test Status: Conditionally mandatory if Secure Mutual Authentication is supported by the devices.

Reference Documents:

- ITU-T G.987.3 [6], Sections 11.3.3.6, 11.3.4.2.
- ITU-T G.987.3/Amd.1 [7], Section 15.3.

Test Objective:

- Verify that session keys are not updated on a registration ID report when there is a valid mutual security association between OLT and ONU.

Test Setup:

- As shown in Section 4

Pretest Conditions:

1. The OLT and ONU are powered and connected according to the test setup.
2. The ONU has been ranged and activated by the OLT.

Test Configuration:

Profiles from the ONU discovery test (6.1.1) are used in this test.

Parameters for registration request message:

- ONU-ID: 1
- MIC is calculated using the default PLOAM integrity key

Parameters for registration message:

- ONU-ID: 1
- Registration ID: At the discretion of the ONU. Suggested value: 36 octets of 0x00
- MIC is calculated using the default PLOAM integrity key

XGEM header parameters for downstream and upstream messages:

- PLI: 48
- Key index: 0
- Port-ID: 1
- Options: 0
- Last fragment: 1

OMCI message contents:

- Transaction correlation identifier: 0x00 0x00
- Message type: 0x00
- Device identifier: 0x00
- Managed entity identifier: 0x00 0x00 0x00 0x00
- Message contents: 0x01 0x02 .. 0x24

Test Procedure and message timeline:

1. After ranging succeeds, OMCI or 802.1x based secure mutual authentication takes place.
2. MSK is updated, based on the results of the secure mutual authentication.
3. Key derivation takes place.
4. OLT sends the bandwidth allocation structures and downstream XGEM frames described above. Only one downstream OMCI XGEM frame should be sent in an XG-PON frame.
5. Upon getting bandwidth grants, ONU responds with the upstream XGEM frame described above or with idle upstream XGEM frames. ONU should respond at least once with the described frame.
6. Both OLT and ONU display the received data and verify that the OMCI MIC is correct. OMCI MIC is calculated using the keys derived after the secure mutual authentication process.
7. OLT sends the registration request message. It then sends a grant with PLOAMu.
8. Upon getting the bandwidth grant, ONU responds with the registration message.
9. OLT detects the registration message and displays the registration ID.
10. OLT sends bandwidth allocation structures and XGEM frames described above. Only one OMCI XGEM frame should be sent in an XG-PON frame.
11. Upon getting bandwidth grants, ONU responds with the upstream XGEM frame described above or with idle upstream XGEM frames. ONU should respond at least once with the described frame.

12. Both OLT and ONU display the received data and verify that the OMCI MIC is correct. OMCI MIC is calculated using the keys derived after the secure mutual authentication process and not from registration ID.

Pass/Fail Criteria:

1. Correct OMCI message with correct MIC detected in both OLT and ONU at least once before registration request (step 6). OMCI MIC is calculated using the keys derived after the secure mutual authentication process.
2. OLT detects the registration message from ONU at step 9.
3. Correct OMCI message with correct MIC detected in both OLT and ONU at least once after registration request (step 12). OMCI MIC is calculated using the keys derived from secure mutual authentication and not from registration ID.

Remarks:

- None

8.2 ONU Power Management Modes

8.2.1 Doze Mode

Test Status: Mandatory

Reference Documents:

- ITU-T G.987.3 [6], Sections 16, 11.3.3.9, 11.3.4.5.
- ITU-T G.988, Section 9.1.14.

Test Objective:

Verify that the ONU can correctly enter doze mode. Verify that the OLT can send FWI to wake up the ONU.

Test Setup:

- As shown in Section 4

Pretest Conditions:

1. The OLT and ONU are powered and connected according to the test setup.
2. The ONU has been ranged and activated by the OLT, the assigned ONU-ID is 1.

Test Configuration:

Profiles from the ONU discovery test (6.1.1) are used in this test. Parameters of the bandwidth grants are at the discretion of the OLT.

Parameters for sleep allow message:

- ONU-ID: 1
- SeqNo: unicast PLOAM sequence number
- Sleep_Allow: 1 (on)

Parameters for sleep request message:

- ONU-ID: 1
- SeqNo: 0
- Activity level: 1 - Sleep request (doze)

Parameters for timers:

The parameters for the timers should be manually set at the ONU and the OLT before executing the test procedure.

- Isleep: Recommended value: 200 ms
- Iaware: Recommended value: 20 ms
- Ihold: Recommended value: 20 ms

Test Procedure:

1. Ensure that the ONU is activated, supports power reduction management capability, and that doze mode only is enabled (see 9.1.14/G.988).
2. Ensure further that the OLT learns the ONU's power management design parameters: Itransinit, Itxinit, and configures ONU's dynamic timing parameters: Isleep, Iaware, Ihold (see 9.1.14/G.988).
3. Ensure that any local activity stimuli at the ONU are suppressed.
4. Initiate ONU power reduction at the OLT (by suppressing any remote ONU wakeup stimuli and/or issuing a console command, as appropriate for the OLT implementation).
5. Verify OLT's actions and ONU's response.
6. Disconnect the ONU fiber connector, or turn off the ONU power completely.
7. Verify OLT's actions.
8. Restore ONU power/fiber connectivity and repeat steps 1 through 5.
9. Terminate ONU power reduction at the OLT (by activating a remote wakeup stimulus or issuing a console command, as appropriate for the OLT implementation).
10. Verify OLT's actions and ONU's response.

Pass/Fail Criteria:

The test passes, if all of the following holds:

1. On Step 5:
 - The OLT sends a Sleep_Allow(ON) message to the ONU.
 - The OLT continues to provide allocations to the ONU, suppressing the FWI flag.
 - The ONU responds with Sleep_Request(Doze) message.
 - The ONU alternates between silence periods of duration at most Isleep+Delta1, where Delta1 is a fixed positive value includes Itxinit and tolerances, and periods when it does respond to bandwidth allocations of duration at least Iaware.
 - The OLT detects, but does not alarm, the missing ONU's bursts.
2. On Step 7:

- The OLT declares the LOBi defect against the ONU within Isleep+Delta2, where Delta2 is a fixed positive value that includes Itxinit, maximum round trip time for the network configuration, and tolerances..
3. On Step 10:
- The OLT sends a Sleep_Allow(OFF) message to the ONU.
 - The OLT continues to provide allocations to the ONU with the FWI flag set,
 - Within Delta2 time, the ONU sends a Sleep_Request(Awake) message and subsequently responds to all bandwidth allocations, where Delta2 is a fixed positive value that includes Itxinit, maximum round trip time for the network configuration, and tolerances.

Remarks:

- None

8.2.2 Doze Mode (ONU Wakeup)

Test Status: Mandatory

Reference Documents:

- ITU-T G.987.3 [6], Sections 16, 11.3.3.9, 11.3.4.5.
- ITU-T G.988, Section 9.1.14.

Test Objective:

Verify that the ONU can correctly enter doze mode. Verify that upon local ONU stimulus it can wake-up from doze mode.

Test Setup:

- As shown in Section 4

Pretest Conditions:

1. The OLT and ONU are powered and connected according to the test setup.
2. The ONU has been ranged and activated by the OLT, the assigned ONU-ID is 1.

Test Configuration:

Profiles from the ONU discovery test (6.1.1) are used in this test. Parameters of the bandwidth grants are at the discretion of the OLT.

Parameters for sleep allow message:

- ONU-ID: 1
- SeqNo: unicast PLOAM sequence number
- Sleep_Allow: 1 (on)

Parameters for sleep request message:

- ONU-ID: 1
- SeqNo: 0
- Activity level: 0, 1 - Sleep request (awake, doze)

Parameters for timers:

The parameters for the timers should be manually set at the ONU and the OLT before executing the test procedure.

- Isleep: Recommended value: 200 ms
- Iaware: Recommended value: 20 ms
- Ihold: Recommended value: 20 ms

Test Procedure:

1. Ensure that the ONU is activated, supports power reduction management capability, and that **doze mode only** is enabled (see 9.1.14/G.988).
2. Ensure further that the OLT learns the ONU's power management design parameters: Itransinit, Itxinit, and configures ONU's dynamic timing parameters: Isleep, Iaware, Ihold (see 9.1.14/G.988).
3. Ensure that any local activity stimuli at the ONU are suppressed.
4. Initiate ONU power reduction at the OLT (by suppressing any remote ONU wakeup stimuli and/or issuing a console command, as appropriate for the OLT implementation).
5. Verify OLT's actions and ONU's response.

NOTE: This is repetition of Steps 1 through 5 of TC 7.2.1

6. Terminate ONU power reduction by activating an appropriate local activity stimulus at the ONU.
7. Verify ONU's actions and OLT's response.

Pass/Fail Criteria:

The test passes, if all of the following holds:

1. On Step 5:
 - See TC 7.2.1
2. On Step 7:
 - Within Delta1 time, the ONU sends a Sleep_Request(Awake) message and subsequently responds to all bandwidth allocations, where Delta1 is a fixed positive value that includes Itxinit and tolerances.

Remarks:

- None

8.2.3 Cyclic Sleep

Test Status: Conditionally mandatory if Cyclic sleep mode is supported by the devices.

Reference Documents:

- ITU-T G.987.3 [6], Sections 16, 11.3.3.9, 11.3.4.5.
- ITU-T G.988, Section 9.1.14.

Test Objective:

Verify that the ONU can correctly enter cyclic sleep mode. Verify that the OLT can send FWI to wake up the ONU.

Test Setup:

- As shown in Section 4

Pretest Conditions:

1. The OLT and ONU are powered and connected according to the test setup.
2. The ONU has been ranged and activated by the OLT, the assigned ONU-ID is 1.

Test Configuration:

Profiles from the ONU discovery test (6.1.1) are used in this test. Parameters of the bandwidth grants are at the discretion of the OLT.

Parameters for sleep allow message:

- ONU-ID: 1
- SeqNo: unicast PLOAM sequence number
- Sleep_Allow: 1 (on)

Parameters for sleep request message:

- ONU-ID: 1
- SeqNo: 0
- Activity level: 2 - Sleep request (sleep)

Parameters for timers:

The parameters for the timers should be manually set at the ONU and the OLT before executing the test procedure.

- Isleep: Recommended value: 200 ms
- Iaware: Recommended value: 20 ms
- Ihold: Recommended value: 20 ms

Test Procedure:

1. Ensure that the ONU is activated, supports power reduction management capability, and that **sleep mode only** is enabled (see 9.1.14/G.988).
2. Ensure further that the OLT learns the ONU's power management design parameters: Itransnit, Itxinit, and configures ONU's dynamic timing parameters: Isleep, Iaware, Ihold (see 9.1.14/G.988).
3. Ensure that any local activity stimuli at the ONU are suppressed.
4. Initiate ONU power reduction at the OLT (by suppressing any remote ONU wakeup stimuli and/or issuing a console command, as appropriate for the OLT implementation).
5. Verify OLT's actions and ONU's response.
6. Disconnect the ONU fiber connector, or turn off the ONU power completely.
7. Verify OLT's actions.
8. Restore ONU power/fiber connectivity and repeat steps 1 through 5.
9. Terminate ONU power reduction at the OLT (by activating a remote wakeup stimulus or issuing a console command, as appropriate for the OLT implementation).
10. Verify OLT's actions and ONU's response.

Pass/Fail Criteria:

The test passes, if all of the following holds:

1. On Step 5:
 - The OLT sends a Sleep_Allow(ON) message to the ONU.
 - The OLT continues to provide allocations to the ONU, suppressing the FWI flag.
 - The ONU responds with Sleep_Request(Sleep) message.
 - The ONU alternates between silence periods of duration at most Isleep+Delta3, where Delta3 is a fixed positive value includes Itransmit and tolerances, and periods when it does respond to bandwidth allocations of duration at least Iaware.
 - The OLT detects, but does not alarm, the missing ONU's bursts.
2. On Step 7:
 - The OLT declares the LOBi defect against the ONU within Isleep+Delta4, where Delta4 is a fixed positive value that includes Itransmit, maximum round trip time for the network configuration, and tolerances.
3. On Step 10:
 - The OLT sends a Sleep_Allow(OFF) message to the ONU.
 - The OLT continues to provide allocations to the ONU with the FWI flag set,

- Within $I_{\text{sleep}} + \Delta_4$, the ONU sends a Sleep_Request(Awake) message and subsequently responds to all bandwidth allocations, where Δ_4 is a fixed positive value that includes I_{transmit} , maximum round trip time for the network configuration, and tolerances.

Remarks:

- None

8.2.4 Cyclic Sleep (ONU Wakeup)

Test Status: Conditionally mandatory if Cyclic sleep mode is supported by the devices.

Reference Documents:

- ITU-T G.987.3 [6], Sections 16, 11.3.3.9, 11.3.4.5.
- ITU-T G.988, Section 9.1.14.

Test Objective:

Verify that the ONU can correctly enter cyclic sleep mode. Verify that upon local ONU stimulus it can wake-up from cyclic sleep.

Test Setup:

- As shown in Section 4

Pretest Conditions:

1. The OLT and ONU are powered and connected according to the test setup.
2. The ONU has been ranged and activated by the OLT, the assigned ONU-ID is 1.

Test Configuration:

Profiles from the ONU discovery test (6.1.1) are used in this test. Parameters of the bandwidth grants are at the discretion of the OLT.

Parameters for sleep allow message:

- ONU-ID: 1
- SeqNo: unicast PLOAM sequence number
- Sleep_Allow: 1 (on)

Parameters for sleep request message:

- ONU-ID: 1
- SeqNo: 0
- Activity level: 0, 2 - Sleep request (awake, sleep)

Parameters for timers:

The parameters for the timers should be manually set at the ONU and the OLT before executing the test procedure.

- Isleep: Recommended value: 200 ms
- Iaware: Recommended value: 20 ms
- Ihold: Recommended value: 20 ms

Test Procedure:

1. Ensure that the ONU is activated, supports power reduction management capability, and that sleep mode only is enabled (see 9.1.14/G.988).
2. Ensure further that the OLT learns the ONU's power management design parameters: Itransnit, Itxinit, and configures ONU's dynamic timing parameters: Isleep, Iaware, Ihold (see 9.1.14/G.988).
3. Ensure that any local activity stimuli at the ONU are suppressed.
4. Initiate ONU power reduction at the OLT (by suppressing any remote ONU wakeup stimuli and/or issuing a console command, as appropriate for the OLT implementation).
5. Verify OLT's actions and ONU's response.

NOTE: This is repetition of Steps 1 through 5 of TC 7.2.3

6. Terminate ONU power reduction by activating an appropriate local activity stimulus at the ONU.
7. Verify ONU's actions and OLT's response.

Pass/Fail Criteria:

The test passes, if all of the following holds:

1. On Step 5:
 - See TC 7.2.3
2. On Step 7:
 - Within Delta3 time, the ONU sends a Sleep_Request(Awake) message and subsequently responds to all bandwidth allocations, where Delta3 is a fixed positive value that includes Itransmit and tolerances.

Remarks:

- None

8.3 Dynamic Bandwidth Allocation

8.3.1 DBA Operation - Single ONU

Test Status: Mandatory

Reference Documents:

- ITU-T G.987.3 [6], Sections 7.2, 7.3 and 8.2.2.

Test Objective:

Verify correct DBA status reporting using allocation overheads in single ONU operation.

Test Setup:

- As shown in Section 4
- If the specified Port-ID and/or Alloc-ID cannot be provisioned manually, automatic provisioning is allowed. In such case, these parameters will be coordinated after pairing.

Pretest Conditions:

1. The OLT and ONU are powered and connected according to the test setup.
2. The ONU has been ranged and activated by the OLT.
3. Port-ID 1024 is provisioned on both downstream and upstream and assigned to Alloc-ID 1024.

Test Configuration:

Profiles from the ONU discovery test (6.1.1) are used in this test.

Additional parameters (e.g. VLAN tag mapping, order of generator and analyzer enable) are to be coordinated after pairing.

Parameters for bandwidth allocation structures:

- Alloc-ID: 1024
- Flags: 2 (DBRu=1, PLOAMu=0)
- Start time: at the discretion of the OLT.
- Grant size: at the discretion of the OLT, according to traffic load.
- FWI: 0
- Burst profile: 0

Test Procedure:

1. After ranging succeeds, Port-ID 1024 is manually provisioned.
2. OLT sends the bandwidth maps described above.
3. The Traffic generator should be configured to generate downstream and upstream traffic.
4. Upon getting bandwidth grants, ONU responds with bursts containing a DBRu structure.
5. OLT tests the CRC field of the DBRu and captures the BufOcc field.
6. OLT responds to the values present in the BufOcc field by increasing or decreasing the upstream bandwidth allocated to the ONU.
7. Received data is tested by the Ethernet traffic analyzer.

Pass/Fail Criteria:

1. OLT detects DBRu structures with correct CRC field. CRC field is correct for all of the DBRu structures detected.
2. Correct status reporting is transmitted in DBRu according to amount of upstream SDU traffic – BuffOcc fields indicate full/empty buffer for heavy/light traffic load.
3. No traffic loss at the upstream and downstream.

Remarks:

- Upstream traffic load should be changed during the test to observe correct DBA algorithm response.

8.3.2 DBA Operation - Multiple ONUs

Test Status: Mandatory

Reference Documents:

- ITU-T G.987.3 [6] , Sections 7.2, 7.3 and 8.2.2.

Test Objective:

Verify correct DBA status reporting using allocation overheads in multiple ONU operation.

Test Setup:

- As shown in Section 4

Pretest Conditions:

1. The OLT and ONU are powered and connected according to the test setup.
2. The ONU has been ranged and activated by the OLT.
3. Port-ID 1024 is provisioned on both downstream and upstream and assigned to Alloc-ID 1024 on ONU1.
4. Port-ID 1025 is provisioned on both downstream and upstream and assigned to Alloc-ID 1025 on ONU2.
5. Other ONUs (if exist) are assigned Alloc-IDs accordingly.

Test Configuration:

Profiles from the ONU discovery test (6.1.1) are used in this test.

Additional parameters (e.g. VLAN tag mapping, order of generator and analyzer enable) are to be coordinated after pairing.

Parameters for bandwidth allocation structures:

- Flags: 2 (DBRu=1, PLOAMu=0)
- Start time: at the discretion of the OLT.
- Grant size: at the discretion of the OLT, according to traffic load.
- FWI: 0
- Burst profile: 0

Test Procedure:

1. After ranging succeeds, Port-IDs are provisioned manually or automatically, as applicable.
2. OLT sends the bandwidth allocation structures described above with bandwidth grants to all ONUs.
3. Traffic generators are enabled for downstream and upstream traffic.

4. Upon getting bandwidth grants, ONU responds with bursts containing a DBRu structure.
5. OLT tests the CRC field of the DBRu and captures the BufOcc field.
6. OLT responds to the values present in the BufOcc field by increasing or decreasing the upstream bandwidth allocated to the ONU.
7. Received data is tested by the Ethernet traffic analyzer.

Pass/Fail Criteria:

1. OLT detects DBRu structures with correct CRC field for each ONU. CRC field is correct for all of the DBRu structures detected.
2. Correct status reporting is transmitted in DBRu according to amount of upstream SDU traffic.
3. Each ONU status reporting allows upstream burst transmission according to DBA algorithm (as implemented in OLT).
4. No traffic loss at the upstream and downstream.

Remarks:

- None

8.3.3 DBA Operation under Different Traffic Loads - Multiple ONUs

Test Status: Mandatory

Reference Documents:

- ITU-T G.987.3 [6], Sections 7.2, 7.3 and 8.2.2.

Test Objective:

Verify correct DBA status reporting using allocation overheads in multiple ONU operation.

Test Setup:

- As shown in Section 4

Pretest Conditions:

1. The OLT and ONU are powered and connected according to the test setup.
2. The ONU has been ranged and activated by the OLT.
3. Port-ID 1024 is provisioned on both downstream and upstream and assigned to Alloc-ID 1024 on ONU1.
4. Port-ID 1025 is provisioned on both downstream and upstream and assigned to Alloc-ID 1025 on ONU2.
5. Other ONUs (if exist) are assigned Alloc-IDs accordingly.

Test Configuration:

Profiles from the ONU discovery test (6.1.1) are used in this test.

Additional parameters (e.g. VLAN tag mapping, order of generator and analyzer enable) are to be coordinated after pairing.

Parameters for bandwidth allocation structures:

- Flags: 2 (DBRu=1, PLOAMu=0)
- Start time: at the discretion of the OLT.
- Grant size: at the discretion of the OLT, according to traffic load.
- FWI: 0
- Burst profile: 0

Test Procedure:

1. After ranging succeeds, Port-IDs are provisioned manually or automatically, as applicable.
2. OLT continuously sends the bandwidth allocation structures described above with bandwidth grants to all ONUs.
3. Upon getting bandwidth grants, ONU responds with bursts containing a DBRu structure.

4. OLT tests the CRC field of the DBRu and captures the BufOcc field.
5. OLT responds to the values present in the BufOcc field by increasing or decreasing the upstream bandwidth allocated to the ONU.
6. Traffic generators are enabled for downstream and upstream traffic. Traffic load is changed per ONU:
 - a. Equal traffic load per ONU.
 - b. Different traffic load for each ONU.
7. Received data is tested by the Ethernet traffic analyzer.

Pass/Fail Criteria:

1. OLT detects DBRu structures with correct CRC field for each ONU. CRC field is correct for all of the DBRu structures detected.
2. Correct status reporting is transmitted in DBRu according to amount of upstream SDU traffic.
3. Upstream bandwidth is granted to each ONU according to status reporting and DBA algorithm (as implemented in OLT).
4. No traffic loss at the upstream and downstream.

Remarks:

- None

8.4 Drift Control and Compensation

8.4.1 Acceptable Transmission Drift Boundary

Test Status: Mandatory

Reference Documents:

- ITU-T G.987.3 [6], Sections 13.1.6 and 14.2.1.

Test Objective:

Verify errorless upstream transmission within the safe (acceptable) transmission drift boundary.

Test Setup:

- As shown in Section 4
- If the ONU is not capable of artificially changing its equalization delay in the required resolution, the required drift can be generated using a spool of fiber in a temperature controlled oven.

Pretest Conditions:

1. The OLT and ONU are powered and connected according to the test setup.
2. The ONU has been ranged and activated by the OLT.
3. Default Port-ID 1 is provisioned on both downstream and upstream and assigned to Alloc-ID 1.

Test Configuration:

Profiles from the ONU discovery test (6.1.1) are used in this test.
Equalization delay is initially set by the OLT during ranging.

Test Procedure:

1. After ranging succeeds, OLT continuously grants bandwidth to ONU.
2. ONU is forced to change its equalization delay in order to create upstream PHY burst drift within the safe margin in two different scenarios:
 - a. Early PHY burst $\rightarrow 0 > \text{drift} \geq -7$ bits
 - b. Late PHY burst $\rightarrow 7 \text{ bits} \geq \text{drift} > 0$

Pass/Fail Criteria:

1. DOWi and TIWi alarms are not raised by the OLT.
2. No EqD adjustment is made by the OLT.
3. Upstream PHY bursts are detected correctly during the test.

Remarks:

- Due to inaccuracies in the ONU transmission or the OLT timing measurement, the OLT might respond to ONU drift earlier than expected. It is the responsibility of the pairing parties to state their inaccuracies and adjust the thresholds accordingly.

8.4.2 Adjustable Transmission Drift Boundary (DOW)

Test Status: Mandatory

Reference Documents:

- ITU-T G.987.3 [6], Sections 13.1.6 and 14.2.1.

Test Objective:

Verify correct in-service equalization delay adjustments in drift of window (DOW) transmission boundary.

Test Setup:

- As shown in Section 4
- If the ONU is not capable of artificially changing its equalization delay in the required resolution, the required drift can be generated using a spool of fiber in a temperature controlled oven.

Pretest Conditions:

1. The OLT and ONU are powered and connected according to the test setup.
2. The ONU has been ranged and activated by the OLT.
3. Default Port-ID 1 is provisioned on both downstream and upstream and assigned to Alloc-ID 1.

Test Configuration:

Profiles from the ONU discovery test (6.1.1) are used in this test. Equalization delay is initially set by the OLT during ranging.

Test Procedure:

1. After ranging succeeds, OLT continuously grants bandwidth to ONU.
2. ONU is forced to change its equalization delay in order to create upstream PHY burst drift in the drift of window (DOW) boundary in two different scenarios:
 - c. Early PHY burst $\rightarrow -9 \text{ bits} \geq \text{drift} \geq -15 \text{ bits}$
 - d. Late PHY burst $\rightarrow 15 \text{ bits} \geq \text{drift} \geq 9 \text{ bits}$
3. For each scenario, OLT recognizes a drift of window event for ONU (DOW_i).
4. OLT calculates a new equalization delay value and transmits it to ONU using a ranging time PLOAM message.
5. ONU prints the received ranging time PLOAM message and adjusts its equalization delay according to the message.
6. Drift of window event for the ONU (DOW_i) is not detected anymore.

Pass/Fail Criteria:

1. Upstream PHY bursts are detected correctly during the test.
2. For each scenario, OLT recognizes a drift of window event for ONU (DOWi).
3. Ranging time PLOAM messages are correctly detected by ONU.
4. After processing of each ranging time PLOAM message, drift of window event for the ONU (DOWi) is not detected anymore.
5. ONU stays in regular operational state (O5) for the whole duration of the test.

Remarks:

- Due to inaccuracies in the ONU transmission or the OLT timing measurement, the OLT might respond to ONU drift earlier than expected. It is the responsibility of the pairing parties to state their inaccuracies and adjust the thresholds accordingly.

8.4.3 Unacceptable Transmission Drift Boundary (TIW)

Test Status: Mandatory

Reference Documents:

- ITU-T G.987.3 [6], Sections 13.1.6 and 14.2.1

Test Objective:

Verify correct OLT-ONU behavior in transmission interference warning (TIW) state – unacceptable transmission drift.

Test Setup:

- As shown in Section 4

Pretest Conditions:

1. The OLT and ONU are powered and connected according to the test setup.
2. The ONU has been ranged and activated by the OLT.
3. Default Port-ID 1 is provisioned on both downstream and upstream and assigned to Alloc-ID 1.

Test Configuration:

Profiles from the ONU discovery test (6.1.1) are used in this test.
Equalization delay is initially set by the OLT during ranging.

Test Procedure:

1. After ranging succeeds, OLT continuously grants bandwidth to ONU.
2. ONU is forced to change its equalization delay in order to create upstream PHY burst drift in the transmission interference warning (TIW) boundary in two different scenarios:
 - e. Early PHY burst → $-16 \text{ bits} > \text{drift}$
 - f. Late PHY burst → $\text{drift} > 16 \text{ bits}$
3. For each scenario, OLT raises a TIWi alarm for ONU.

Pass/Fail Criteria:

1. For each scenario, OLT raises a transmission interference warning alarm for ONU (TIWi).
2. After appropriate corrective measures have been taken, upstream PHY bursts are detected correctly and the TIWi alarm is cancelled.

Remarks:

- Due to inaccuracies in the ONU transmission or the OLT timing measurement, the OLT might respond to ONU drift earlier than expected. It is the responsibility of the pairing parties to state their inaccuracies and adjust the thresholds accordingly.
- If the ONU is not capable of artificially changing its equalization delay in the required resolution, the required drift can be generated using a spool of fiber in a temperature controlled oven.
- Depending on the mitigation actions taken by the OLT in response to a TIWi alarm, additional actions such as a new discovery and activation process might be performed between the two scenarios at the discretion of the OLT.

8.5 Time of Day Distribution over XG-PON1

8.5.1 Time of Day Distribution – Fixed Equalization Delay, Single ONU

Test Status: Mandatory

Reference Documents:

- ITU-T G.987.3 [6], Section 13.
- ITU-T G.988 [8], Section 9.12.2.

Test Objective:

Verify correct time of day synchronization using the OMCI channel in a single ONU link when the equalization delay of the ONU is fixed throughout the test.

Test Setup:

- As shown in Section 4

Pretest Conditions:

1. The OLT and ONU are powered and connected according to the test setup.
2. The ONU has been ranged and activated by the OLT.
3. Default Port-ID 1 is provisioned on both downstream and upstream and assigned to Alloc-ID 1.
4. OMCI message channel is established between OLT and ONU.

Test Configuration:

Profiles from the ONU discovery test (6.1.1) are used in this test.

Equalization delay is initially set by the OLT during ranging and stays constant for the duration of the test.

Test Procedure:

1. After ranging succeeds, OLT and ONU ToD clock synchronization process is manually initialized.
2. OLT selects downstream XGTC frame to be used as timing reference. This frame is identified as superframe counter #N. OLT generates the pair N, TstampN and sends it to ONU using the relevant OMCI ME.
3. ONU calculates the time of day based on the information communicated using the OMCI ME, its equalization delay and its response time.
4. 1PPS outputs from ONU and OLT are compared using a scope.

5. OLT and ONU periodically print their ToD with corresponding values of superframe counter.

Pass/Fail Criteria:

1. 1PPS outputs from ONU and OLT are accurate within $\pm 1\mu\text{s}$.
2. ToD values printed with values of superframe counter match between ONU and OLT.
3. ONU ToD synchronization was completed within up to 10sec from the communication of the downstream frame parameters over the OMCI channel.

Remarks:

- None

8.5.2 Time of Day Distribution – Equalization Delay Adjustments, Single ONU

Test Status: Mandatory

Reference Documents:

- ITU-T G.987.3 [6], Section 13.
- ITU-T G.988 [8], Section 9.12.2.

Test Objective:

Verify correct time of day synchronization using the OMCI channel in a single ONU link when the equalization delay of the ONU is adjusted throughout the test.

Test Setup:

- As shown in Section 4

Pretest Conditions:

1. The OLT and ONU are powered and connected according to the test setup.
2. The ONU has been ranged and activated by the OLT.
3. Default Port-ID 1 is provisioned on both downstream and upstream and assigned to Alloc-ID 1.
4. OMCI message channel is established between OLT and ONU.

Test Configuration:

Profiles from the ONU discovery test (6.1.1) are used in this test. Equalization delay is initially set by the OLT during ranging.

Test Procedure:

1. After ranging succeeds, OLT continuously grants bandwidth to ONU.
2. OLT and ONU ToD clock synchronization process is manually initialized.
3. OLT selects downstream XGTC frame to be used as timing reference. This frame is identified as superframe counter #N. OLT generates the pair N, TstampN and sends it to ONU using the relevant OMCI ME.
4. ONU calculates the time of day based on the information communicated using the OMCI ME, its equalization delay and its response time.
5. 1PPS output from ONU and OLT are compared using a scope.
6. OLT and ONU periodically print their ToD with corresponding values of superframe counter.

7. Controlled upstream PHY burst drift in the drift of window (DOW) boundary is generated, for example using a spool of fiber in a temperature controlled oven.
8. OLT recognizes a drift of window event for ONU (DOWi). OLT calculates a new equalization delay value and transmits it to ONU using a ranging time PLOAM message.
9. ONU prints the received ranging time PLOAM message and adjusts its equalization delay according to the message.
10. ONU fixes the ToD calculation according to the new equalization delay.
11. 1PPS output from ONU and OLT are compared using a scope.
12. OLT and ONU periodically print their ToD with corresponding values of superframe counter.

Pass/Fail Criteria:

1. 1PPS outputs from ONU and OLT are accurate within $\pm 1\mu\text{s}$ in steps 5 and 11.
2. ToD values printed with values of superframe counter match between ONU and OLT in steps 6 and 12.
3. ONU ToD synchronization was completed within up to 10sec from the communication of the downstream frame parameters over the OMCI channel.
4. Ranging time PLOAM messages are correctly detected by ONU.
5. ONU stays in regular operational state (O5) for the whole duration of the test.

Remarks:

- None

8.5.3 Time of Day Synchronization - Multiple ONUs

Test Status: Mandatory

Reference Documents:

- ITU-T G.987.3 [6], Section 13.
- ITU-T G.988 [8], Section 9.12.2.

Test Objective:

Verify correct time of day synchronization using the OMCI channel with multiple ONUs.

Test Setup:

- As shown in Section 4

Pretest Conditions:

1. The OLT and ONU are powered and connected according to the test setup.
2. The ONU has been ranged and activated by the OLT.
3. Default Port-ID 1 is provisioned on both downstream and upstream and assigned to Alloc-ID 1 on ONU1.
4. Default Port-ID 2 is provisioned on both downstream and upstream and assigned to Alloc-ID 2 on ONU2.
5. Other ONUs (if exist) are assigned Alloc-IDs accordingly.

Test Configuration:

Profiles from the ONU discovery test (6.1.1) are used in this test.

Parameters for bandwidth maps, XGEM header and OMCI message are the same as the OMCI channel establishment test for a single ONU, with the relevant Alloc-IDs.

Equalization delay is initially set by the OLT during ranging.

Test Procedure:

1. After ranging succeeds, OLT and ONU ToD clock synchronization process is manually initialized.
2. OLT selects downstream XGTC frame to be used as timing reference. This frame is identified as superframe counter #N. OLT generates the pair N, TstampN and sends it to each ONU using separate OMCI channels.
3. Each ONU calculates the time of day based on the information communicated using the OMCI ME, its equalization delay and its response time.
4. 1PPS outputs from all ONUs and OLT are compared using a scope.
5. OLT and ONUs periodically print their ToD with corresponding values of superframe counter.

Pass/Fail Criteria:

1. 1PPS outputs from all ONUs and OLT are accurate within $\pm 1\mu\text{s}$.
2. ToD values printed with values of superframe counter match between all ONUs and OLT.
3. ONU ToD synchronization for each ONU was completed within up to 10sec from the communication of the downstream frame parameters over the OMCI channel.

Remarks:

- None

8.6 Protection Switching

8.6.1 Intermittent LODS

Test Status: Mandatory

Reference Documents:

- ITU-T G.987.3 [6], Section 12.2.

Test Objective:

Verify correct ONU response to an intermittent loss of downstream synchronization.

Test Setup:

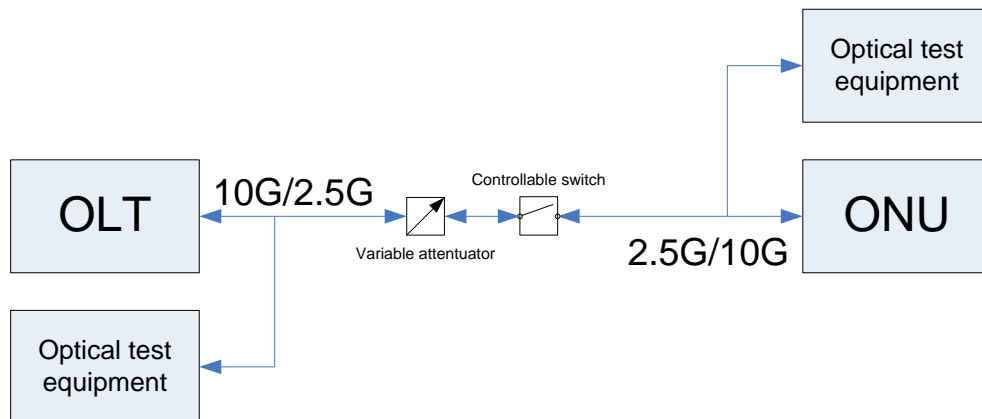


Figure 5 – Test Setup for Intermittent LODS

Pretest Conditions:

1. The OLT and ONU are powered and connected according to the test setup.
2. Switch is initially set to closed (connected) position.
3. The ONU has been ranged and activated by the OLT.

Test Configuration:

Profiles from the ONU discovery test (6.1.1) are used in this test.

TO2 timer is increased according to the properties of the controllable switch.

Test Procedure:

1. After ranging succeeds, TO2 timer is increased from the recommended initial value of 100ms to a higher value according to the properties of the controllable switch (e.g. 1sec).
2. The switch is briefly set to open position and back to closed position.

3. ONU transitions to intermittent LODS state (O6) while the switch is open and transitions back to regular operational state (O5) once the switch is closed.

Pass/Fail Criteria:

1. ONU transitions to intermittent LODS state (O6) while the switch is open and transitions back to regular operational state (O5) once the switch is closed.
2. ONU does not transition to initial state (O1) or serial number state (O2-3).

Remarks:

- Bandwidth grants to the ONU should be disabled for the duration of the test in order to prevent LOBi alarms at the OLT, leading to a deactivation or disable for the ONU.
- The controllable switch can be replaced by a simulation of a brief disconnection by the OLT or ONU, if such procedure is available.

End of Broadband Forum Technical Report TR-309