TECHNICAL REPORT

TR-426
NG-PON2 TC Layer Interoperability Test Plan

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1 Executive Summary

Broadband Forum, after extending the GPON conformance and interoperability test plans for service architecture to XG-PON (TR-247 and TR-255), enhances the document suite on ITU-T PON technologies with a XG-PON, XGS-PON and NG-PON2 TWDM physical layer interoperability test plans.

The scope of TR-426 is the verification of NG-PON2 TWDM OLT and ONU interoperability with respect to the Physical Media Dependent (PMD) sub-layer (ITU-T G.989.2 [6]) and the Transmission Convergence (TC) sub-layer (ITU-T G.989.3 [7]).

Note, in this test plan, much of the PMD layer testing is performed indirectly, as a result of testing the TC layer. PMD layer test cases are covered in TR-423 [12].

2 Purpose and Scope

2.1 Purpose

TR-426 defines a set of test cases whose purpose is to verify interoperability between an NG-PON2 TWDM OLT and a BBF.247 certified ONU. These test cases address the Physical Media Dependent (PMD) sub-layer (ITU-T G.989.2 [6]) and the Transmission Convergence (TC) sub-layer (ITU-T G.989.3 [7]). 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). This requirement is not enforced for test events focusing on the functionality of the lower layers of the protocol.

The tests are partitioned to three categories:

1. Basic TC layer tests - which focus on the frame structure and isolated TC layer functions
2. Comprehensive TC layer tests - which are oriented towards a more comprehensive TC layer behavior
3. NG-PON2 specific tests - pertaining to unique aspects of NG-PON2

2.2 Scope

The test cases specified in TR-426 are focused on exploring multi-supplier interoperability at the NG-PON2 PMD and TC sub-layer level of NG-PON2 systems or NG-PON2 test platforms. The test cases are written to allow for the participation of prototype NG-PON2 implementations, which may not have complete G.989.x functionality. The test cases provided in the body of TR-426 provide a minimum set of PMD and TC sub-layer interoperability tests and are not an exhaustive set of 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-426 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. NG-PON2 PtP WDM systems are out of scope of this document.

TR-426 contains test cases for features and capabilities that are optional according to G.989.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.

3 References and Terminology

3.1 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 be in RFC 2119 [10].

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.

3.2 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	*G-PON ONU Conformance Test Plan*	BBF	2011
[2]	TR-255	*G-PON Interoperability Test Plan*	BBF	2011

[3]	TR-309 Issue 2	*XG-PON and XGS-PON TC Layer Interoperability Test Plan*	BBF	2018
[4]	G.989	*40-Gigabit-capable passive optical network (NG-PON2) systems: Definitions, abbreviations and acronyms (10/15)*	ITU-T	2015
[5]	G.989.1	*40-Gigabit-capable passive optical networks (NG-PON2): General requirements (03/13)*	ITU-T	2013
[6]	G.989.2	*40-Gigabit-capable passive optical networks (NG-PON2): Physical media dependent (PMD) layer specification (12/14)*	ITU-T	2014
[7]	G.989.3	*40-Gigabit-capable passive optical networks (NG-PON2): Transmission convergence (TC) layer specification (10/15)*	ITU-T	2015
[8]	G.988	*ONU Management and Control Interface Specification (OMCI) (10/12)*	ITU-T	2012
[9]	G.988 Amd.1	*Recommendation G.988 (2012) Amendment 1 (05/14)*	ITU-T	2014
[10]	RFC 2119	*Key words for use in RFCs to Indicate Requirement Levels*	IETF	1997
[11]	G.989.3 Amd.1	*Recommendation G.989.3 (2015) Amendment 1 (11/16)*	ITU-T	2016
[12]	TR-423	*PON PMD Layer Conformance Test Plan*	BBF	2018

3.3 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.
NG-PON2 Network	An NG-PON2 OLT connected using an Optical Distribution Network (ODN) to one or more NG-PON2 ONUs or ONTs. An NG-PON2 network is a subset of the Access Network. An NG-PON2 system implements the suite of protocols specified in the ITU-T G.989.x series Recommendations.
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.989, 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 *XGEM Port-ID*
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.
TWDM TC service adaptation	The TWDM TC service adaptation sublayer is a sublayer of the NG-PON2 Transmission Convergence layer that supports the functions of user data fragmentation and de-fragmentation, XGEM encapsulation, XGEM frame delineation, and XGEM Port-ID filtering.
Vendor-ID	ONU Vendor-ID code, a four-character combination discovered at SN acquisition.
XGEM	A data frame transport scheme used in NG-PON2 systems that is connection-oriented and that supports fragmentation of user data frames into variable sized transmission fragments.
XGEM Port	An abstraction on the TWDM TC service 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 connection transported over the NG-PON2 interface and which is carried in the header of all the XGEM frames associated with the given logical connection.

3.4 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
DOWi	Drift of Window for ONU i
DSL	Digital Subscriber Line
FEC	Forward Error Correction
FE	Fast Ethernet (100Mbps)
FITH	Fiber into the Home
FS	Framing Sublayer
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

NG-PON2	Next Generation Passive Optical Network 2, ITU-T G.989.x-series
NSP	Network Service Provider
OAM	Operations, Adminsitration and Maintenance
ODN	Optical Distribution Network – as defined in G.989.1 [5]
OLT	Optical Line Termination – as defined in G.989.1
OMCI	ONU Management and Control Interface – as defined in G.988 [8]
OMCC	ONU Management and Control Channel
ONT	Optical Network Termination – as defined in G.989.1
ONU	Optical Network Unit – as defined in G.989.1
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
ToD	Time of Day
TWDM	Time and Wavelength Division Multiplexing
VDSL	Very high speed Digital Subscriber Line
VSSN	Vendor Specific Serial Number
WG	Working Group
WT	Working Text
xDSL	Any variety of DSL
XGEM	NG-PON2 Encapsulation Method
XG-PON	10-Gigabit-capable Passive Optical Network, ITU-T G.987.x-series
XGS-PON	10-Gigabit-capable Symmetric Passive Optical Network, ITU-T G.9807.1

4 Technical Report Impact

4.1 Energy Efficiency

TR-426 has no impact on energy efficiency.

4.2 IPv6

TR-426 has no impact on IPv6.

4.3 Security

TR-426 has no impact on security.

4.4 Privacy

Any issues regarding privacy are not affected by TR-426.

5 Test Configuration and Equipment

5.1 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.

5.2 Basic TC Layer Test Setup

The following setup is used for single ONU tests:

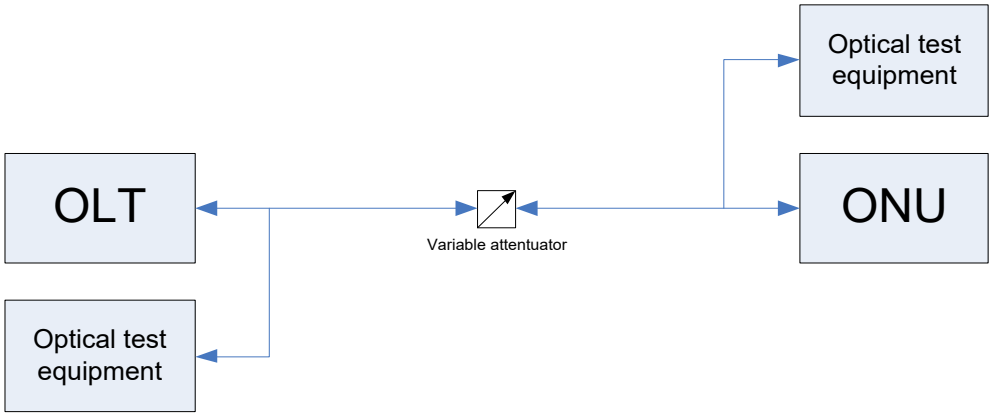


Figure 5-1 - Basic TC Layer Test Setup

A spool of fiber of 20km is optionally added between the OLT and ONU.

5.3 Ethernet Traffic Test Setup

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

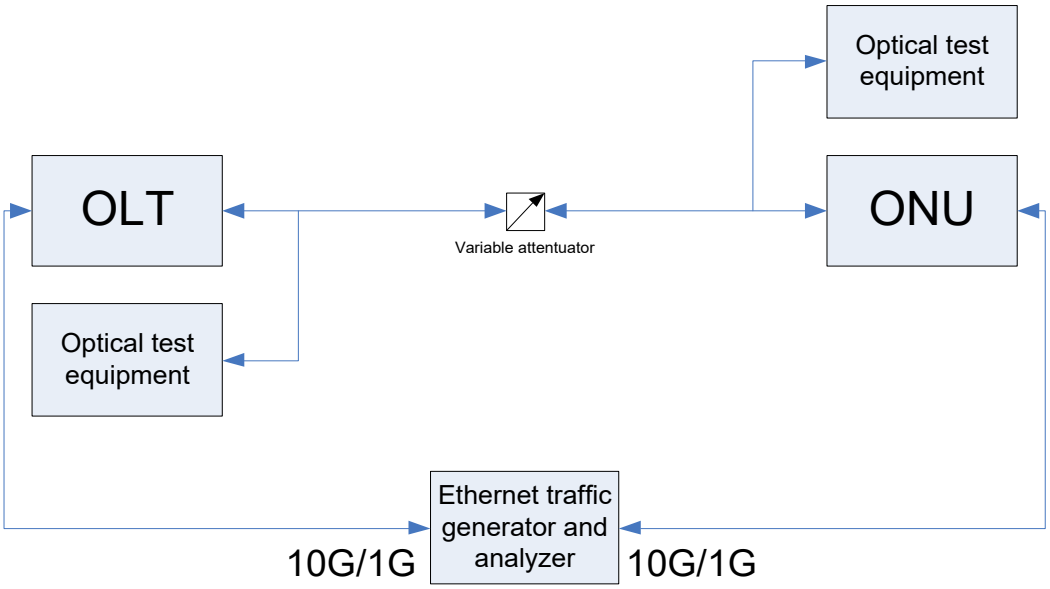


Figure 5-2 – Ethernet Traffic Test Setup

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

5.4 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 is optionally used in front of one ONU and none shall be used in front of the other ONU.

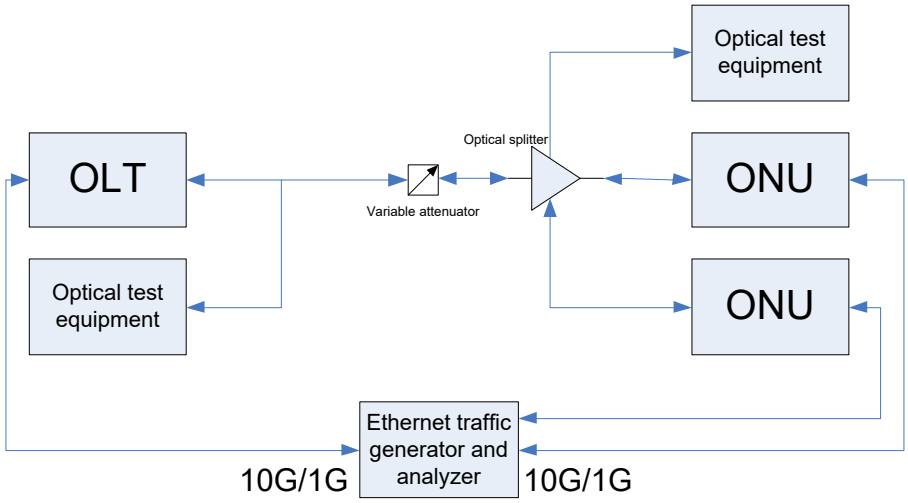


Figure 5-3 – Multiple ONU Test Setup with Ethernet Traffic

5.5 Alternative Test Setup for Forward Error Correction Tests

The following is an alternative setup which could be used for FEC tests:

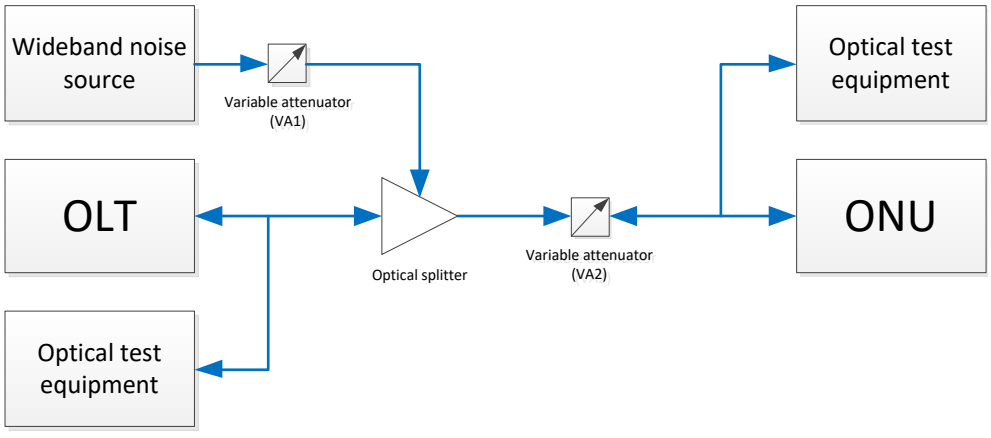


Figure 5-4 – Alternative Test Setup for FEC Tests

When using this setup, signal at the receiver input should be set to a fixed nominal value to maintain coherency between tests and prevent triggering optical LOS condition.

The signal to noise ratio of the optical signal received by the ONU is adjusted using VA1. VA2 is used to ensure that the optical signal received at the ONU is within the ONU's specifications and to keep the ONU's total received signal power at the same level during the test and as the wideband noise source's contribution changes.

5.6 Multiple Wavelength Channel Test Setup

This setup applies specifically to testing of multi-wavelength features with the use of ONU and OLT in a debug mode.

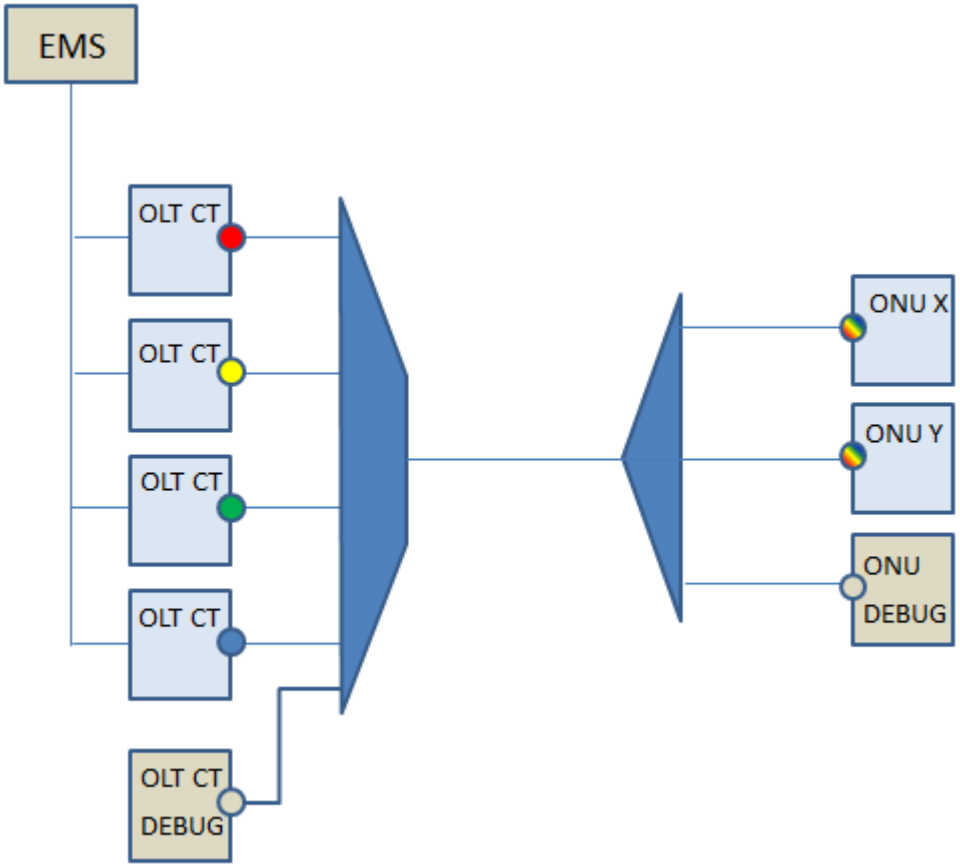


Figure 5-5 – Multiple Wavelength Channel Test Setup

5.7 Single Channel Emulation of Multi-Wavelength System

This setup applies specifically to testing of wavelength-invariant NG-PON2 features. It assumes the use of fixed (non-tunable) transceiver and an NG-PON2 protocol analyzer.

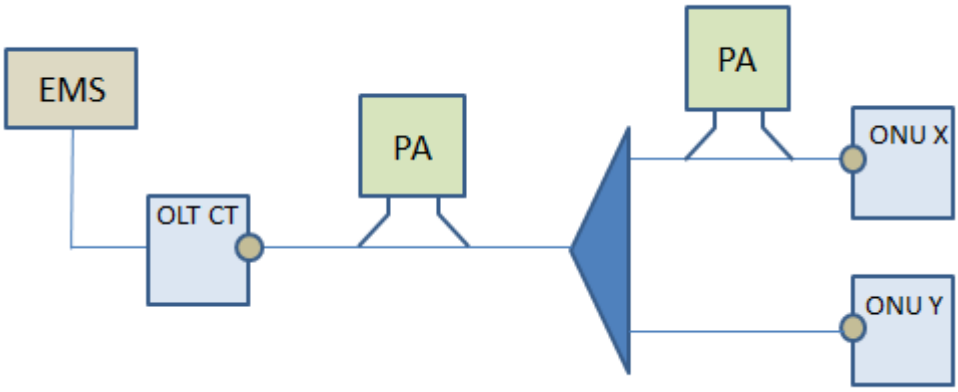


Figure 5-6 – Single Channel Emulation of a Multi-Wavelength System

5.8 PMD Parameters for TC Layer Tests

The focus of TR-426 is the TC layer and the main role of the PMD layer to is to enable TC layer tests. Transmission power should be within the limits defined in G.989.2 [6] and receiver sensitivity can be anywhere within the defined range.

For TC layer tests, optimal parameters shall be implemented by the PMD layer to maintain interoperability. For instance, transceivers must meet the wavelength plans so to be able to work with each other. Sufficient 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, with reasonable differential when two ONUs are involved.

NG-PON2 allows a certain degree of freedom in the PMD layer implementation. However, in order to enable TC layer operation, the following parameters should be coordinated between the OLT and ONU:

- Upstream operating wavelength grid (band, channel spacing)
- ONU calibration status
- Class of transmitter/receiver wavelength channel tuning times
- Downstream line coding

5.8.1 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.

5.8.2 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 for 2.5G upstream
    - 32 for 10G upstream
- Preamble value: 0xAAAA AAAA AAAA AAAA

Those parameters are set by the OLT using "profile" PLOAM message and referred within TR-426 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 for 2.5G upstream
    - 32 for 10G upstream
- Preamble value: 0xAAAA AAAA AAAA AAAA

Those parameters are set by the OLT using "profile" PLOAM message and referred within TR-426 as burst profile number 1.

5.9 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
- NG-PON2 analyzer, when available
- Optical splitter

5.10 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 FS 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

6 Test Case Summary

6.1 General

This section contains a summary of PMD and TC Layer tests, as applicable to different system types. Test sets are partitioned according to OLT downstream and upstream line rate combinations: 10/2.5, 2.5/2.5, 10/10 and dual rate upstream (10/10+2.5). A system which claims to support a given combination of line rates is expected to comply with the full corresponding test set.
Test cases for features and capabilities that are optional according to G.989.x are labeled as "conditionally mandatory", and are to be tested only if claimed to be supported by both the OLT and the ONU.

Many of the test cases and test procedures are common to XG-PON, XGS-PON and NG-PON2, and are re-used by reference to BBF TR-309 [3]. Additional test cases, most of which pertaining to tuning and other wavelength related aspects, are unique to NG-PON2 systems.

6.2 NG-PON2 TC Layer – Basic Tests

Test sets are partitioned according to OLT downstream and upstream line rate combinations: 10/2.5, 2.5/2.5, 10/10 and dual rate upstream (10/10+2.5). A system which claims to support a given combination of line rates is expected to comply with the full corresponding test set.

Test cases for features and capabilities that are optional according to G.989.x are labeled as "conditionally mandatory", and are to be tested only if claimed to be supported by both the OLT and the ONU. Refer to section 6.1.

	Test Set			
Test Name	**NG-PON2 10G/2.5G**	**NG-PON2 2.5G/2.5G**	**NG-PON2 10G/10G**	**NG-PON2 10G/10G+2.5G**
ONU Start-Up	**(test section)**			
7.1.1 ONU Discovery - Single ONU (cold OLT, cold ONU)	Mandatory	Mandatory	Mandatory	N/A
7.1.2 ONU Activation – Single ONU	Mandatory	Mandatory	Mandatory	N/A
7.1.3 ONU Discovery – Multiple ONUs (warm PON)	Mandatory (single rate)	Mandatory (single rate)	Mandatory (single rate)	Mandatory (mixed rate)

7.1.4 ONU Activation – Multiple ONUs without Data Transmission	Mandatory (single rate)	Mandatory (single rate)	Mandatory (single rate)	Mandatory (mixed rate)
7.1.5 ONU Discovery – Multiple ONUs (cold OLT, cold ONUs)	Mandatory (single rate)	Mandatory (single rate)	Mandatory (single rate)	Mandatory (mixed rate)
7.1.6 ONU Discovery and Activation during Data Transmission	Mandatory (single rate)	Mandatory (single rate)	Mandatory (single rate)	Mandatory (mixed rate)
7.1.7 Differential Reach Operation	Mandatory (DD40)	Mandatory (DD40)	Mandatory (DD40)	Mandatory (DD40)
Bandwidth Allocation	**(test section)**			
7.2.1 Single Allocation	Mandatory	Mandatory	Mandatory	N/A
Repetitive Allocation	Mandatory	Mandatory	Mandatory	N/A
7.2.3 Burst Series	Mandatory	Mandatory	Mandatory	N/A
7.2.4 Maximal Allocation	Mandatory	Mandatory	Mandatory	N/A
7.2.5 Allocations to Different ONUs	Mandatory (single rate)	Mandatory (single rate)	Mandatory (single rate)	Mandatory (mixed rate)
7.2.6 Adjacent Allocations to Different ONUs	Mandatory (single rate)	Mandatory (single rate)	Mandatory (single rate)	Mandatory (mixed rate)
Embedded OAM Operation	**(test section)**			
7.3.1 Operation Control	Mandatory	Mandatory	Mandatory	Mandatory
7.3.2 Dying Gasp	Mandatory	Mandatory	Mandatory	Mandatory
7.3.3 PLOAM Queue Status	Mandatory	Mandatory	Mandatory	Mandatory
7.3.4 Dynamic	Mandatory	Mandatory	Mandatory	Mandatory

Bandwidth Reporting				
7.3.5 PIT Field	Mandatory	Mandatory	Mandatory	Mandatory
7.3.6 Downstream BIP	Mandatory	Mandatory	Mandatory	Mandatory
PLOAM Channel Operation	**(test section)**			
7.4.1 Multiple PLOAM Messages per Frame	Conditionally Mandatory for OLT, Mandatory for ONU	Conditionally Mandatory for OLT, Mandatory for ONU	Conditionally Mandatory for OLT, Mandatory for ONU	Conditionally Mandatory for OLT, Mandatory for ONU
7.4.2 Burst Profile Version Changes – Single ONU	Mandatory	Mandatory	Mandatory	N/A
07.4.3 Burst Profile Version Changes – Mixed Rate	N/A	N/A	N/A	Mandatory
7.4.4 ONU Deactivation and Disable SN	Mandatory	Mandatory	Mandatory	Mandatory
7.4.5 Alloc-ID Allocation and De-allocation	Mandatory	Mandatory	Mandatory	Mandatory
7.4.6 Encryption Key Exchange	Mandatory	Mandatory	Mandatory	Mandatory
7.4.7 Disable Discovery	Mandatory	Mandatory	Mandatory	Mandatory
7.4.8 Deny Upstream Access	Mandatory	Mandatory	Mandatory	Mandatory
7.4.9 System and Channel Profiles	Mandatory	Mandatory	Mandatory	Mandatory
7.4.10 Change Power Level	Conditionally Mandatory	Conditionally Mandatory	Conditionally Mandatory	N/A
7.4.11 Power Consumption Inquire/Report	Mandatory	Mandatory	Mandatory	N/A
Forward error correction	**(test section)**			

7.5.1 Downstream FEC Operation	Mandatory	Mandatory	Mandatory	N/A
7.5.2 Upstream FEC Operation – Integral Multiple of Codeword Size	Mandatory	Mandatory	Mandatory	N/A
7.5.3 Upstream FEC Operation – Non-Integral Multiple of Codeword Size	Mandatory	Mandatory	Mandatory	N/A
7.5.4 Upstream FEC Operation – Burst Series with Shared Parity Words	Mandatory	Mandatory	Mandatory	N/A
7.5.5 Upstream FEC Operation – Mixed FEC and No-FEC Accesses – Multiple ONUs – Single Rate	Mandatory	Mandatory	Mandatory	N/A
7.5.6 Upstream FEC Operation – Multiple Rate	N/A	N/A	N/A	Mandatory
7.5.7 Upstream FEC Operation – Mixed FEC and No-FEC Accesses – Single ONU – Single Rate	Mandatory	Mandatory	Mandatory	N/A
7.5.8 Downstream Non-FEC Operation	Mandatory	Mandatory	Mandatory	N/A
Data transmission	**(test section)**			
7.6.1 OMCI Channel Establishment	Mandatory	Mandatory	Mandatory	N/A
7.6.2 OMCI Channel Establishment – Multiple ONUs	Mandatory (single rate)	Mandatory (single rate)	Mandatory (single rate)	Mandatory (mixed rate)
7.6.3 Downstream Encryption Operation	Mandatory	Mandatory	Mandatory	Mandatory
7.6.4 Upstream Encryption	Mandatory	Mandatory	Mandatory	N/A

Operation				
7.6.5 Downstream Ethernet Traffic Transmission	Mandatory	Mandatory	Mandatory	N/A
7.6.6 Upstream Ethernet Traffic Transmission	Mandatory	Mandatory	Mandatory	N/A
7.6.7 Bidirectional Ethernet Traffic Transmission	Mandatory	Mandatory	Mandatory	N/A
7.6.8 Multiple Port-ID/Alloc-ID Data Transmission – Single ONU	Mandatory	Mandatory	Mandatory	N/A
7.6.9 Bidirectional Ethernet Traffic Transmission – Multiple ONUs	Mandatory (single rate)	Mandatory (single rate)	Mandatory (single rate)	Mandatory (mixed rate)

6.3 NG-PON2 TC Layer - Comprehensive Tests

Test sets are partitioned according to OLT downstream and upstream line rate combinations: 10/2.5, 2.5/2.5, 10/10 and dual rate upstream (10/10+2.5). A system which claims to support a given combination of line rates is expected to comply with the full corresponding test set.

Test cases for features and capabilities that are optional according to G.989.x are labeled as "conditionally mandatory", and are to be tested only if claimed to be supported by both the OLT and the ONU. Refer to section 6.1.

	Test Set			
Test Name	**NG-PON2 10G/2.5G**	**NG-PON2 2.5G/2.5G**	**NG-PON2 10G/10G**	**NG-PON2 10G/10G+2.5G**
Authentication and Encryption	**(test section)**			
8.1.1 Registration-ID Based Authentication	Mandatory	Mandatory	Mandatory	N/A
8.1.2 Automatic Encryption Key Exchange and Traffic Transmission	Mandatory	Mandatory	Mandatory	N/A
8.1.3 Encrypted Ethernet	Mandatory	Mandatory	Mandatory	N/A

Transmission				
8.1.4 Multicast Encryption Operation	Mandatory	Mandatory	Mandatory	Mandatory
8.1.5 ONU Re-Activation After Fiber Disconnection with Registration-ID Based Authentication	Mandatory	Mandatory	Mandatory	N/A
8.1.6 Automatic Encryption Key Exchange during Traffic	Mandatory	Mandatory	Mandatory	N/A
8.1.7 Secure Mutual Authentication – OMCI Based	Conditionally Mandatory	Conditionally Mandatory	Conditionally Mandatory	N/A
8.1.8 Secure Mutual Authentication – 802.1x	Conditionally Mandatory	Conditionally Mandatory	Conditionally Mandatory	N/A
8.1.9 ONU Re-Activation after Fiber Disconnection with Secure Mutual Authentication	Conditionally Mandatory	Conditionally Mandatory	Conditionally Mandatory	N/A
8.1.10 Request Registration after Secure Mutual Authentication	Conditionally Mandatory	Conditionally Mandatory	Conditionally Mandatory	N/A
ONU Power Management Modes	**(test section)**			
8.2.1 Watchful Sleep	Mandatory	Mandatory	Mandatory	Mandatory
8.2.2 Watchful Sleep (ONU Wakeup)	Mandatory	Mandatory	Mandatory	Mandatory
Dynamic Bandwidth Allocation	**(test section)**			
8.3.1 DBA Operation - Single ONU	Mandatory	Mandatory	Mandatory	N/A
8.3.2 DBA Operation - Multiple ONUs	Mandatory (single rate)	Mandatory (single rate)	Mandatory (single rate)	Mandatory (mixed rate)
8.3.3 DBA Operation under Different Traffic Loads - Multiple ONUs	Mandatory (single rate)	Mandatory (single rate)	Mandatory (single rate)	Mandatory (mixed rate)
Drift Control and Compensation	**(test section)**			
8.4.1 Acceptable	Mandatory	Mandatory	Mandatory	N/A

Transmission Drift Boundary				
8.4.2 Adjustable Transmission Drift Boundary (DOW)	Mandatory	Mandatory	Mandatory	N/A
8.4.3 Unacceptable Transmission Drift Boundary (TIW)	Mandatory	Mandatory	Mandatory	N/A
Time of Day Distribution over PON	**(test section)**			
8.5.1 Time of Day Distribution – Fixed Equalization Delay, Single ONU	Mandatory	Mandatory	Mandatory	N/A
8.5.2 Time of Day Distribution – Equalization Delay Adjustments, Single ONU	Mandatory	Mandatory	Mandatory	N/A
8.5.3 Time of Day Synchronization - Multiple ONUs	Mandatory	Mandatory	Mandatory	Mandatory
Protection Switching	**(test section)**			
8.6.1 Intermittent LODS	Mandatory	Mandatory	Mandatory	Mandatory
8.6.2 Type B Protection Switching	Mandatory	Mandatory	Mandatory	Mandatory
8.6.3 Type C Protection Switching	Mandatory	Mandatory	Mandatory	Mandatory

6.4 NG-PON2 Specific TC Layer Tests

Test sets are partitioned according to OLT downstream and upstream line rate combinations: 10/2.5, 2.5/2.5, 10/10 and dual rate upstream (10/10+2.5). A system which claims to support a given combination of line rates is expected to comply with the full corresponding test set.

Test cases for features and capabilities that are optional according to G.989.x are labeled as "conditionally mandatory", and are to be tested only if claimed to be supported by both the OLT and the ONU. Refer to section 6.1.

	Test Set			
Test Name	**NG-PON2 10G/2.5G**	**NG-PON2 2.5G/2.5G**	**NG-PON2 10G/10G**	**NG-PON2 10G/10G+2.5G**
ONU Discovery and Activation in a Multi-Wavelength Environment	**(test section)**			
9.1.1 ONU Discovery and Activation – CPI Handling on Single Channel Pair	Mandatory	Mandatory	Mandatory	N/A
9.1.2 ONU Discovery and Activation – CPI Handling on Multiple Channel Pairs	Mandatory	Mandatory	Mandatory	N/A
9.1.3 ONU Discovery and Activation – Different Rates	N/A	N/A	N/A	Mandatory
9.1.4 ONU Discovery and Activation – CPI Change	Mandatory	Mandatory	Mandatory	N/A
ONU Tuning	**(test section)**			
9.2.1 ONU Handover	Mandatory	Mandatory	Mandatory	N/A
9.2.2 Failed Handover – Source OLT Timeout	Mandatory	Mandatory	Mandatory	N/A
9.2.3 Failed Handover – Target OLT Timeout	Mandatory	Mandatory	Mandatory	N/A
9.2.4 Failed Handover – ONU Timeout	Mandatory	Mandatory	Mandatory	N/A
9.2.5 Failed Handover – NACK	Mandatory	Mandatory	Mandatory	N/A
9.2.6 Failed Handover –	Mandatory	Mandatory	Mandatory	N/A

Rollback				
9.2.7 Failed Handover – Channel Partitioning	Mandatory	Mandatory	Mandatory	N/A
9.2.8 Flexible DS/US Channel Association	Mandatory	Mandatory	Mandatory	N/A
9.2.9 Tuning Control / Response Message Formats	Conditionally Mandatory	Conditionally Mandatory	Conditionally Mandatory	N/A
ONU Calibration and Wavelength Drift Control	**(test section)**			
9.3.1 ONU Calibration Status Reporting	Mandatory	Mandatory	Mandatory	N/A
9.3.2 Wavelength Drift Control	Conditionally Mandatory	Conditionally Mandatory	Conditionally Mandatory	N/A
Lambda Type Protection	**(test section)**			
9.4.1 Protection Channel Not Configured, Default TO2	Mandatory	Mandatory	Mandatory	N/A
9.4.2 Protection Channel Not Configured, Large Configured TO2	Conditionally Mandatory	Conditionally Mandatory	Conditionally Mandatory	N/A
9.4.3 Protection Switching	Mandatory	Mandatory	Mandatory	N/A
9.4.4 Protection Channel Unavailable	Mandatory	Mandatory	Mandatory	N/A
9.4.5 Protection Switching – Multiple ONUs	Mandatory	Mandatory	Mandatory	Mandatory
9.4.6 Protection Switching – Multiple ONUs, Different TO3 Values	Mandatory	Mandatory	Mandatory	Mandatory
System Misconfiguration Detection	**(test section)**			
9.5.1 Transmitter Parameter Mismatch	Mandatory	Mandatory	Mandatory	N/A
9.5.2 NG2SYS ID Mismatch	Conditionally Mandatory	Conditionally Mandatory	Conditionally Mandatory	N/A
9.5.3 PON-ID Mismatch – In Channel	Mandatory	Mandatory	Mandatory	N/A

9.5.4 PON-ID Mismatch – Cross Channel	Conditionally Mandatory	Conditionally Mandatory	Conditionally Mandatory	N/A
Auxiliary Management and Control Channel (AMCC)	**(test section)**			
Test cases TBD				

7 TC Layer Basic Tests

7.1 ONU Start-Up

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

A	**Test Status**	Refer to Section 6.
B	**Reference Documents**	ITU-T G.989.3 [7], Sections 6.1, 8.1, 10.1, 11 and 12.1. BBF TR-309 [3], Section 7.1.1.
C	**Test Objective**	Verify that the OLT is able to detect the ONU. Verify NG-PON2 framing, synchronization and serial number acquisition.
D	**Test setup**	As shown in Section 5.2.
E	**Pre-test conditions**	The OLT and ONU are connected according to the test setup (except the PON fiber connection to the ONU).
F	**Test Configuration**	
	Optical parameters: • Downstream frequency: 187.8 THz (channel 1) • Upstream frequency: 195.5 THz (channel 1) ONU CPI: 0 (default) Parameters for System_Profile message: • ONU-ID: 0x03FF (broadcast ONU-ID) • System profile version: 0 • Upstream operating wavelength bands: 0x00 (wide band option), or as applicable • TWDM channel count: 1 • Channel spacing: 0x64 (100 GHz), or as applicable • Upstream MSE: 5 (5 GHz), or as applicable • FSR: 0, or as applicable • TWDM AMCC control: 0000 0011 (sufficient calibration), or as applicable • Loose calibration bound for TWDM channels: 0x00, or as applicable • Other fields: are at the discretion of the OLT Parameters for Channel_Profile message: • ONU-ID: 0x03FF (broadcast ONU-ID) • Control octet: 0001 0100 (channel profile index 1, channel profile pertains to this TWDM channel, valid downstream descriptor, valid upstream descriptor) • Channel profile version: 0 • PON-ID: same as the PON-ID carried in the OC structure • Downstream frequency offset: 0000 0000 (no offset) • Downstream line rate: 0 (9.95328 Gbit/s) or 1 (2.48832 Gbit/s), as applicable • Downstream line code: 0000 (NRZ) • Channel partition: 0	

	• Default response channel: same as the PON-ID carried in the OC structure
	• Serial number grant type indication: 0000 0010 (in-band serial number grants are offered)
	• UWLCH ID: 0000 0001
	• Upstream frequency: 0x1DD4B8 (195.5 THz)
	• Optical link type: 0000 0010 (type A supported, type B not supported), or as applicable
	• Upstream rate: 0000 0010 (9.95328 Gb/s supported, 2.48832 Gb/s not supported), or as applicable
	• Default ONU attenuation: 0000 0000 (no attenuation requested)
	• Response threshold: 0 (OLT CT does not encourage ONU activated power levelling)
	• Other fields: are at the discretion of the OLT
	
	Parameters for burst profile message #1:
	• ONU-ID: 0x3FF/0x3FE (broadcast ONU-ID, according to the protocol and upstream rate under test and at the discretion of the OLT)
	• Burst profile applicability flag (F): 0 for 2.5G upstream, 1 for 10G upstream
	• 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 5.8 for burst profile 0.
	
	Parameters for burst profile message #2:
	• ONU-ID: 0x3FF/0x3FE (broadcast ONU-ID, according to the protocol and upstream rate under test and at the discretion of the OLT)
	• Burst profile applicability flag (F): 0 for 2.5G upstream, 1 for 10G upstream
	• 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 5.8 for burst profile 1.
	
	Parameters for serial number grant:
	• Alloc-ID:
	  o 0x03FF for 2.5G upstream
	  o 0x03FE for 10G upstream
	• 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”)
	• Downstream/upstream PON-ID: as applicable
	• Upstream line rate capability: 0x0 for 2.5G upstream, 0x3 for 10G upstream, or as appropriate
	• Other fields: are at the discretion of the ONU

G	**Test procedure**	
	User Action	**Expected reaction and message timeline**
1	Power-up the ONU and attach the PON fiber.	1. ONU is at state O1.1 until downstream frame synchronization is attained. It then transitions to state O1.2. 2. OLT transmits the channel, system and burst profile messages. Each message is sent at least twice. 3. ONU determines that the downstream channel is ok and transitions to state O2-3. 4. OLT sends a serial number grant. 5. ONU responds with a serial number ONU message. 6. OLT prints the received serial number.
H	**Pass/fail criteria**	
	1. Serial number detected by the OLT is correct. 2. ONU has entered serial number state (O2-3).	
I	**Remarks**	
	• PON-TAG can be chosen to a different value at the discretion of the OLT, but must be the same for the two burst profiles. • Other burst profile parameters should be chosen according to Section **5.8**. • 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 – Single ONU

A	**Test Status**	Refer to Section 6.
B	**Reference Documents**	ITU-T G.989.3 [7], Sections 6.1, 8.1, 11 and 12.1. BBF TR-309 **[**3], Section 7.1.2.
C	**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.
D	**Test setup**	As shown in Section 5.2.
E	**Pre-test 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).
F	**Test Configuration**	
	Profiles from the ONU discovery test (7.1.1) 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 • Upstream line rate indicator (if applicable): 0 for 2.5G upstream, 1 for 10G upstream 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) • Downstream/upstream PON-ID: as applicable • MIC is calculated using the new derived PLOAM-IK (see comment at 5.1) 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 5.1)
G	**Test procedure**

	User Action	**Expected reaction and message timeline**
1	Activate the ONU (if not performed automatically after discovery).	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 O5.1 and sends an acknowledge message.

H	**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 (O5.1). 4. OLT received the acknowledge message.
I	**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)

A	**Test Status**	Refer to Section 6.
B	**Reference Documents**	ITU-T G.989.3 [7], Sections 6.1, 8.1, 10.1, 11 and 12.1. BBF TR-309 **[**3], Section 7.1.3.
C	**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.
D	**Test setup**	As shown in Section 5.4.
E	**Pre-test conditions**	1. The OLT and first ONU are powered and connected according to the test setup. 2. First ONU is in operational state (O5.1). 3. Other ONUs are powered off (see remarks).
F	**Test Configuration**	
	Profiles from the ONU discovery test (**7.1.1**) are used in this test. Parameters for serial number grant: • Alloc-ID: o 0x03FF for 2.5G upstream o 0x03FE for 10G upstream • 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 • Downstream/upstream PON-ID: as applicable • Upstream line rate capability: 0x0 for 2.5G upstream, 0x3 for 10G upstream, or as appropriate	

	• Other fields: are at the discretion of the ONU	
G	**Test procedure**	
	User Action	**Expected reaction and message timeline**
1	Power-up other ONUs and attach the PON fiber.	1. ONU (except first ONU) to be detected is at state O1.1 until downstream frame synchronization is attained. Each ONU (except first ONU) then transitions to states O1.2 and 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. Steps 1-5 are repeated until all of the serial numbers are learned.
H	**Pass/fail criteria**	
	1. Serial numbers detected by the OLT are correct. 2. First ONU stays at operational state (O5.1). 3. All additional ONUs have entered serial number state (O2-3).	
I	**Remarks**	
	• For single rate test scenario all ONUs operate using the same upstream rate. • For mixed rate test scenario at least one ONU operates at 10G upstream rate and at least one ONU operates at 2.5G upstream rate. Multiple tests should be performed with different upstream rate for the "first ONU". • 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

A	**Test Status**	Refer to Section 6.
B	**Reference Documents**	ITU-T G.989.3 [7], Sections 6.1, 8.1, 11 and 12.1. BBF TR-309 [3], Section 7.1.4.
C	**Test Objective**	Verify that the OLT is able to activate additional ONUs. This test follows the ONU discovery – multiple ONUs test.
D	**Test setup**	As shown in Section 5.4.
E	**Pre-test conditions**	1. The OLT and ONUs are powered and connected according to the test setup. 2. First ONU is in operational state (O5.1). 3. The OLT learned the serial number of the other ONUs. 4. Other ONUs are in serial number state (O2-3).
F	**Test Configuration**	
	Profiles from the ONU discovery test (**7.1.1**) are used in this test. Parameters for other messages are defined in test ONU activation – single ONU test (**7.1.2**). ONU-IDs are at the discretion of the OLT.	
G	**Test procedure**	
	User Action	**Expected reaction and message timeline**
1	Activate the other ONUs (if not performed automatically after discovery).	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 O5.1 and sends an acknowledge message. 7. OLT repeats the procedure for each additional ONU.
H	**Pass/fail criteria**	
	1. All ONUs (except fisrt 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 (O5.1). 4. OLT received acknowledge messages.	
I	**Remarks**	
	• OLT should count the number of answered allocations and ONU should count the number of granted allocations. • For single rate test scenario all ONUs operate using the same upstream rate.	

	• For mixed rate test scenario at least one ONU operates at 10G upstream rate and at least one ONU operates at 2.5G upstream rate. Multiple tests should be performed with different upstream rate for the "first ONU". • 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)

A	**Test Status**	Refer to Section 6.
B	**Reference Documents**	ITU-T G.989.3 [7], Sections 6.1, 8.1, 10.1, 11 and 12.1. BBF TR-309 [3], Section 7.1.5.
C	**Test Objective**	Verify that the OLT is able to detect multiple ONUs simultaneously.
D	**Test setup**	As shown in Section **5.4**.
E	**Pre-test conditions**	1. The OLT and ONUs connected according to the test setup (except the PON fiber connection to the ONUs). 2. The OLT is powered on and is in its initial reset state. 3. All ONUs are powered off.
F	**Test Configuration**	
	Profiles from the ONU discovery test (**7.1.1**) are used in this test.	
G	**Test procedure**	
X	**User Action**	**Expected reaction and message timeline**
1	Power-up the ONUs and attach the PON fiber.	1. ONUs are at state O1.1 until downstream frame synchronization is attained. Each ONU then transitions to states O1.2 and 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.
H	**Pass/fail criteria**	
	1. Serial numbers detected by the OLT are correct. 2. All ONUs have entered serial number state (O2-3).	
I	**Remarks**	
	• For single rate test scenario all ONUs operate using the same upstream rate. • For mixed rate test scenario at least one ONU operates at 10G upstream rate and at least one ONU operates at 2.5G upstream rate. Multiple tests should be performed with a different order of serial number grants (0x3FE, 0x3FF).	

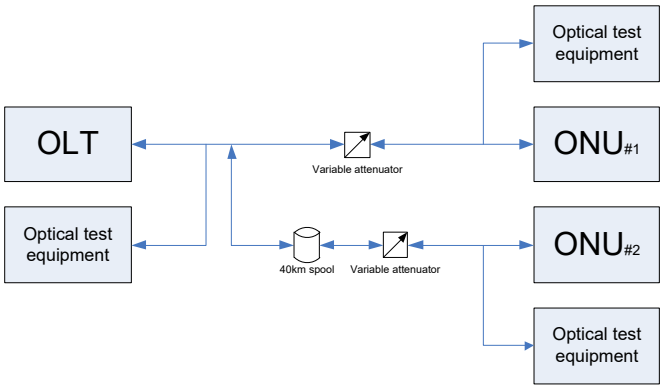
7.1.6 ONU Discovery and Activation during Data Transmission

A	**Test Status**	Refer to Section 6.
B	**Reference Documents**	ITU-T G.989.3 [7], Sections 6.1, 8.1, 11 and 12.1. BBF TR-309 [3], Section 7.1.6.
C	**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.
D	**Test setup**	As shown in Section **5.4**. 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.
E	**Pre-test conditions**	1. The OLT and ONUs are powered and connected according to the test setup (except the PON fiber of the other ONUs). 2. First ONU is in operational state (O5.1). 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.
F	**Test Configuration**	
	Profiles from the ONU discovery test (**7.1.1**) are used in this test. Parameters for other messages are defined in test ONU activation – single ONU test (7.1.2). 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	
G	**Test procedure**	
	User Action	**Expected reaction and message timeline**
1	Enable traffic generators for downstream and upstream traffic.	1. Received data is tested by the Ethernet traffic analyzer for both downstream and upstream.
2	Attach the PON fiber to the other ONUs.	1. Other ONUs are at state O1.1 until downstream frame synchronization is attained. Each ONU then transitions to states O1.2 and 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 number. 6. OLT sends an assign ONU-ID message to the newly 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 to an inactive ONU. 9. The 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 O5.1 and sends an acknowledge message. 12. OLT repeats the procedure for each additional ONU.
H	**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 (O5.1). 4. OLT received acknowledge messages. 5. No errors are detected in downstream and upstream traffic during the whole duration of the test.	
I	**Remarks**	
	• OLT should count the number of answered allocations and ONU should count the number of granted allocations. • For single rate test scenario all ONUs operate using the same upstream rate. • For mixed rate test scenario at least one ONU operates at 10G upstream rate and at least one ONU operates at 2.5G upstream rate. Multiple tests should be performed with different upstream rate for the "first ONU". • Interoperability between three or more vendors should also be tested.	

7.1.7 Differential Reach Operation

A	**Test Status**	Refer to Section 6.
B	**Reference Documents**	ITU-T G.989.3 [7], Sections 6.1, 8.1, 10.1, 11 and 12.1. BBF TR-309 [3], Section 7.1.7.
C	**Test Objective**	Verify that the OLT is able to detect two ONUs with a differential distance of 40km.

D	**Test setup**	 **Figure 7-1 – Test Setup for DD40 Differential Reach Test**
E	**Pre-test conditions**	1. The OLT and ONUs connected according to the test setup (except the PON fiber connection to the ONUs). 2. The OLT is powered on and is in its initial reset state. 3. All ONUs are powered off.
F	**Test Configuration**	
	Profiles from the ONU discovery test (**7.1.1**) are used in this test.	
G	**Test procedure**	
	User Action	**Expected reaction and message timeline**
1	Power-up the ONUs and attach the PON fiber.	1. ONUs are at state O1.1 until downstream frame synchronization is attained. Each ONU then transitions to states O1.2 and 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 O5.1 and sends an acknowledge message. 12. Steps 3-11 are repeated for the second ONU.
H	**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
I	**Remarks**
	• If this test fails, a differential distance of 20km can be tested.

7.2 Bandwidth Allocation

7.2.1 Single Allocation

A	**Test Status**	Refer to Section 6.
B	**Reference Documents**	ITU-T G.989.3 [7], Section 8.1.1.2. BBF TR-309 **[**3], Section 7.2.1.
C	**Test Objective**	Verify correct generation and parsing of bandwidth allocation structures.
D	**Test setup**	As shown in Section **5.2**.
E	**Pre-test 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.
F	**Test Configuration**	

Profiles from the ONU discovery test (**7.1.1**) 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 10G ONU

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*	1	0	0	Minimal XGEM section
1	100*	9719	0	0	Maximal allocation size
1	100*	1	0	1	DBRu only grant
1	100*	1	1	1	PLOAM + DBRu only
1	100*	2	0	1	Minimal XGEM + DBRu
1	100*	2	1	1	Minimal XGEM + PLOAM + DBRu

Table 7-2 – Bandwidth Allocation Parameters For 2.5G ONU

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	
G	**Test procedure**	
X	**User Action**	**Expected reaction and message timeline**
1	Apply bandwidth settings at the OLT to generate bandwidth allocation structures corresponding to the first line of the applicable table above.	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 FS frames. Test results are recorded separately for each scenario. 2. Upon getting bandwidth grants, ONU responds appropriately and at the correct time: a. FS 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 1or not present if DBRu is 0. c. FS payload section: idle XGEMs. 3. OLT verifies that idle traffic is received from ONU at the FS payload section. Steps 1-3 are repeated for each additional bandwidth map.
H	**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.	
I	**Remarks**	
	• None	

7.2.2 Repetitive Allocation

A	**Test Status**	Refer to Section 6.
B	**Reference Documents**	ITU-T G.989.3 [7], Section 8.1.1.2. BBF TR-309 **[**3], Section 7.2.2.
C	**Test Objective**	Verify correct generation and parsing of bandwidth allocation structures.
D	**Test setup**	As shown in Section **5.2**.
E	**Pre-test conditions**	Refer to BBF TR-309 [3], Section 7.2.2.
F	**Test Configuration**	
G	**Test procedure**	
H	**Pass/fail criteria**	
I	**Remarks**	

7.2.3 Burst Series

A	**Test Status**	Refer to Section 6.
B	**Reference Documents**	ITU-T G.989.3 [7], Section 8.1.1.2. BBF TR-309 [3], Section 7.2.3.
C	**Test Objective**	Verify correct generation and parsing of bandwidth maps containing burst series allocation structures.
D	**Test setup**	As shown in Section **5.2**.
E	**Pre-test conditions**	Refer to BBF TR-309 [3], Section 7.2.3.
F	**Test Configuration**	
G	**Test procedure**	
H	**Pass/fail criteria**	
I	**Remarks**	

7.2.4 Maximal Allocation

A	**Test Status**	Refer to Section 6.
B	**Reference Documents**	ITU-T G.989.3 [7], Section 8.1.1.2. BBF TR-309 **[**3], Section 7.2.4.
C	**Test Objective**	Verify correct generation and parsing of bandwidth maps containing bandwidth allocation structures with maximal grant sizes.
D	**Test setup**	As shown in Section **5.2**.
E	**Pre-test conditions**	Refer to BBF TR-309 [3], Section 7.2.4.
F	**Test Configuration**	
G	**Test procedure**	
H	**Pass/fail criteria**	
I	**Remarks**	

7.2.5 Allocations to Different ONUs

A	**Test Status**	Refer to Section 6.
B	**Reference Documents**	ITU-T G.989.3 [7], Section 8.1.1.2. BBF TR-309 **[**3], Section 7.2.5.
C	**Test Objective**	Verify correct system behavior with bandwidth maps containing allocation structures to different ONUs.
D	**Test setup**	As shown in Section **5.2**.
E	**Pre-test conditions**	Refer to BBF TR-309 [3], Section 7.2.5.
F	**Test Configuration**	
G	**Test procedure**	
H	**Pass/fail criteria**	
I	**Remarks**	

7.2.6 Adjacent Allocations to Different ONUs

A	**Test Status**	Refer to Section 6.
B	**Reference Documents**	ITU-T G.989.3 [7], Section 8.1.1.2. BBF TR-309 **[**3], Section 7.2.6.
C	**Test Objective**	Verify correct system behavior with bandwidth maps containing allocation structures with adjacent bursts.
D	**Test setup**	As shown in Section **5.2**.
E	**Pre-test conditions**	Refer to BBF TR-309 [3], Section 7.2.6.
F	**Test Configuration**	
G	**Test procedure**	
H	**Pass/fail criteria**	
I	**Remarks**	

7.3 Embedded OAM Operation

7.3.1 Operation Control

A	**Test Status**	Refer to Section 6.
B	**Reference Documents**	ITU-T G.989.3 [7], Section 10.1.1.1.3. BBF TR-309 **[**3], Section 7.3.1.
C	**Test Objective**	Verify that the OLT can generate and the ONU can properly process the OC structure in the PSBd.
D	**Test setup**	As shown in Section **5.2**.
E	**Pre-test conditions**	Refer to BBF TR-309 [3], Section 7.3.1.
F	**Test Configuration**	
G	**Test procedure**	
H	**Pass/fail criteria**	
I	**Remarks**	

7.3.2 Dying Gasp

A	**Test Status**	Refer to Section 6.
B	**Reference Documents**	ITU-T G.989.3 [7], Section 8.1.2.1.2. BBF TR-309 **[**3], Section 7.3.2.
C	**Test Objective**	Verify that the ONU can generate and the OLT can properly process the following upstream embedded OAM indication: • Dying gasp
D	**Test setup**	As shown in Section **5.2**.
E	**Pre-test conditions**	Refer to BBF TR-309 [3], Section 7.3.2.
F	**Test Configuration**	
G	**Test procedure**	
H	**Pass/fail criteria**	
I	**Remarks**	

7.3.3 PLOAM Queue Status

A	**Test Status**	Refer to Section 6.
B	**Reference Documents**	ITU-T G.989.3 [7], Section 8.1.2.1.2. BBF TR-309 **[**3], Section 7.3.3.
C	**Test Objective**	Verify that the ONU can generate and the OLT can properly process the following upstream embedded OAM indication: • PLOAM queue status
D	**Test setup**	As shown in Section **5.2**.
E	**Pre-test conditions**	Refer to BBF TR-309 [3], Section 7.3.3.
F	**Test Configuration**	
G	**Test procedure**	
H	**Pass/fail criteria**	
I	**Remarks**	

7.3.4 Dynamic Bandwidth Reporting

A	**Test Status**	Refer to Section 6.
B	**Reference Documents**	ITU-T G.989.3 [7], Section 8.1.2.2. BBF TR-309 **[**3], Section 7.3.4.
C	**Test Objective**	Verify that the OLT can request and the ONU can generate DBR reports.
D	**Test setup**	As shown in Section **5.2**.
E	**Pre-test conditions**	Refer to BBF TR-309 [3], Section 7.3.4.
F	**Test Configuration**	
G	**Test procedure**	
H	**Pass/fail criteria**	
I	**Remarks**	

7.3.5 PIT Field

A	**Test Status**	Refer to Section 6.
B	**Reference Documents**	ITU-T G.989.3 [7], Section 10.1.1.1.3.
C	**Test Objective**	Verify that the OLT can generate and the ONU can properly process the PIT field in the PSBd.OC structure.
D	**Test setup**	As shown in Section **5.2**.
E	**Pre-test conditions**	1. The OLT and ONU are powered and connected according to the test setup. 2. Value of OC structure is set at the OLT. 3. The ONU has been ranged and activated by the OLT.
F	**Test Configuration**	
	Profiles from the ONU discovery test (**7.1.1**) are used in this test. Parameters for Operation Control structure: • PIT.DS_FEC: 0 (FEC disabled) or 1 (FEC enabled), according to the FEC state in use. • PIT.P: 1 (G.989.3 TC layer protocol) • Other parameters are at the discretion of the OLT.	
G	**Test procedure**	
	User Action	**Expected reaction and message timeline**
1	Report received OC value.	1. ONU reports the received OC value. This value is compared with the value set at the OLT.
H	**Pass/fail criteria**	
	1. OC.PIT value recognized by the ONU is identical to the value set by the OLT.	
I	**Remarks**	
	• None	

7.3.6 Downstream BIP

A	**Test Status**	Refer to Section 6.
B	**Reference Documents**	ITU-T G.989.3 [7], Section 8.1.1.5.
C	**Test Objective**	Verify that the OLT can generate and the ONU can properly process the downstream FS trailer.
D	**Test setup**	• As shown in Section **5.2**. • Attenuation should be set for error-free operation.
E	**Pre-test 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.

F	**Test Configuration**	
	Profiles from the ONU discovery test (**7.1.1**) are used in this test. OLT is set to FEC off mode. No downstream FEC parity bytes are sent. Parameters for Operation Control structure: • PIT.DS_FEC: 0 (FEC disabled). • PIT.P: 1 (G.989.3 TC layer protocol) • Other parameters are at the discretion of the OLT.	
G	**Test procedure**	
X	**User Action**	**Expected reaction and message timeline**
1	Variable attenuator is set to optimal (error free) range.	1. After ranging succeeds, OLT sends idle XGEM frames. 2. ONU tests the received data.
H	**Pass/fail criteria**	
	1. ONU detects idle traffic. 2. Number of BIP errors on ONU is zero when ONU operates under optimal conditions.	
I	**Remarks**	
	• None	

7.4 PLOAM Channel Operation

7.4.1 Multiple PLOAM Messages per Frame

A	**Test Status**	Refer to Section 6 (Conditional for OLT, Mandatory for ONU).
B	**Reference Documents**	ITU-T G.989.3 [7], Sections 8.1.1.1, 8.1.1.4 and 11. BBF TR-309 **[**3], Section 7.4.1.
C	**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 FS frame.
D	**Test setup**	As shown in Section **5.2**.
E	**Pre-test conditions**	Refer to BBF TR-309 [3], Section 7.4.1.
F	**Test Configuration**	
G	**Test procedure**	
H	**Pass/fail criteria**	
I	**Remarks**	

7.4.2 Burst Profile Version Changes – Single ONU

A	**Test Status**	Refer to Section 6.
B	**Reference Documents**	ITU-T G.989.3 [7], Section 11.3.3.1. BBF TR-309 **[**3], Section 7.4.2.
C	**Test Objective**	Verify that the OLT can generate and the ONU can properly process the following downstream PLOAM message: • Burst profile version changes
D	**Test setup**	As shown in Section **5.2**.
E	**Pre-test conditions**	Refer to BBF TR-309 [3], Section 7.4.2.
F	**Test Configuration**	
G	**Test procedure**	
H	**Pass/fail criteria**	
I	**Remarks**	

7.4.3 Burst Profile Version Changes – Mixed Rate

A	**Test Status**	Refer to Section 6.
B	**Reference Documents**	ITU-T G.989.3 [7], Section 11.3.3.1. BBF TR-309 **[**3], Section 7.4.3.
C	**Test Objective**	Verify that the OLT can generate and the ONU can properly process the following downstream PLOAM message in a mixed rate system: • Broadcast Burst profile version changes
D	**Test setup**	As shown in Section **5.2**.
E	**Pre-test conditions**	Refer to BBF TR-309 [3], Section 7.4.3.
F	**Test Configuration**	
G	**Test procedure**	
H	**Pass/fail criteria**	
I	**Remarks**	

7.4.4 ONU Deactivation and Disable SN

A	**Test Status**	Refer to Section 6.
B	**Reference Documents**	ITU-T G.989.3 [7], Sections 11.3.3.1, 11.3.3.5. BBF TR-309 **[**3], Section 7.4.4.
C	**Test Objective**	Verify that the OLT can generate and the ONU can properly process the following downstream PLOAM messages: • ONU deactivation • Disable serial number
D	**Test setup**	As shown in Section **5.2**.
E	**Pre-test conditions**	Refer to BBF TR-309 [3], Section 7.4.4.
F	**Test Configuration**	
G	**Test procedure**	
H	**Pass/fail criteria**	
I	**Remarks**	

7.4.5 Alloc-ID Allocation and De-allocation

A	**Test Status**	Refer to Section 6.
B	**Reference Documents**	ITU-T G.989.3 [7], Section 11.3.3.7. BBF TR-309 **[**3], Section 7.4.5.
C	**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
D	**Test setup**	As shown in Section **5.2**.
E	**Pre-test conditions**	Refer to BBF TR-309 [3], Section 7.4.5.
F	**Test Configuration**	
G	**Test procedure**	
H	**Pass/fail criteria**	
I	**Remarks**	

7.4.6 Encryption Key Exchange

A	**Test Status**	Refer to Section 6.
B	**Reference Documents**	ITU-T G.989.3 [7], Section 15.5.3. BBF TR-309 **[**3], Section 7.4.6.
C	**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.
D	**Test setup**	As shown in Section **5.2**.
E	**Pre-test conditions**	Refer to BBF TR-309 [3], Section 7.4.6.
F	**Test Configuration**	
G	**Test procedure**	
H	**Pass/fail criteria**	
I	**Remarks**	

7.4.7 Disable Discovery

A	**Test Status**	Refer to Section 6.
B	**Reference Documents**	ITU-T G.989.3 [7], Section 11.3.3.5.
C	**Test Objective**	Verify that the OLT can generate and the ONU can properly process the Disable_Serial_Number (Disable_Discovery, 0x3F) downstream PLOAM message.
D	**Test setup**	As shown in Section **5.2**.
E	**Pre-test 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.
F	**Test Configuration**	
	Profiles from the ONU discovery test (**7.1.1**) are used in this test. Parameters for other messages are defined in test ONU activation – single ONU test (**7.1.2**). Parameters for Disable_Serial_Number message #1: • ONU-ID: 0x03FF • SeqNo: broadcast PLOAM sequence number • Disable/enable: 0x3F (Disable_Discovery: the tuned-in ONUs in O2-3 state are denied upstream access). • The content of bytes 6..13 is ignored Parameters for Disable_Serial_Number message #2: • ONU-ID: 0x03FF • SeqNo: broadcast PLOAM sequence number • 0xF0: All tuned-in ONUs are allowed upstream access	
G	**Test procedure**	
	User Action	**Expected reaction and message timeline**
1	Configure OLT to send Disable_ Serial_Number message #1.	1. OLT should start sending downstream Disable_Serial_Number (Disable_Discovery) 2. The associated ONU is not affected.
2	Disconnect then reconnect ONU fiber.	1. ONU cannot be activated, it goes from state O2-3 to state O7 and does not respond to serial number grants.
3	Configure OLT to send Disable_ Serial_Number message #2.	1. ONU leaves O7 state and enters O1.1 state. 2. ONU achieves DSYNC on PON-ID. 3. OLT CT discovers and activates the ONU.
H	**Pass/fail criteria**	

	1. Step 1: Associated ONU is not affected. ONU stays in O5.1 state. 2. Step 2: ONU stays in state O7 and does not respond to the grants. 3. Step 3: ONU can be discovered and activated successfully.
I	**Remarks**
	• None

7.4.8 Deny Upstream Access

A	**Test Status**	Refer to Section 6.
B	**Reference Documents**	ITU-T G.989.3 [7], Section 11.3.3.5.
C	**Test Objective**	Verify that the OLT can generate and the ONU can properly process the Disable_Serial_Number (Disable/Enable: 0xFF) downstream PLOAM message.
D	**Test setup**	As shown in Section **5.2**.
E	**Pre-test 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.
F	**Test Configuration**	
	Profiles from the ONU discovery test (**7.1.1**) are used in this test. Parameters for other messages are defined in test ONU activation – single ONU test (**7.1.2**). Parameters for Disable_Serial_Number message: • ONU-ID: 0x03FF • SeqNo: broadcast PLOAM sequence number • Disable/enable: 0xFF (ONU with this serial number is denied upstream access). • Vendor_ID: vendor ID of associated ONU. • VSSN: vendor specific serial number of associated ONU.	
G	**Test procedure**	
	User Action	**Expected reaction and message timeline**
1	Show associated ONU serial number from OLT.	
2	Configure OLT to send Disable_ Serial_Number (Disable/enable: 0xFF) to the associated ONU.	1. ONU detects the Vendor_ID and VSSN field in Disable_Serial_Number PLOAM matches local Vendor_ID and VSSN. 2. ONU transitions to state O7 and does not respond to the grants.

3	OLT sends a Disable_Serial_Number message with the enable setting (0x00).	1. ONU detects the Vendor_ID and VSSN field in Disable_Serial_Number PLOAM matches local Vendor_ID and VSSN. 2. ONU transitions to state O1.1. 3. OLT ranges and activates the ONU.
H	**Pass/fail criteria**	
	1. Step 2: ONU transitions to state O7 and does not respond to the grants. 2. Step 3: OLT ranges and activates the ONU successfully.	
I	**Remarks**	
	• None	

7.4.9 System and Channel Profiles

A	**Test Status**	Refer to Section 6.
B	**Reference Documents**	ITU-T G.989.3 [7], Sections 11.3.3.13, 11.3.3.14.
C	**Test Objective**	Verify that the OLT can generate and the ONU can properly process the System and Channel Profiles downstream PLOAM messages.
D	**Test setup**	As shown in Section **5.2**.
E	**Pre-test 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.
F	**Test Configuration**	
	Profiles from the ONU discovery test (**7.1.1**) are used in this test. Parameters for other messages are defined in test ONU activation – single ONU test (**7.1.2**). Parameters for System_Profile message: • ONU-ID: 0x03FF • SeqNo: broadcast PLOAM sequence number • System profile version: 0x10 • Upstream operating wavelength bands: 0x00 (Wide band option) • TWDM channel count: 4 • Channel spacing/TWDM: 0x64 • Upstream MSE/TWDM: 5 • FSR/TWDM: 0 • TWDM/AMCC control: 0000 0011 (sufficient calibration) • Loose calibration bound for TWDM channels: 0x00 • Other fields: are at the discretion of the OLT Parameters for Channel_Profile message #1: • ONU-ID: 0x03FF	

	• SeqNo: broadcast PLOAM sequence number • Control octet: 0001 0100 (channel profile index 1, channel profile pertains to this TWDM channel, valid downstream descriptor, valid upstream descriptor) • Channel profile version: 0001 0000 • PON-ID: AAAAAAA1 • Downstream frequency offset: 0000 0000 (no offset) • Downstream line rate: 0 (9.95328 Gbit/s) or 1 (2.48832 Gbit/s), as applicable • Downstream line code: 0000 (NRZ) • Channel partition: 0x1 • Default response channel: AAAAAAA1 • Serial number grant type indication: 0000 0010 (in-band serial number grants are offered) • UWLCH ID: 0000 0001 • Upstream frequency: 195.6 • Optical link type: 0000 0010 (type A supported, type B not supported), or as applicable • Upstream rate: 0000 0010 (9.95328 Gbit/s supported, 2.48832 Gbit/s not supported), or as applicable • Default ONU attenuation: 0000 0000 (no attenuation requested) • Response threshold: 0 (OLT CT does not encourage ONU activated power levelling) • Other fields: are at the discretion of the OLT Parameters for Channel_Profile message #2: • ONU-ID: 0x03FF • SeqNo: broadcast PLOAM sequence number • Control octet: 0010 0100 (channel profile index 2, channel profile pertains to this TWDM channel, valid downstream descriptor, valid upstream descriptor) • Channel profile version: 0001 0000 • PON-ID: AAAAAAA2 • Downstream frequency offset: 0000 0000 (no offset) • Downstream line rate: 0 (9.95328 Gbit/s) or 1 (2.48832 Gbit/s), as applicable • Downstream line code: 0000 (NRZ) • Channel partition: 0x2 • Default response channel: AAAAAAA1 • Serial number grant type indication: 0000 0010 (in-band serial number grants are offered) • UWLCH ID: 0000 0002 • Upstream frequency: 195.5 • Optical link type: 0000 0010 (type A supported, type B not supported), or as applicable • Upstream rate: 0000 0010 (9.95328 Gbit/s supported, 2.48832 Gbit/s not supported), or as applicable • Default ONU attenuation: 0000 0000 (no attenuation requested) • Response threshold: 0 (OLT CT does not encourage ONU activated power levelling) • Other fields: are at the discretion of the OLT
G	**Test procedure**

	User Action	**Expected reaction and message timeline**
1	Configure OLT to send system profile and channel profiles	1. ONU should learn system profile, channel profiles #1 and #2 2. ONU achieves DSYNC on PON-ID of channel profile #1. 3. OLT CT discovers and activates the ONU.

	#1 and #2. Disconnect, then re-connect ONU attachment fiber to force re-association.	4. Show ONU serial number from OLT.
H	**Pass/fail criteria**	
	1. Use protocol analyzer to check system profile and channel profile PLOAMs sent by the OLT.	
I	**Remarks**	
	• None	

7.4.10 Change Power Level

A	**Test Status**	Refer to Section 6.
B	**Reference Documents**	ITU-T G.989.3 [7], Sections 11.2.6.7, 11.2.6.8, 11.3.3.16, 11.3.4.4 and 12.1.6.2.
C	**Test Objective**	Verify that the OLT can generate and the ONU can properly process the Change_Power_Level downstream PLOAM message.
D	**Test setup**	As shown in Section **5.2**.
E	**Pre-test 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 (ONU ID: 1).
F	**Test Configuration**	
	Profiles from the ONU discovery test (**7.1.1**) are used in this test. Parameters for other messages are defined in test ONU activation – single ONU test (**7.1.2**). Parameters for Change_Power_Level message #1: • ONU-ID: 0x03FF • SeqNo: broadcast PLOAM sequence number • Operation type: 0000 0000 (direct attenuation level control) • Attenuation: 0000 0001 (3 dB attenuation) Parameters for Change_Power_Level message #2: • ONU-ID: 1 • SeqNo: unicast PLOAM sequence number • Operation type: 0000 0001 (decrease launch optical power level by applying next supported attenuation level) Parameters for Change_Power_Level message #3: • ONU-ID: 1 • SeqNo: unicast PLOAM sequence number • Operation type: 0000 0010 (increase launch optical power level by applying next supported attenuation level)	

	Parameters for Change_Power_Level message #4: • ONU-ID: 1 • SeqNo: unicast PLOAM sequence number • Operation type: 0000 0011 (request current attenuation level) Parameters for Acknowledgement message #1: • ONU-ID: 1 • SeqNo: Same as downstream sequence number • Completion_code: 0x02: Busy, preparing a response • Attenuation: 0000 MMMM (MMMM is the current attenuation level of transceiver) • Power leveling capability: 0CCC CCCC (CCC CCCC is the attenuation level supported by ONU) Parameters for Acknowledgement message #2: • ONU-ID: 1 • SeqNo: Same as downstream sequence number • Completion_code: 0x00: OK • Attenuation: 0000 MMMM (MMMM is the current attenuation level of transceiver) • Power leveling capability: 0CCC CCCC (CCC CCCC is the attenuation level supported by ONU)

G	**Test procedure**	
	User Action	**Expected reaction and message timeline**
1	Configure OLT to send Change_ Power_Level message #1.	1. ONU receives and parses Change_Power_Level PLOAM. 2. ONU sends Acknowledgement message #1. 3. OLT receives, parses and reports values in Acknowledgement message #1. 4. ONU then commences the launch optical power adjustment operation. 5. Once the launch optical power adjustment operation is completed, the ONU sends another Acknowledgement PLOAM message #2. 6. OLT receives, parse and report Acknowledgement message #2
2	Configure OLT to send Change_ Power_Level message #2.	1. ONU receives and parses Change_Power_Level PLOAM. 2. ONU sends Acknowledgement message #1. 3. OLT receives, parses and reports values in Acknowledgement message #1. 4. ONU then commences the launch optical power adjustment operation. 5. Once the launch optical power adjustment operation is completed, the ONU sends another Acknowledgement PLOAM message #2. 6. OLT receives, parse and report Acknowledgement message #2
3	Configure OLT to send Change_ Power_Level message #3.	1. ONU receives and parses Change_Power_Level PLOAM. 2. ONU sends Acknowledgement message #1. 3. OLT receives, parses and reports values in Acknowledgement message #1. 4. ONU then commences the launch optical power adjustment operation. 5. Once the launch optical power adjustment operation is completed, the

		ONU sends another Acknowledgement PLOAM message #2. 6. OLT receives, parse and report Acknowledgement message #2
4	Configure OLT to send Change_ Power_Level message #4.	1. ONU receives and parses Change_Power_Level PLOAM. 2. ONU sends Acknowledgement message #2. 3. OLT receives, parse and report Acknowledgement message #2
H	**Pass/fail criteria**	
	1. Steps 1-4: Use protocol analyzer or debug console to check the correctness of PLOAM messages sent by ONU and OLT for each step. 2. Steps 1-3: Verify that the attenuation levels received by OLT in Acknowledgement message #1 and #2 are different. 3. Step 1: The attenuation level in Acknowledgement message #2 should match the value specified in Change_Power_Level message #1.	
I	**Remarks**	
	• None	

7.4.11 Power Consumption Inquire/Report

A	**Test Status**	Refer to Section 6.
B	**Reference Documents**	ITU-T G.989.3 [7], Sections 11.3.3.17 and 11.3.4.7.
C	**Test Objective**	• Verify that the OLT can generate and the ONU can properly process the Power_Consumption_Inquire downstream PLOAM message. • Verify that the ONU can generate and the OLT can properly process the Power_Consumption_Report upstream PLOAM message.
D	**Test setup**	As shown in Section **5.2**.
E	**Pre-test 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 (ONU ID: 1).
F	**Test Configuration**	
	Profiles from the ONU discovery test (**7.1.1**) are used in this test. Parameters for other messages are defined in test ONU activation – single ONU test (**7.1.2**). Parameters for Power_Consumption_Inquire message: • ONU-ID: 1 • SeqNo: unicast PLOAM sequence number Parameters for Power_Consumption_Report message: • ONU-ID: 1 • SeqNo: Same as downstream sequence number • Power consumption: repeat 8 times the following pattern	

	DDDDUUUUXXXXXXXXXXXXXXXX (D – downstream TWDM channel id, U-upstream TWDM channel id, X – 16 bit power consumption of associated TWDM channel in milliwatt)	
G	**Test procedure**	
	User Action	**Expected reaction and message timeline**
1	Configure OLT to send Power_ Consumption_ Inquire.	1. ONU receives and parse Power_Consumption_Inquire PLOAM. 2. ONU builds and sends Power_Consumption_Report PLOAM upstream. 3. OLT reports the received value. This value is compared with the value expected from the ONU.
H	**Pass/fail criteria**	
	1. Use protocol analyzer or debug console to check the correctness of PLOAM messages sent by OLT and ONU. 2. Power consumption value recognized by the OLT is identical the value sent by the ONU.	
I	**Remarks**	
	• None	

7.5 Forward error correction

7.5.1 Downstream FEC Operation

A	**Test Status**	Refer to Section 6.
B	**Reference Documents**	ITU-T G.989.3 [7], Sections 10.1.1.1.3, 10.1.3. BBF TR-309 **[**3], Section 7.5.1.
C	**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.
D	**Test setup**	• As shown in Section **5.2** or 5.5. • Attenuation should be set to keep the ONU in the correctable range (for example: FEC correction counters show non-zero results, whereas FEC uncorrectable codewords counter and BIP error counter show zero results).
E	**Pre-test 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.
F	**Test Configuration**	
	Profiles from the ONU discovery test (**7.1.1**) are used in this test. Downstream FEC parity bytes are processed. Parameters for Operation Control structure: • PIT.DS_FEC: 1 (FEC enabled) • PIT.P: 1 (G.989.3 TC layer protocol)	
G	**Test procedure**	
	User Action	**Expected reaction and message timeline**
1	Variable attenuator is set to optimal (error free) range.	1. After ranging succeeds, OLT sends idle XGEM frames. 2. ONU tests the received data.
2	Variable attenuator is set to correctable range.	1. Variable attenuator is changed to make FEC correction evident. 2. ONU tests the received data.
H	**Pass/fail criteria**	
	1. ONU detects idle traffic with no errors (except FEC correctable errors when expected). 2. Number of bit errors on ONU is zero when ONU operates under optimal conditions.	
I	**Remarks**	
	• None	

7.5.2 Upstream FEC Operation – Integral Multiple of Codeword Size

A	**Test Status**	Refer to Section 6.
B	**Reference Documents**	ITU-T G.989.3 [7], Section 10.1.3. BBF TR-309 **[**3], Section 7.5.2.
C	**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.
D	**Test setup**	• As shown in Section **5.2** or 5.5. • Attenuation should be set to keep the ONU in the correctable range (for example: with FEC off, the attenuation is reduced until the BIP error counter over a fixed period of observation produces a distribution with some non-zero mean (matching BER of 10^{-3}/10^{-4} is not a target). Then turning FEC On is expected to drop the value of BIP error counter to zero, whereas FEC correction counters would show non-zero results).
E	**Pre-test conditions**	Refer to BBF TR-309 [3], Section 7.5.2. Different Grant Size values apply depending on the upstream rate: GrantSize = 288 for 2.5G upstream. GrantSize = 67 for 10G upstream.
F	**Test Configuration**	
G	**Test procedure**	
H	**Pass/fail criteria**	
I	**Remarks**	

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

A	**Test Status**	Refer to Section 6.
B	**Reference Documents**	ITU-T G.989.3 [7], Section 10.1.3. BBF TR-309 **[**3], Section 7.5.3.
C	**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.
D	**Test setup**	• As shown in Section **5.2** or 5.5. • Attenuation should be set to keep the ONU in the correctable range (refer to test case 7.5.2).
E	**Pre-test conditions**	Refer to BBF TR-309 [3], Section 7.5.3. Different Grant Size values apply depending on the upstream rate: GrantSize = 289 for 2.5G upstream. GrantSize = 68 for 10G upstream.
F	**Test Configuration**	
G	**Test procedure**	
H	**Pass/fail criteria**	
I	**Remarks**	

7.5.4 Upstream FEC Operation – Burst Series with Shared Parity Words

A	**Test Status**	Refer to Section 6.
B	**Reference Documents**	ITU-T G.989.3 [7], Section 10.1.3. BBF TR-309 **[**3], Section 7.5.4.
C	**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.
D	**Test setup**	• As shown in Section **5.2** or 5.5. • Attenuation should be set to keep the ONU in the correctable range (refer to test case 7.5.2).
E	**Pre-test conditions**	Refer to BBF TR-309 [3], Section 7.5.4. Different Grant Size values apply depending on the upstream rate: GrantSize = 288 for 2.5G upstream. GrantSize = 67 for 10G upstream.
F	**Test Configuration**	
G	**Test procedure**	
H	**Pass/fail criteria**	
I	**Remarks**	

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

A	**Test Status**	Refer to Section 6.
B	**Reference Documents**	ITU-T G.989.3 [7], Section 10.1.3. BBF TR-309 **[**3], Section 7.5.5.
C	**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.
D	**Test setup**	• As shown in Section **5.4**. • Attenuation should be set to keep the ONU in the correctable range (refer to test case 7.5.2).
E	**Pre-test conditions**	Refer to BBF TR-309 [3], Section 7.5.5.
F	**Test Configuration**	
G	**Test procedure**	
H	**Pass/fail criteria**	
I	**Remarks**	

7.5.6 Upstream FEC Operation – Multiple Rate

A	**Test Status**	Refer to Section 6.
B	**Reference Documents**	ITU-T G.989.3 [7], Section 10.1.3. BBF TR-309 **[**3], Section 7.5.6.
C	**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 in a multi rate system.
D	**Test setup**	• As shown in Section **5.4**. • Attenuation should be set to keep the ONU in the correctable range (refer to test case 7.5.2).
E	**Pre-test conditions**	Refer to BBF TR-309 [3], Section 7.5.6.
F	**Test Configuration**	
G	**Test procedure**	
H	**Pass/fail criteria**	
I	**Remarks**	

7.5.7 Upstream FEC Operation – Mixed FEC and No-FEC Accesses – Single ONU – Single Rate

A	**Test Status**	Refer to Section 6.
B	**Reference Documents**	ITU-T G.989.3 [7], Section 10.1.3.
C	**Test Objective**	Verify that the ONU can correctly and dynamically switch between FEC and non-FEC upstream transmission.
D	**Test setup**	• As shown in Section **5.2** or 5.5. • Attenuation should be set for error-free operation.
E	**Pre-test 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.
F	**Test Configuration**	
	Profiles from the ONU discovery test (**7.1.1**) are used in this test. Downstream FEC parity bytes can be ignored (error-free reception is assumed). Parameters for bandwidth allocation structures:	

Table 7-3 – 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	Set by OLT (FEC off)
2	1	1000*	256	0	0	0	Set by OLT (FEC on)

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.

G	**Test procedure**	
X	**User Action**	**Expected reaction and message timeline**
1	Apply bandwidth settings at the OLT to generate bandwidth allocation structures per the table above.	1. After ranging succeeds, OLT sends the bandwidth map described above. 2. Upon getting the bandwidth grants, the ONU responds with XGEM idle upstream traffic with/without FEC, at the correct times. 3. OLT verifies that correct traffic is received within both allocations.
H	**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.	
I	**Remarks**	

	• None

7.5.8 Downstream Non-FEC Operation

A	**Test Status**	Refer to Section 6.
B	**Reference Documents**	ITU-T G.989.3 [7], Sections 10.1.1.1.3, 10.1.3.
C	**Test Objective**	Verify that the OLT and ONU can correctly perform error-free non-FEC downstream data transmission.
D	**Test setup**	• As shown in Section **5.2** or 5.5. • Attenuation should be set for error-free operation.
E	**Pre-test 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.
F	**Test Configuration**	
	Profiles from the ONU discovery test (**7.1.1**) are used in this test. OLT is set to FEC off mode. No downstream FEC parity bytes are sent. Parameters for Operation Control structure: • PIT.DS_FEC: 0 (FEC disabled) • PIT.P: 1 (G.989.3 TC layer protocol)	
G	**Test procedure**	
	User Action	**Expected reaction and message timeline**
1	Variable attenuator is set to optimal (error free) range.	1. After ranging succeeds, OLT sends idle XGEM frames. 2. ONU tests the received data.
H	**Pass/fail criteria**	
	1. ONU detects idle traffic. 2. Number of bit errors on ONU is zero when ONU operates under optimal conditions.	
I	**Remarks**	
	• None	

7.6 Data transmission

7.6.1 OMCI Channel Establishment

A	**Test Status**	Refer to Section 6.
B	**Reference Documents**	ITU-T G.989.3 [7], Section 9. ITU-T G.988 [8], Section 11.2. BBF TR-309 **[**3], Section 7.6.1.
C	**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.
D	**Test setup**	As shown in Section **5.2**.
E	**Pre-test conditions**	Refer to BBF TR-309 **[**3], Section 7.6.1.
F	**Test Configuration**	
G	**Test procedure**	
H	**Pass/fail criteria**	
I	**Remarks**	

7.6.2 OMCI Channel Establishment – Multiple ONUs

A	**Test Status**	Refer to Section 6.
B	**Reference Documents**	ITU-T G.989.3 [7], Section 9. ITU-T G.988 [8], Section 11.2. BBF TR-309 **[**3], Section 7.6.2.
C	**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.
D	**Test setup**	As shown in Section **5.4**.
E	**Pre-test conditions**	Refer to BBF TR-309 **[**3], Section 7.6.2.
F	**Test Configuration**	
G	**Test procedure**	
H	**Pass/fail criteria**	
I	**Remarks**	

7.6.3 Downstream Encryption Operation

A	**Test Status**	Refer to Section 6.
B	**Reference Documents**	ITU-T G.989.3 [7], Section 15.4. BBF TR-309 **[**3], Section 7.6.3.
C	**Test Objective**	Verify that the OLT can correctly transmit encrypted data to the ONU.
D	**Test setup**	As shown in Section **5.2**.
E	**Pre-test conditions**	Refer to BBF TR-309 **[**3], Section 7.6.3.
F	**Test Configuration**	
G	**Test procedure**	
H	**Pass/fail criteria**	
I	**Remarks**	

7.6.4 Upstream Encryption Operation

A	**Test Status**	Refer to Section 6.
B	**Reference Documents**	ITU-T G.989.3 [7], Section 15.4. BBF TR-309 **[**3], Section 7.6.4.
C	**Test Objective**	Verify that the ONU can correctly transmit encrypted data to the OLT.
D	**Test setup**	As shown in Section **5.2**.
E	**Pre-test conditions**	Refer to BBF TR-309 **[**3], Section 7.6.4.
F	**Test Configuration**	
G	**Test procedure**	
H	**Pass/fail criteria**	
I	**Remarks**	

7.6.5 Downstream Ethernet Traffic Transmission

A	**Test Status**	Refer to Section 6.
B	**Reference Documents**	ITU-T G.989.3 [7], Section 9. BBF TR-309 **[**3], Section 7.6.5.
C	**Test Objective**	Verify that the OLT can send and the ONU can properly receive Ethernet frames.
D	**Test setup**	• As shown in Section 5.3. • 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.
E	**Pre-test conditions**	Refer to BBF TR-309 **[**3], Section 7.6.5.
F	**Test Configuration**	
G	**Test procedure**	
H	**Pass/fail criteria**	
I	**Remarks**	

7.6.6 Upstream Ethernet Traffic Transmission

A	**Test Status**	Refer to Section 6.
B	**Reference Documents**	ITU-T G.989.3 [7], Section 9. BBF TR-309 **[**3], Section 7.6.6.
C	**Test Objective**	Verify that the ONU can send and the OLT can properly receive Ethernet frames.
D	**Test setup**	• As shown in Section 5.3. • 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.
E	**Pre-test conditions**	Refer to BBF TR-309 **[**3], Section 7.6.6.
F	**Test Configuration**	
G	**Test procedure**	
H	**Pass/fail criteria**	
I	**Remarks**	

7.6.7 Bidirectional Ethernet Traffic Transmission

A	**Test Status**	Refer to Section 6.
B	**Reference Documents**	ITU-T G.989.3 [7], Section 9. BBF TR-309 **[**3], Section 7.6.7.
C	**Test Objective**	Verify that the OLT and ONU can properly transfer Ethernet frames.
D	**Test setup**	• As shown in Section 5.3. • 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.
E	**Pre-test conditions**	Refer to BBF TR-309 **[**3], Section 7.6.7.
F	**Test Configuration**	
G	**Test procedure**	
H	**Pass/fail criteria**	
I	**Remarks**	

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

A	**Test Status**	Refer to Section 6.
B	**Reference Documents**	ITU-T G.989.3 [7], Section 9. BBF TR-309 **[**3], Section 7.6.8.
C	**Test Objective**	Verify that the OLT and ONU can properly transfer Ethernet frames using multiple Port-IDs and Alloc-IDs.
D	**Test setup**	• As shown in Section 5.3. • 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.
E	**Pre-test conditions**	Refer to BBF TR-309 **[**3], Section 7.6.8.
F	**Test Configuration**	
G	**Test procedure**	
H	**Pass/fail criteria**	
I	**Remarks**	

7.6.9 Bidirectional Ethernet Traffic Transmission – Multiple ONUs

A	**Test Status**	Refer to Section 6.
B	**Reference Documents**	ITU-T G.989.3 [7], Section 9. BBF TR-309 **[**3], Section 7.6.9.
C	**Test Objective**	Verify that the OLT and multiple ONUs can properly transfer Ethernet frames.
D	**Test setup**	• As shown in Section 5.3. • 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.
E	**Pre-test conditions**	Refer to BBF TR-309 **[**3], Section 7.6.9.
F	**Test Configuration**	
G	**Test procedure**	
H	**Pass/fail criteria**	
I	**Remarks**	

8 TC Layer - Comprehensive Tests

8.1 Authentication and Encryption

8.1.1 Registration-ID Based Authentication

A	**Test Status**	Refer to Section 6.
B	**Reference Documents**	ITU-T G.989.3 [7], Sections 11.3.3.6, 11.3.4.2. BBF TR-309 **[**3], Section 8.1.1.
C	**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 O5.1)
D	**Test setup**	As shown in Section **5.2**.
E	**Pre-test conditions**	Refer to BBF TR-309 **[**3], Section 8.1.1.
F	**Test Configuration**	
G	**Test procedure**	
H	**Pass/fail criteria**	
I	**Remarks**	

8.1.2 Automatic Encryption Key Exchange and Traffic Transmission

A	**Test Status**	Refer to Section 6.
B	**Reference Documents**	ITU-T G.989.3 [7], Sections 15.4 and 15.5.3. BBF TR-309 **[**3], Section 8.1.2.
C	**Test Objective**	Verify that the OLT and ONU can correctly perform automatic key exchange and encrypted data transmission.
D	**Test setup**	As shown in Section **5.2**.
E	**Pre-test conditions**	Refer to BBF TR-309 **[**3], Section 8.1.2.
F	**Test Configuration**	
G	**Test procedure**	
H	**Pass/fail criteria**	
I	**Remarks**	

8.1.3 Encrypted Ethernet Transmission

A	**Test Status**	Refer to Section 6.
B	**Reference Documents**	ITU-T G.989.3 [7], Sections 15.4 and 15.5.3. BBF TR-309 **[**3], Section 8.1.3.
C	**Test Objective**	Verify that the OLT and ONU can correctly perform encrypted Ethernet transmission.
D	**Test setup**	• As shown in Section 5.3. • 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.
E	**Pre-test conditions**	Refer to BBF TR-309 **[**3], Section 8.1.3.
F	**Test Configuration**	
G	**Test procedure**	
H	**Pass/fail criteria**	
I	**Remarks**	

8.1.4 Multicast Encryption Operation

A	**Test Status**	Refer to Section 6.
B	**Reference Documents**	ITU-T G.989.3 [7], Section 15.4. BBF TR-309 **[**3], Section 8.1.4.
C	**Test Objective**	Verify that the OLT can correctly transmit multicast encrypted data to multiple ONUs.
D	**Test setup**	• As shown in Section 5.3. • Additional parameters (e.g. VLAN tag mapping, order of generator and analyzer enable) are to be coordinated after pairing.
E	**Pre-test conditions**	Refer to BBF TR-309 **[**3], Section 8.1.4.
F	**Test Configuration**	
G	**Test procedure**	
H	**Pass/fail criteria**	
I	**Remarks**	

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

A	**Test Status**	Refer to Section 6.
B	**Reference Documents**	ITU-T G.989.3 [7], Sections 9, 15.2, 15.3 and 15.5.7. ITU-T G.988 [8], Section 11.2. BBF TR-309 **[**3], Section 8.1.5.
C	**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.
D	**Test setup**	As shown in Section **5.2**.
E	**Pre-test conditions**	Refer to BBF TR-309 **[**3], Section 8.1.5.
F	**Test Configuration**	
G	**Test procedure**	
H	**Pass/fail criteria**	
I	**Remarks**	

8.1.6 Automatic Encryption Key Exchange during Traffic

A	**Test Status**	Refer to Section 6.
B	**Reference Documents**	ITU-T G.989.3 [7], Sections 15.4 and 15.5.3. BBF TR-309 **[**3], Section 8.1.6.
C	**Test Objective**	Verify that the OLT and ONU can correctly perform automatic key exchange and encrypted data transmission.
D	**Test setup**	As shown in Section 5.3.
E	**Pre-test conditions**	Refer to BBF TR-309 **[**3], Section 8.1.6.
F	**Test Configuration**	
G	**Test procedure**	
H	**Pass/fail criteria**	
I	**Remarks**	

8.1.7 Secure Mutual Authentication – OMCI Based

A	**Test Status**	Refer to Section 6 (Conditionally Mandatory if Secure Mutual Authentication based on OMCI is supported by the devices).
B	**Reference Documents**	ITU-T G.989.3 [7], Sections 9, 15.2, 15.3 and 15.5.7. ITU-T G.989.3 [7], Annex C. ITU-T G.988 [8], Section 9.13.11. BBF TR-309 **[**3], Section 8.1.7.
C	**Test Objective**	Verify that session keys are initialized correctly following a secure mutual authentication and re-activation.
D	**Test setup**	As shown in Section **5.2**.
E	**Pre-test conditions**	Refer to BBF TR-309 **[**3], Section 8.1.7.
F	**Test Configuration**	
G	**Test procedure**	
H	**Pass/fail criteria**	
I	**Remarks**	

8.1.8 Secure Mutual Authentication – 802.1x

A	**Test Status**	Refer to Section 6 (Conditionally Mandatory if Secure Mutual Authentication based on IEEE 802.1X is supported by the devices).
B	**Reference Documents**	ITU-T G.989.3 [7], Sections 9, 15.2, 15.3 and 15.5.7. ITU-T G.989.3 [7], Annex D. BBF TR-309 **[**3], Section 8.1.8.
C	**Test Objective**	Verify that session keys are initialized correctly following a secure mutual authentication and re-activation.
D	**Test setup**	• As shown in Section **5.2**. • 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.
E	**Pre-test conditions**	Refer to BBF TR-309 **[**3], Section 8.1.8.
F	**Test Configuration**	
G	**Test procedure**	
H	**Pass/fail criteria**	
I	**Remarks**	

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

A	**Test Status**	Refer to Section 6 (Conditionally Mandatory if Secure Mutual Authentication based on OMCI or IEEE 802.1X is supported by the devices).
B	**Reference Documents**	ITU-T G.989.3 [7], Sections 9, 15.2, 15.3 and 15.5.7. ITU-T G.989.3 [7], Annexes C and D. BBF TR-309 **[**3], Section 8.1.9.
C	**Test Objective**	Verify that session keys are initialized correctly following a secure mutual authentication and re-activation.
D	**Test setup**	• As shown in Section **5.2**. • 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.
E	**Pre-test conditions**	Refer to BBF TR-309 **[**3], Section 8.1.9.
F	**Test Configuration**	
G	**Test procedure**	
H	**Pass/fail criteria**	
I	**Remarks**	

8.1.10 Request Registration after Secure Mutual Authentication

A	**Test Status**	Refer to Section 6 (Conditionally Mandatory if Secure Mutual Authentication is supported by the devices).
B	**Reference Documents**	ITU-T G.989.3 [7], Sections 11.3.3.6, 11.3.4.2 and 15.3. BBF TR-309 **[**3], Section 8.1.10.
C	**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.
D	**Test setup**	As shown in Section **5.2**.
E	**Pre-test conditions**	Refer to BBF TR-309 **[**3], Section 8.1.10.
F	**Test Configuration**	
G	**Test procedure**	
H	**Pass/fail criteria**	
I	**Remarks**	

8.2 ONU Power Management Modes

8.2.1 Watchful Sleep

A	**Test Status**	Refer to Section 6 (Conditionally Mandatory if Watchful Sleep mode is supported by the devices).
B	**Reference Documents**	ITU-T G.989.3 [7], Sections 16.1, 11.3.3.9 and 11.3.4.5. ITU-T G.988/Amd.1 [9], Section 9.1.14. BBF TR-309 **[**3], Section 8.2.5.
C	**Test Objective**	Verify that the ONU can correctly enter watchful sleep mode. Verify that the OLT can send FWI to wake up the ONU.
D	**Test setup**	As shown in Section **5.2**.
E	**Pre-test conditions**	Refer to BBF TR-309 **[**3], Section 8.2.5.
F	**Test Configuration**	
G	**Test procedure**	
H	**Pass/fail criteria**	
I	**Remarks**	

8.2.2 Watchful Sleep (ONU Wakeup)

A	**Test Status**	Refer to Section 6 (Conditionally Mandatory if Watchful Sleep mode is supported by the devices).
B	**Reference Documents**	ITU-T G.989.3 [7], Sections 16.1, 11.3.3.9 and 11.3.4.5. ITU-T G.988/Amd.1 [9], Section 9.1.14. BBF TR-309 **[**3], Section 8.2.6.
C	**Test Objective**	Verify that the ONU can correctly enter watchful sleep mode. Verify that upon local ONU stimulus it can wake-up from watchful sleep.
D	**Test setup**	As shown in Section **5.2**.
E	**Pre-test conditions**	Refer to BBF TR-309 **[**3], Section 8.2.6.
F	**Test Configuration**	
G	**Test procedure**	
H	**Pass/fail criteria**	
I	**Remarks**	

8.3 Dynamic Bandwidth Allocation

8.3.1 DBA Operation - Single ONU

A	**Test Status**	Refer to Section 6.
B	**Reference Documents**	ITU-T G.989.3 [7], Sections 7.2, 7.3 and 8.1.2.2. BBF TR-309 **[**3], Section 8.3.1.
C	**Test Objective**	Verify correct DBA status reporting using allocation overheads in single ONU operation.
D	**Test setup**	• As shown in Section **5.2**. • 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.
E	**Pre-test conditions**	Refer to BBF TR-309 **[**3], Section 8.3.1.
F	**Test Configuration**	
G	**Test procedure**	
H	**Pass/fail criteria**	
I	**Remarks**	

8.3.2 DBA Operation - Multiple ONUs

A	**Test Status**	Refer to Section 6.
B	**Reference Documents**	ITU-T G.989.3 [7], Sections 7.2, 7.3 and 8.1.2.2. BBF TR-309 **[**3], Section 8.3.2.
C	**Test Objective**	Verify correct DBA status reporting using allocation overheads in multiple ONU operation.
D	**Test setup**	As shown in Section **5.4**.
E	**Pre-test conditions**	Refer to BBF TR-309 **[**3], Section 8.3.2.
F	**Test Configuration**	
G	**Test procedure**	
H	**Pass/fail criteria**	
I	**Remarks**	

8.3.3 DBA Operation under Different Traffic Loads - Multiple ONUs

A	**Test Status**	Refer to Section 6.
B	**Reference Documents**	ITU-T G.989.3 [7], Sections 7.2, 7.3 and 8.1.2.2. BBF TR-309 **[**3], Section 8.3.3.
C	**Test Objective**	Verify correct DBA status reporting using allocation overheads in multiple ONU operation.
D	**Test setup**	As shown in Section **5.4**.
E	**Pre-test conditions**	Refer to BBF TR-309 **[**3], Section 8.3.3.
F	**Test Configuration**	
G	**Test procedure**	
H	**Pass/fail criteria**	
I	**Remarks**	

8.4 Drift Control and Compensation

8.4.1 Acceptable Transmission Drift Boundary

A	**Test Status**	Refer to Section 6.
B	**Reference Documents**	ITU-T G.989.3 [7], Sections 13.1.6 and 14.2.1. BBF TR-309 **[**3], Section 8.4.1.
C	**Test Objective**	Verify errorless upstream transmission within the safe (acceptable) transmission drift boundary.
D	**Test setup**	• As shown in Section **5.2**. • 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.
E	**Pre-test conditions**	Refer to BBF TR-309 **[**3], Section 8.4.1.
F	**Test Configuration**	
G	**Test procedure**	
H	**Pass/fail criteria**	
I	**Remarks**	

8.4.2 Adjustable Transmission Drift Boundary (DOW)

A	**Test Status**	Refer to Section 6.
B	**Reference Documents**	ITU-T G.989.3 [7], Sections 13.1.6 and 14.2.1. BBF TR-309 **[**3], Section 8.4.2.
C	**Test Objective**	Verify correct in-service equalization delay adjustments in drift of window (DOW) transmission boundary.
D	**Test setup**	• As shown in Section **5.2**. • 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.
E	**Pre-test conditions**	Refer to BBF TR-309 **[**3], Section 8.4.2.
F	**Test Configuration**	
G	**Test procedure**	
H	**Pass/fail criteria**	
I	**Remarks**	

8.4.3 Unacceptable Transmission Drift Boundary (TIW)

A	**Test Status**	Refer to Section 6.
B	**Reference Documents**	ITU-T G.989.3 [7], Sections 13.1.6 and 14.2.1. BBF TR-309 **[**3], Section 8.4.3.
C	**Test Objective**	Verify correct OLT-ONU behavior in transmission interference warning (TIW) state – unacceptable transmission drift.
D	**Test setup**	• As shown in Section **5.2**. • 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.
E	**Pre-test conditions**	Refer to BBF TR-309 **[**3], Section 8.4.3.
F	**Test Configuration**	
G	**Test procedure**	
H	**Pass/fail criteria**	
I	**Remarks**	

8.5 Time of Day Distribution over PON

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

A	**Test Status**	Refer to Section 6.
B	**Reference Documents**	ITU-T G.989.3 [7], Section 13. ITU-T G.988 [8], Section 9.12.2. BBF TR-309 **[**3], Section 8.5.1.
C	**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.
D	**Test setup**	As shown in Section **5.2**.
E	**Pre-test conditions**	Refer to BBF TR-309 **[**3], Section 8.5.1.
F	**Test Configuration**	
G	**Test procedure**	
H	**Pass/fail criteria**	
I	**Remarks**	

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

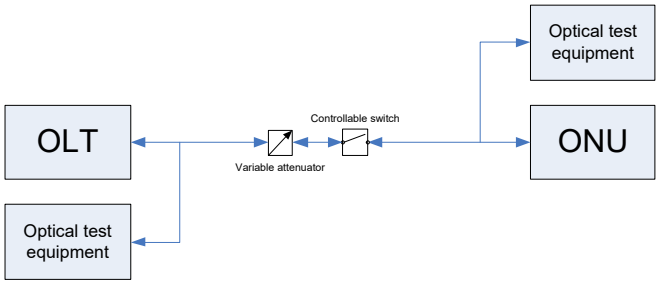
A	**Test Status**	Refer to Section 6.
B	**Reference Documents**	ITU-T G.989.3 [7], Section 13. ITU-T G.988 [8], Section 9.12.2. BBF TR-309 **[**3], Section 8.5.2.
C	**Test Objective**	Verify correct time of day synchronization using the OMCI channel in a single ONU link when the equalization delay of the ONU is adjusted throughout the test.
D	**Test setup**	As shown in Section **5.2**.
E	**Pre-test conditions**	Refer to BBF TR-309 **[**3], Section 8.5.2.
F	**Test Configuration**	
G	**Test procedure**	
H	**Pass/fail criteria**	
I	**Remarks**	

8.5.3 Time of Day Synchronization - Multiple ONUs

A	**Test Status**	Refer to Section 6.
B	**Reference Documents**	ITU-T G.989.3 [7], Section 13. ITU-T G.988 [8], Section 9.12.2. BBF TR-309 **[**3], Section 8.5.3.
C	**Test Objective**	Verify correct time of day synchronization using the OMCI channel with multiple ONUs.
D	**Test setup**	As shown in Section **5.4**.
E	**Pre-test conditions**	Refer to BBF TR-309 **[**3], Section 8.5.3.
F	**Test Configuration**	
G	**Test procedure**	
H	**Pass/fail criteria**	
I	**Remarks**	

8.6 Protection Switching

8.6.1 Intermittent LODS

A	**Test Status**	Refer to Section 6.
B	**Reference Documents**	ITU-T G.989.3 [7], Section 12.1.2. BBF TR-309 **[**3], Section 8.6.1.
C	**Test Objective**	Verify correct ONU response to an intermittent loss of downstream synchronization.
D	**Test setup**	 **Figure 8-1** – Test Setup for Intermittent LODS
E	**Pre-test 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.
F	**Test Configuration**	
	Profiles from the ONU discovery test (**7.1.1**) are used in this test. TO2 timer is increased according to the properties of the controllable switch.	
G	**Test procedure**	
	User Action	**Expected reaction and message timeline**
1	Configure TO2	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.	1. ONU transitions to intermittent LODS state (O6) while the switch is open and transitions back to regular operational state (O5.1) once the switch is closed.

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

8.6.2 Type B Protection Switching

A	**Test Status**	Refer to Section 6.
B	**Reference Documents**	ITU-T G.989.3/Amd.1 [11], Section 18.
C	**Test Objective**	Left for further study.
D	**Test setup**	
E	**Pre-test conditions**	
F	**Test Configuration**	
G	**Test procedure**	
H	**Pass/fail criteria**	
I	**Remarks**	

8.6.3 Type C Protection Switching

A	**Test Status**	Refer to Section 6.
B	**Reference Documents**	ITU-T G.989.3/Amd.1 [11], Section 18.
C	**Test Objective**	Left for further study.
D	**Test setup**	
E	**Pre-test conditions**	
F	**Test Configuration**	
G	**Test procedure**	
H	**Pass/fail criteria**	
I	**Remarks**	

9 NG-PON2 Specific TC Layer Tests

9.1 ONU Discovery and Activation in a Multi-Wavelength Environment

9.1.1 ONU Discovery and Activation – CPI Handling on Single Channel Pair

A	**Test Status**	Refer to Section 6.
B	**Reference Documents**	ITU-T G.989.3 [7], Sections 6.1.5.9, 12.1.
C	**Test Objective**	Verify that the ONU complies with the CPI activation rules when one TWDM channel is available.
D	**Test setup**	As shown in Section 5.6. One OLT CT, single ONU.
E	**Pre-test conditions**	The OLT CT powered up, connected to ODN. The cold ONU (CPI = 0000) powered up, disconnected from ODN.
F	**Test Configuration**	
	• The OLT CT periodically transmits System profile PLOAM message with the default parameters. • The OLT CT periodically transmits Channel profile PLOAM message with the default parameters and Channel Partition Index set to 0000. • The OLT CT periodically transmits Burst profile messages with the default parameters. • The OLT CT offers In-band Serial number grants.	
G	**Test procedure**	
	User Action	**Expected reaction and message timeline**
1	Connect the ONU to the PON fiber; wait for activation to be completed; if activated successfully, read ONU's CPI.	OLT CT discovers and activates the ONU.
2	Disconnect the ONU; change the CPI of the Channel profile PLOAM message to 0001; reconnect the ONU to the PON fiber; wait for activation to be completed; if activated successfully, read ONU's CPI.	OLT CT discovers and activates the ONU.

3	Disconnect the ONU; change the CPI of the Channel profile PLOAM message to 0002; reconnect the ONU to the PON fiber; wait for activation to be completed; if activated successfully, read ONU's CPI.	ONU fails to activate.
4	Disconnect the ONU; change the CPI of the Channel profile PLOAM message to 0001; reconnect the ONU to the PON fiber; wait for activation to be completed; if activated successfully, read ONU's CPI.	OLT CT discovers and activates the ONU.
5	Disconnect the ONU; change the CPI of the Channel profile PLOAM message to 0000; reconnect the ONU to the PON fiber; wait for activation to be completed; if activated successfully, read ONU's CPI.	ONU fails to activate.
H	**Pass/fail criteria**	
	1. Step 1: ONU is activated with post-activation CPI of 0000. 2. Step 2: ONU is activated with post-activation CPI of 0001. 3. Step 3: ONU fails to activate, stops responding to serial number grants. 4. Step 4: ONU is activated with post-activation CPI of 0001. 5. Step 5: ONU fails to activate, stops responding to serial number grants.	
I	**Remarks**	
	• None	

9.1.2 ONU Discovery and Activation – CPI Handling on Multiple Channel Pairs

A	**Test Status**	Refer to Section 6.
B	**Reference Documents**	ITU-T G.989.3 [7], Sections 6.1.5.9, 12.1.
C	**Test Objective**	Verify that the ONU complies with the CPI activation rules when one TWDM channel is available.
D	**Test setup**	As shown in Section **5.6**. Two OLT CTs, single ONU.
E	**Pre-test conditions**	Both OLT CTs powered up, connected to ODN. The cold ONU (CPI = 0000) powered up, disconnected from ODN.
F	**Test Configuration**	
	• Both OLT CTs periodically transmit System profile PLOAM message with the default parameters. • Both OLT CTs periodically transmit Channel profile PLOAM message for their own channel with the default parameters and Channel Partition Index set to 0000. • Both OLT CTs periodically transmit Burst profile messages with the default parameters. • Both OLT CTs offer In-band activation grants.	
G	**Test procedure**	
	User Action	**Expected reaction and message timeline**
1	Connect the ONU to the PON fiber; wait for activation to be completed; if activated successfully, read ONU's CPI.	One of the OLT CTs discovers and activates the ONU. This OLT CT is referred herein as the first OLT CT.
2	Disconnect the ONU; disable the first OLT CT; reconnect the ONU to the PON fiber; wait for activation to be completed; if activated, read ONU's CPI.	The second OLT CT discovers and activates the ONU.
3	Disconnect the ONU; change the CPI of the Channel profile PLOAM message transmitted by the second OLT CT to 0002; reconnect the ONU to the PON fiber; wait for activation to be completed; if	The second OLT CT discovers and activates the ONU.

	activated, read ONU's CPI.	
4	Disconnect the ONU; re-enable the first OLT CT while changing the CPI of its Channel profile PLOAM message to 0001; reconnect the ONU to the PON fiber; wait for activation to be completed; if activated, read ONU's CPI.	The second OLT CT discovers and activates the ONU.
5	Disconnect the ONU; disable the second OLT CT; reconnect the ONU to the PON fiber; wait for activation to be completed; if activated successfully, read ONU's CPI.	ONU fails to activate.
6	Turn the ONU power off and then on again; wait for activation to be completed; if activated successfully, read ONU's CPI.	ONU fails to activate.
H	**Pass/fail criteria**	
	1. Step 1: ONU is activated on the first OLT CT with post-activation CPI of 0000. 2. Step 2: ONU is activated on the second OLT CT with post-activation CPI of 0000. 3. Step 3: ONU is activated on the second OLT CT with post-activation CPI of 0002. 4. Step 4: ONU is activated on the second OLT CT with post-activation CPI of 0002. 5. Step 5: ONU fails to activate, does not respond to serial number grants by the first OLT CT. 6. Step 6: ONU fails to activate, does not respond to serial number grants by the first OLT CT.	
I	**Remarks**	
	• None	

9.1.3 ONU Discovery and Activation – Different Rates

A	**Test Status**	Refer to Section 6.
B	**Reference Documents**	ITU-T G.989.3 [7], Section 12.1.
C	**Test Objective**	Verify that the ONU complies with the CPI activation rules when one TWDM channel is available.
D	**Test setup**	As shown in Section **5.6**. Three 10G/2.5G OLT CTs, one 10G/10G OLT CT, single 10G/10G ONU.
E	**Pre-test conditions**	All OLT CTs powered up, connected to ODN. The cold ONU (CPI = 0000) powered up, disconnected from ODN.
F	**Test Configuration**	
	• Each OLT CT periodically transmits System profile PLOAM message with the default parameters. • Each OLT CT periodically transmits Channel profile PLOAM message for its own channel with the default parameters and Channel Partition Index set to 0000. • Each OLT CT periodically transmits Burst profile messages with the default parameters. • Each OLT CT offers In-band activation grants for its own upstream rate.	
G	**Test procedure**	
X	**User Action**	**Expected reaction and message timeline**
1	Connect the ONU to the PON fiber; wait for activation to be completed; if activated successfully, read ONU's CPI.	The 10/10G OLT CT discovers and activates the ONU.
H	**Pass/fail criteria**	
	1. ONU is activated on the 10/10G OLT CT with post-activation CPI of 0000. No activation attempt is observed on any of 10/2.5G OLT CTs.	
I	**Remarks**	
	• None	

9.1.4 ONU Discovery and Activation – CPI Change

A	**Test Status**	Refer to Section 6.
B	**Reference Documents**	ITU-T G.989.3 [7], Sections 6.1.5.9, 12.1.
C	**Test Objective**	Verify that the ONU detects and reacts to a TWDM CPI change.
D	**Test setup**	As shown in Section **5.6**. Single OLT CT, single ONU.
E	**Pre-test conditions**	The OLT CT powered up, connected to ODN. The cold ONU (CPI = 0000)

		powered up, disconnected from ODN.
F	**Test Configuration**	
	• The OLT CT periodically transmits System profile PLOAM message with the default parameters. • The OLT CT periodically transmits Channel profile PLOAM message for its own channel with the default parameters, and the Channel Partition Index 0001. • The OLT CT periodically transmits Burst profile messages with the default parameters. • The OLT CT offers In-band activation grants.	
G	**Test procedure**	
	User Action	**Expected reaction and message timeline**
1	Connect the ONU to the PON fiber; wait for activation to be completed; if activated successfully, read ONU's CPI.	The OLT CTs discovers and activates the ONU.
2	Change the CPI of the Channel profile PLOAM message transmitted by the second OLT CT to 0002.	The ONU operates continuously.
3	Reactivate the ONU.	The ONU deactivates itself and fails to activate again for 5 min.
H	**Pass/fail criteria**	
	1. Step 1: ONU is activated on the first OLT CT with post-activation CPI of 0001. 2. Step 3: ONU fails to activate, does not respond to serial number grants by the OLT CT for 5 min; then activates with post-activation CPI of 0002.	
I	**Remarks**	
	• None	

9.2 ONU Tuning

9.2.1 ONU Handover

A	**Test Status**	Refer to Section 6.
B	**Reference Documents**	ITU-T G.989.3 [7], Sections 11.3.3.12, 11.3.4.6, 17.3 and F.1.
C	**Test Objective**	Verify successful ONU handover between OLT CTs.
D	**Test setup**	As shown in Section **5.6**. Two OLT CTs, single ONU.
E	**Pre-test 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 using CPI 0xA.
F	**Test Configuration**	
	Profiles from the ONU discovery test (**7.1.1**) are used in this test. Parameters for other messages are defined in test ONU activation – single ONU test (**7.1.2**). Configure ONU to support: • DWLCH 1-4 (187.8, 187.7, 187.6, 187.5 THz). • UWLCH 1-4 (195.6, 195.5, 195.4, 195.3 THz). • Type A optical link type. Parameters for channel profile #1 – TWDM channel A on source OLT CT: • PON-ID: 0xAAAAAAA1 • Downstream line rate: 0 (9.95328 Gbit/s) or 1 (2.48832 Gbit/s), as applicable • Downstream line code: 0000 (NRZ) • CPI: 0xA • Default response channel: 0xAAAAAAA1 • UWLCH ID: 1 • Upstream frequency: 195.6 • Optical link type: 0000 0010 (type A supported, type B not supported), or as applicable • Upstream rate: 0000 0010 (9.95328 Gbit/s supported, 2.48832 Gbit/s not supported), or as applicable • Other fields: at the discretion of the OLT. Parameters for channel profile #2 – TWDM channel B on target OLT CT: • PON-ID: 0xAAAAAAA2 • Downstream line rate: 0 (9.95328 Gbit/s) or 1 (2.48832 Gbit/s), as applicable • Downstream line code: 0000 (NRZ) • CPI: 0xA • Default response channel: 0xAAAAAAA2 • UWLCH ID: 2 • Upstream frequency: 195.5	

	• Optical link type: 0000 0010 (type A supported, type B not supported), or as applicable • Upstream rate: 0000 0010 (9.95328 Gbit/s supported, 2.48832 Gbit/s not supported), or as applicable • Other fields: at the discretion of the OLT. Parameters for tuning control (Request) message: • Operation code: 0x0 (Request) • Scheduled SFC: current SFC + 1000 • Rollback flag: 0 (no rollback available when tuning fails) • Target downstream PON-ID: PON-ID of target OLT CT 0xAAAAAAA2 (or 0xAAAAAAA1) • Target upstream PON-ID: PON-ID of target OLT CT 0xAAAAAAA2 (or 0xAAAAAAA1) • Calibration flag: 1 (execute tuning if no calibration information for target wavelength channel) Parameters for tuning response (ACK) message: • Operation code: 0x0 (ACK) • Response code: 0x0 Parameters for tuning response (Complete_u) message: • Operation code: 0x3 (Complete_u) • Response code: 0x0 Parameters for tuning control (Complete_d) message: • Operation code: 0x1 (Complete_d) Parameters for OLT timers: • Tsource: 10 seconds • Ttarget: 10 seconds Parameters for ONU timers: • TO4: 1 second • TO5: 1 second
G	**Test procedure**

	User Action	**Expected reaction and message timeline**
1	Configure source OLT CT to send channel profile #1, target OLT CT to send channel profile #2.	1. ONU scans and achieves DSYNC on one of the TWDM channels, learns both channel profiles (#1 and #2). 2. ONU achieves DSYNC on PON-ID of channel profile #1 or #2. 3. OLT CT discovers and activates the ONU. 4. Show ONU serial number from OLT CT. Find out which channel is active (source), which channel is target.

2	Issue source OLT command to tune ONU to target OLT CT's downstream and upstream PON-IDs. Tuning control (Request) message.	1. ICTP:Tune-Out and ICTP:Tune-In are issued on source and target OLT CTs. 2. Source OLT CT sends tuning control (Request) message. Source and target OLT CT send periodic PLOAMu grants. 3. ONU sends a tuning response (ACK) message to source OLT CT. 4. ONU waits until the specified SFC (16 least significant bits), transitions to state O8.1, starts tuning its transceiver to target upstream and downstream PON-IDs, and starts timer TO4. 5. ONU achieves DSYNC on target downstream DWLCH before TO4 expires. 6. ONU transitions to state O8.2 and starts learning system, channel and burst profiles. 7. ONU checks if target DWLCH is OK to work. 8. ONU receives PLOAMu grants from target OLT CT on target downstream PON-ID. 9. ONU sends tuning response (Complete_u) to target OLT CT, stops TO4, transitions to state O9 and starts TO5. 10. Target OLT CT sends ICTP:confirm to source OLT CT after receiving tuning response (Complete_u) message from ONU. Source OLT CT stops sending PLOAMu grants to ONU. 11. ONU receives tuning control (Complete_d) from target OLT CT, stops TO5 and transitions to state O5.1.
3	Configure traffic generator to generate upstream and downstream traffic on target OLT CT and ONU.	1. Upstream traffic and downstream traffic should go through. No error in received traffic.
H	**Pass/fail criteria**	
	1. Step 2: Use protocol analyzer to check source OLT CT sends tuning control (Request) to ONU. Check ONU sends tuning response (ACK, response code 0) in response to tuning control (Request). Check target OLT CT receives tuning response (Complete_u) message at appropriate channel. Check target OLT CT sends tuning control (Complete_d) to ONU. 2. Step 3: No error in received traffic.	
I	**Remarks**	
	• None	

9.2.2 Failed Handover – Source OLT Timeout

A	**Test Status**	Refer to Section 6.
B	**Reference Documents**	ITU-T G.989.3 [7], Sections 11.3.3.12, 11.3.4.6, 17.3 and F.1.
C	**Test Objective**	Verify failed ONU handover between OLT CTs due to source OLT timeout. Source OLT CT goes back to HOSTING state and issues a broadcast ICTP alert.
D	**Test setup**	As shown in Section **5.6**. Two OLT CTs, single ONU.
E	**Pre-test 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 using CPI 0xA.
F	**Test Configuration**	
	Profiles from the ONU discovery test (**7.1.1**) are used in this test. Parameters for other messages are defined in test ONU activation – single ONU test (**7.1.2**). Channel profiles from the ONU handover test (9.2.1) are used in this test. Parameters for tuning control (Request) message: • Operation code: 0x0 (Request) • Scheduled SFC: current SFC + 65535 • Rollback flag: 0 (no rollback available when tuning fails) • Target downstream PON-ID: 0xAAAAAAA2 • Target upstream PON-ID: 0xAAAAAAA2 • Calibration flag: 1 (execute tuning if no calibration information for target wavelength channel) Parameters for tuning response (ACK) message: • Operation code: 0x0 (ACK) • Response code: 0x0 Parameters for OLT timers: • Tsource: 1 second • Ttarget: 10 seconds Parameters for ONU timers: • TO4: 2 seconds • TO5: 2 seconds	

G	**Test procedure**	
	User Action	**Expected reaction and message timeline**
1	Configure source OLT CT to send channel profile #1, target OLT CT to send channel profile #2.	1. ONU scans and achieves DSYNC on one of the TWDM channels, learns both channel profiles (#1 and #2). 2. ONU achieves DSYNC on PON-ID of channel profile #1 or #2. 3. OLT CT discovers and activates the ONU. 4. Show ONU serial number from OLT CT. Find out which channel is active (source), which channel is target. 5. If active OLT CT is on PON-ID 0xAAAAAAA2, perform test procedure 9.2.1 to switch active (source) OLT CT to 0xAAAAAAA1.
2	Issue source OLT command to tune ONU to target OLT CT's downstream and upstream PON-IDs. Tuning control (Request) message.	1. ICTP:Tune-Out and ICTP:Tune-In are issued on source and target OLT CTs. 2. Source OLT CT sends tuning control (Request) message. Source and target OLT CTs send periodic PLOAMu grants. 3. ONU sends a tuning response (ACK) message to source OLT CT.
3	Unplug attachment fiber for the target OLT CT before the scheduled handover SFC time.	1. ONU waits until the specified SFC (16 least significant bits), transitions to state O8.1, starts tuning its transceiver to target upstream and downstream PON-IDs and starts timer TO4. 2. ONU fails to achieve DSYNC on target downstream DWLCH since fiber was disconnected. 3. Source OLT CT Tsource expires after 1 second. 4. Source OLT CT transitions back to HOSTING state and issues a broadcast ICTP alert against the ONU-ID. 5. ONU returns to O1.1 after TO4 expired since rollback is not allowed.
H	**Pass/fail criteria**	
	1. Step 2: Use protocol analyzer to check source OLT CT sends tuning control (Request) to ONU. Check ONU sends tuning response (ACK, response code 0) in response to tuning control (Request). 2. Step 3: Source OLT CT Tsource timeout expires, sends out ICTP:abort. ONU returns to state O1.1 and attempts DSYNC with source OLT. Use protocol analyzer to check for activities (serial number ONU and assign ONU-ID PLOAMs) at source OLT CT.	
I	**Remarks**	
	• None	

9.2.3 Failed Handover – Target OLT Timeout

A	**Test Status**	Refer to Section 6.
B	**Reference Documents**	ITU-T G.989.3 [7], Sections 11.3.3.12, 11.3.4.6, 17.3 and F.1.
C	**Test Objective**	Verify failed ONU handover between OLT CTs due to target OLT timeout. Target OLT CT goes back to UNAWARE state and issues a broadcast ICTP alert.
D	**Test setup**	As shown in Section **5.6**. Two OLT CTs, single ONU.
E	**Pre-test 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 using CPI 0xA.
F	**Test Configuration**	
	Profiles from the ONU discovery test (**7.1.1**) are used in this test. Parameters for other messages are defined in test ONU activation – single ONU test (**7.1.2**). Channel profiles from the ONU handover test (9.2.1) are used in this test. Parameters for tuning control (Request) message: • Operation code: 0x0 (Request) • Scheduled SFC: current SFC + 65535 • Rollback flag: 0 (no rollback available when tuning fails) • Target downstream PON-ID: 0xAAAAAAA2 • Target upstream PON-ID: 0xAAAAAAA2 • Calibration flag: 1 (execute tuning if no calibration information for target wavelength channel) Parameters for tuning response (ACK) message: • Operation code: 0x0 (ACK) • Response code: 0x0 Parameters for OLT timers: • Tsource: 10 seconds • Ttarget: 1 second Parameters for ONU timers: • TO4: 2 seconds • TO5: 2 seconds	

G	Test procedure	
	User Action	**Expected reaction and message timeline**
1	Configure source OLT CT to send channel profile #1, target OLT CT to send channel profile #2.	1. ONU scans and achieves DSYNC on one of the TWDM channels, learns both channel profiles (#1 and #2). 2. ONU achieves DSYNC on PON-ID of channel profile #1 or #2. 3. OLT CT discovers and activates the ONU. 4. Show ONU serial number from OLT CT. Find out which channel is active (source), which channel is target. 5. If active OLT CT is on PON-ID 0xAAAAAAA2, perform test procedure 9.2.1 to switch active (source) OLT CT to 0xAAAAAAA1.
2	Issue source OLT command to tune ONU to target OLT CT's downstream and upstream PON-IDs. Tuning control (Request) message.	1. ICTP:Tune-Out and ICTP:Tune-In are issued on source and target OLT CTs. 2. Source OLT CT sends tuning control (Request) message. Source and target OLT CTs send periodic PLOAMu grants. 3. ONU sends a tuning response (ACK) message to source OLT CT.
3	Unplug attachment fiber for the target OLT CT before the scheduled handover SFC time.	1. ONU waits until the specified SFC (16 least significant bits), transitions to state O8.1, starts tuning its transceiver to target upstream and downstream PON-IDs and starts timer TO4. 2. ONU fails to achieve DSYNC on target downstream DWLCH since fiber was disconnected. 3. Target OLT CT fails to receive tuning response (Complete_u) from ONU. 4. Ttarget expires after 1 second. 5. Target OLT CT transitions back to UNAWARE state and issues a broadcast ICTP alert against the ONU-ID. 6. ONU returns to O1.1 after TO4 expired since rollback is not allowed.
H	**Pass/fail criteria**	
	1. Step 2: Use protocol analyzer to check source OLT CT sends tuning control (Request) to ONU. Check ONU sends tuning response (ACK, response code 0) in response to tuning control (Request). 2. Step 3: Target OLT CT Ttarget timeout expires, sends out ICTP:abort. ONU returns to state O1.1 and attempts DSYNC with source OLT. Use protocol analyzer to check for activities (serial number ONU and assign ONU-ID PLOAMs) at source OLT CT.	
I	**Remarks**	
	• None	

9.2.4 Failed Handover – ONU Timeout

A	**Test Status**	Refer to Section 6.
B	**Reference Documents**	ITU-T G.989.3 [7], Sections 11.3.3.12, 11.3.4.6, 17.3 and F.1.
C	**Test Objective**	Verify failed ONU handover between OLT CTs due to ONU timeout.
D	**Test setup**	As shown in Section **5.6**. Two OLT CTs, single ONU.
E	**Pre-test 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 using CPI 0xA.
F	**Test Configuration**	
	Profiles from the ONU discovery test (**7.1.1**) are used in this test. Parameters for other messages are defined in test ONU activation – single ONU test (**7.1.2**). Channel profiles from the ONU handover test (9.2.1) are used in this test. Parameters for tuning control (Request) message: • Operation code: 0x0 (Request) • Scheduled SFC: current SFC + 65535 • Rollback flag: 0 (no rollback available when tuning fails) • Target downstream PON-ID: 0xAAAAAAA2 • Target upstream PON-ID: 0xAAAAAAA2 • Calibration flag: 1 (execute tuning if no calibration information for target wavelength channel) Parameters for tuning response (ACK) message: • Operation code: 0x0 (ACK) • Response code: 0x0 Parameters for OLT timers: • Tsource: 10 seconds • Ttarget: 10 seconds Parameters for ONU timers: • TO4: 1 second • TO5: 1 second	

G	**Test procedure**	
	User Action	**Expected reaction and message timeline**
1	Configure source OLT CT to send channel profile #1, target OLT CT to send channel profile #2.	1. ONU scans and achieves DSYNC on one of the TWDM channels, learns both channel profiles (#1 and #2). 2. ONU achieves DSYNC on PON-ID of channel profile #1 or #2. 3. OLT CT discovers and activates the ONU. 4. Show ONU serial number from OLT CT. Find out which channel is active (source), which channel is target. 5. If active OLT CT is on PON-ID 0xAAAAAAA2, perform test procedure 9.2.1 to switch active (source) OLT CT to 0xAAAAAAA1.
2	Issue source OLT command to tune ONU to target OLT CT's downstream and upstream PON-IDs. Tuning control (Request) message.	1. ICTP:Tune-Out and ICTP:Tune-In are issued on source and target OLT CTs. 2. Source OLT CT sends tuning control (Request) message. Source and target OLT CTs send periodic PLOAMu grants. 3. ONU sends a tuning response (ACK) message to source OLT CT.
3	Unplug attachment fiber for the target OLT CT before the scheduled handover SFC time.	1. ONU waits until the specified SFC (16 least significant bits), transitions to state O8.1, starts tuning its transceiver to target upstream and downstream PON-IDs and starts timer TO4. 2. ONU fails to achieve DSYNC on target downstream DWLCH since fiber was disconnected. 3. ONU returns to O1.1 after TO4 expired since rollback is not allowed.
H	**Pass/fail criteria**	
	3. Step 2: Use protocol analyzer to check source OLT CT sends tuning control (Request) to ONU. Check ONU sends tuning response (ACK, response code 0) in response to tuning control (Request). 4. Step 3: ONU returns to state O1.1 and attempts DSYNC with source OLT CT. Use protocol analyzer to check for activities (serial number ONU and assign ONU-ID PLOAMs) at source OLT CT.	
I	**Remarks**	
	• None	

9.2.5 Failed Handover – NACK

A	**Test Status**	Refer to Section 6.
B	**Reference Documents**	ITU-T G.989.3 [7], Sections 11.3.3.12, 11.3.4.6, 17.3 and F.1.
C	**Test Objective**	Verify that ONU sends NACK when administrative label of downstream PON-ID is invalid and source OLT handles tuning response (NACK) correctly.
D	**Test setup**	As shown in Section **5.6**. Two OLT CTs, single ONU.
E	**Pre-test 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 using CPI 0xA.
F	**Test Configuration**	
	Profiles from the ONU discovery test (**7.1.1**) are used in this test. Parameters for other messages are defined in test ONU activation – single ONU test (**7.1.2**). Channel profiles from the ONU handover test (9.2.1) are used in this test. Parameters for tuning control (Request) message: • Operation code: 0x0 (Request) • Scheduled SFC: current SFC + 1000 • Rollback flag: 0 (no rollback available when tuning fails) • Target downstream PON-ID: 0xAAAAAAB2 • Target upstream PON-ID: 0xAAAAAAB2 • Calibration flag: 1 (execute tuning if no calibration information for target wavelength channel) Parameters for tuning response (NACK) message: • Operation code: 0x1 (NACK) • Response code: 0x0082 (DS_ALBL | US_ALBL) Parameters for OLT timers: • Tsource: 10 seconds • Ttarget: 10 seconds Parameters for ONU timers: • TO4: 1 second • TO5: 1 second	

G	**Test procedure**	
	User Action	**Expected reaction and message timeline**
1	Configure source OLT CT to send channel profile #1, target OLT CT to send channel profile #2.	1. ONU scans and achieves DSYNC on one of the TWDM channels, learns both channel profiles (#1 and #2). 2. ONU achieves DSYNC on PON-ID of channel profile #1 or #2. 3. OLT CT discovers and activates the ONU. 4. Show ONU serial number from OLT CT. Find out which channel is active (source), which channel is target. 5. If active OLT CT is on PON-ID 0xAAAAAAA2, perform test procedure 9.2.1 to switch active (source) OLT CT to 0xAAAAAAA1.
2	Issue source OLT command to tune ONU to target OLT CT's downstream and upstream PON-IDs. Tuning control (Request) message.	1. ICTP:Tune-Out and ICTP:Tune-In are issued on source and target OLT CTs. 2. Source OLT CT sends tuning control (Request) message. Source and target OLT CTs send periodic PLOAMu grants. 3. ONU detects the target upstream and downstream PON-ID administrative label inconsistency, sends a tuning response (NACK, response code DS_ALBL | US_ALBL) to source OLT. 4. Source OLT send ICTP:abort to target OLT, stops Tsource and returns to HOSTING state. 5. Target OLT stops sending PLOAMu grants and stops Ttarget after receiving ICTP:abort. Target OLT returns to UNAWARE state. 6. ONU stays in O5.1 state.
3	Configure traffic generator to generate upstream and downstream traffic on source OLT and ONU.	1. Upstream traffic and downstream traffic should go through. No error in received traffic.
H	**Pass/fail criteria**	
	1. Step 2: Use protocol analyzer to check source OLT CT sends tuning control (Request) to ONU. Check ONU sends tuning response (NACK, response code DS_ALBL | US_ALBL) in response to tuning control (Request). Source OLT sends ICTP:abort to target OLT. 2. Step 3: No error in received traffic.	
I	**Remarks**	
	• None	

9.2.6 Failed Handover – Rollback

A	**Test Status**	Refer to Section 6.
B	**Reference Documents**	ITU-T G.989.3 [7], Sections 11.3.3.12, 11.3.4.6, 17.3 and F.1.
C	**Test Objective**	Verify ONU rollback to source OLT CT when it fails to achieve downstream synchronization on target OLT CT.
D	**Test setup**	As shown in Section **5.6**. Two OLT CTs, single ONU.
E	**Pre-test 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 using CPI 0xA.
F	**Test Configuration**	
	Profiles from the ONU discovery test (**7.1.1**) are used in this test. Parameters for other messages are defined in test ONU activation – single ONU test (**7.1.2**). Channel profiles from the ONU handover test (9.2.1) are used in this test. Parameters for tuning control (Request) message: • Operation code: 0x0 (Request) • Scheduled SFC: current SFC + 65535 • Rollback flag: 1 (rollback available when tuning fails) • Target downstream PON-ID: 0xAAAAAAA2 • Target upstream PON-ID: 0xAAAAAAA2 • Calibration flag: 1 (execute tuning if no calibration information for target wavelength channel) Parameters for tuning response (ACK) message: • Operation code: 0x0 (ACK) • Response code: 0x0 Parameters for tuning response (Rollback) message: • Operation code: 0x4 (Rollback) • Response code: 0x1 (COM_DS) Parameters for tuning control (Complete_d) message: • Operation code: 0x1 (Complete_d) Parameters for OLT timers: • Tsource: 10 seconds • Ttarget: 10 seconds Parameters for ONU timers: • TO4: 2 seconds • TO5: 2 seconds	

G	Test procedure	
	User Action	**Expected reaction and message timeline**
1	Configure source OLT CT to send channel profile #1, target OLT CT to send channel profile #2.	1. ONU scans and achieves DSYNC on one of the TWDM channels, learns both channel profiles (#1 and #2). 2. ONU achieves DSYNC on PON-ID of channel profile #1 or #2. 3. OLT CT discovers and activates the ONU. 4. Show ONU serial number from OLT CT. Find out which channel is active (source), which channel is target. 5. If active OLT CT is on PON-ID 0xAAAAAAA2, perform test procedure 9.2.1 to switch active (source) OLT CT to 0xAAAAAAA1.
2	Issue source OLT command to tune ONU to target OLT CT's downstream and upstream PON-IDs. Tuning control (Request) message.	1. ICTP:Tune-Out and ICTP:Tune-In are issued on source and target OLT CTs. 2. Source OLT CT sends tuning control (Request) message. Source and target OLT CTs send periodic PLOAMu grants. 3. ONU sends a tuning response (ACK) message to source OLT CT.
3	Unplug attachment fiber for the target OLT CT before the scheduled handover SFC time.	1. ONU waits until the specified SFC (16 least significant bits), transitions to state O8.1, starts tuning its transceiver to target upstream and downstream PON-IDs and starts timer TO4. 2. ONU fails to achieve DSYNC on target downstream DWLCH since fiber was disconnected. 3. ONU tunes its transceiver back to source OLT CT downstream and upstream PON-IDs, restarts timer TO4 and stays in state O8.1. 4. ONU achieves DSYNC with source OLT CT before TO4 expires. 5. ONU enters state O8.2 and learns system, channel and burst profiles from source OLT CTon original downstream PON-ID. 6. ONU receives PLOAMu grant from source OLT, sends tuning response (ROLLBACK) - response code COM_DS. 7. ONU stops timer TO4, transitions to state O9 and starts timer TO5. 8. Source OLT CT stops Tsource, sends ICTP:abort to target OLT, sends tuning control (Complete_d) to ONU and returns to HOSTING state. 9. ONU receives tuning control (Complete_d), stops TO5 and returns to state O5.1.
4	Configure traffic generator to generate upstream and downstream traffic on source OLT and ONU.	1. Upstream traffic and downstream traffic should go through. No error in received traffic.

H	**Pass/fail criteria**
	1. Step 2: Use protocol analyzer to check source OLT CT sends tuning control (Request) to ONU. Check ONU sends tuning response (ACK, response code 0) in response to tuning control (Request). 2. Step 3: Use protocol analyzer to check ONU sends tuning response (ROLLBACK, response code: COM_DS) in response PLOAMu grant from source OLT CT. Source OLT stops Tsource, sends ICTP:abort to target OLT. Check source OLT sends tuning control (Complete_d) to ONU. 3. Step 4: No error in received traffic.
I	**Remarks**
	• None

9.2.7 Failed Handover – Channel Partitioning

A	**Test Status**	Refer to Section 6.
B	**Reference Documents**	ITU-T G.989.3 [7], Sections 11.3.3.12, 11.3.4.6, 17.3 and F.1.
C	**Test Objective**	Verify that ONU sends NACK to source OLT CT when the channel partition in the target channel profile does not match the channel partition stored locally at ONU.
D	**Test setup**	As shown in Section **5.6**. Two OLT CTs, single ONU.
E	**Pre-test 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 using CPI 0xA.
F	**Test Configuration**	
	Profiles from the ONU discovery test (**7.1.1**) are used in this test. Parameters for other messages are defined in test ONU activation – single ONU test (**7.1.2**). Channel profiles from the ONU handover test (9.2.1) are used in this test except for CPI value: • Channel profile #1 – TWDM channel A on source OLT CT - CPI: 0xA • Channel profile #2 – TWDM channel B on source OLT CT - CPI: 0xB Parameters for tuning control (Request) message: • Operation code: 0x0 (Request) • Scheduled SFC: current SFC + 65535 • Rollback flag: 0 (no rollback available when tuning fails) • Target downstream PON-ID: 0xAAAAAAA2 • Target upstream PON-ID: 0xAAAAAAA2 • Calibration flag: 1 (execute tuning if no calibration information for target wavelength channel) Parameters for tuning response (NACK) message: • Operation code: 0x1 (NACK) • Response code: 0x0008 (DS_PART) Parameters for OLT timers: • Tsource: 10 seconds • Ttarget: 10 seconds Parameters for ONU timers: • TO4: 1 second • TO5: 1 second	

G	**Test procedure**	
	User Action	**Expected reaction and message timeline**
1	Configure source OLT CT to send channel profile #1, target OLT CT to send channel profile #2.	1. ONU scans and achieves DSYNC on one of the TWDM channels, learns both channel profiles (#1 and #2). 2. ONU achieves DSYNC on PON-ID of channel profile #1 or #2. 3. OLT CT discovers and activates the ONU on channel profile #1 (ONU has been previously active with CPI 0xA)
2	Issue source OLT command to tune ONU to target OLT CT's downstream and upstream PON-IDs. Tuning control (Request) message.	1. ICTP:Tune-Out and ICTP:Tune-In are issued on source and target OLT CTs. 2. Source OLT CT sends tuning control (Request) message. Source and target OLT CTs send periodic PLOAMu grants. 3. ONU detects invalid CPI in target PON-ID, sends a tuning response (NACK, response code DS_PART) to source OLT. 4. Source OLT send ICTP:abort to target OLT, stops Tsource and returns to HOSTING state. 5. Target OLT stops sending PLOAMu grants and stops Ttarget after receiving ICTP:abort. Target OLT returns to UNAWARE state. 6. ONU stays in O5.1 state.
3	Configure traffic generator to generate upstream and downstream traffic on source OLT and ONU.	1. Upstream traffic and downstream traffic should go through. No error in received traffic.
H	**Pass/fail criteria**	
	3. Step 2: Use protocol analyzer to check source OLT CT sends tuning control (Request) to ONU. Check ONU sends tuning response (NACK, response code DS_PART) in response to tuning control (Request). Source OLT sends ICTP:abort to target OLT. 4. Step 3: No error in received traffic.	
I	**Remarks**	
	• None	

9.2.8 Flexible DS/US Channel Association

A	**Test Status**	Refer to Section 6.
B	**Reference Documents**	ITU-T G.989.3 [7], Sections 11.3.1 and 11.3.3.14.
C	**Test Objective**	Verify ONU support of flexible downstream/upstream channel association.
D	**Test setup**	As shown in Section **5.6**. One OLT CT, single ONU.
E	**Pre-test 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 using CPI 0xA.
F	**Test Configuration**	
	Profiles from the ONU discovery test (**7.1.1**) are used in this test. Parameters for other messages are defined in test ONU activation – single ONU test (**7.1.2**). Configure ONU to support: • DWLCH 1-4 (187.8, 187.7, 187.6, 187.5 THz). • UWLCH 1-4 (195.6, 195.5, 195.4, 195.3 THz). • Type A optical link type. Parameters for channel profile #1 (void upstream descriptor): • Control octet: 0001 0101 (channel profile index 1, channel profile pertains to the TWDM channel in which it is transmitted, valid downstream descriptor, ignore upstream descriptor) • PON-ID: 0xAAAAAAA1 • Downstream line rate: 0 (9.95328 Gbit/s) or 1 (2.48832 Gbit/s), as applicable • Downstream line code: 0000 (NRZ) • CPI: 0xA • Default response channel: 0xAAAAAAA1 • UWLCH ID: 1 • Upstream frequency: 195.5 • Optical link type: 0000 0010 (type A supported, type B not supported), or as applicable • Upstream rate: 0000 0010 (9.95328 Gbit/s supported, 2.48832 Gbit/s not supported), or as applicable • Other fields: at the discretion of the OLT. Parameters for channel profile #2 (void downstream descriptor): • Control octet: 0001 0010 (channel profile index 1, channel profile pertains to another channel, ignore downstream descriptor, valid upstream descriptor) • PON-ID: 0xAAAAAAA1 • Downstream line rate: 0 (9.95328 Gbit/s) or 1 (2.48832 Gbit/s), as applicable • Downstream line code: 0000 (NRZ) • CPI: 0xA • Default response channel: 0xAAAAAAA1 • UWLCH ID: 1 • Upstream frequency: 195.5	

	• Optical link type: 0000 0010 (type A supported, type B not supported), or as applicable • Upstream rate: 0000 0010 (9.95328 Gbit/s supported, 2.48832 Gbit/s not supported), or as applicable • Other fields: at the discretion of the OLT.	
G	**Test procedure**	
	User Action	**Expected reaction and message timeline**
1	Configure OLT CT to transmit two channel profiles #1 and #2. Each message is sent at least twice.	1. ONU stays in state O1.1 until DSYNC is achieved. It then transitions to state O1.2. 2. OLT CT transmits the profile messages. Each message is sent at least twice. 3. ONU learns and stores DWLCHID and UWLCHID from channel profile #1 and #2. 4. ONU tunes its transceiver to workable DWLCH and UWLCH frequencies. 5. ONU achieves DSYNC on new downstream DWLCH. 6. OLT sends a serial number grant on DWLCH. 7. ONU responds with a serial number message on UWLCH. 8. OLT receives ONU serial number and sends Assign_ONU-ID PLOAM on DWLCH. 9. ONU receives ONU-ID on DWLCH.
H	**Pass/fail criteria**	
	1. Use protocol analyzer to check OLT sends two channel profiles. ONU sends serial_number_ONU PLOAM upstream on UWLCH. OLT sends Assign_ONU-ID PLOAM downstream on DWLCH.	
I	**Remarks**	
	• None	

9.2.9 Tuning Control / Response Message Formats

A	**Test Status**	Refer to Section 6.
B	**Reference Documents**	ITU-T G.989.3 [7], Sections 11.3.3.12, 11.3.4.6, 17.3 and F.1.
C	**Test Objective**	Verify that the OLT and ONU can generate and properly process the following downstream and upstream PLOAM messages: • Tuning control • Tuning response
D	**Test setup**	As shown in Section **5.6**. Two OLT CTs, single ONU.
E	**Pre-test 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 using CPI 0xA.
F	**Test Configuration**	
	Profiles from the ONU discovery test (**7.1.1**) are used in this test. Parameters for other messages are defined in test ONU activation – single ONU test (**7.1.2**). Configure ONU to support: • DWLCH 1-4 (187.8, 187.7, 187.6, 187.5 THz). • UWLCH 1-4 (195.6, 195.5, 195.4, 195.3 THz). • Type A optical link type. Parameters for channel profile #1 – TWDM channel A on source OLT CT: • Control octet: 0001 0100 (channel profile index 1, channel profile pertains to the TWDM channel in which it is transmitted, valid downstream descriptor, valid upstream descriptor) • Channel profile version: 0001 0000 • PON-ID: 0xAAAAAAA1 • Downstream line rate: 0 (9.95328 Gbit/s) or 1 (2.48832 Gbit/s), as applicable • Downstream line code: 0000 (NRZ) • CPI: 0xA • Default response channel: 0xAAAAAAA1 • UWLCH ID: 1 • Upstream frequency: 195.6 • Optical link type: 0000 0010 (type A supported, type B not supported), or as applicable • Upstream rate: 0000 0010 (9.95328 Gbit/s supported, 2.48832 Gbit/s not supported), or as applicable • Other fields: at the discretion of the OLT. Parameters for channel profile #2 – TWDM channel B on target OLT CT (for NACK tests):	

	• Control octet: 0010 0111 (channel profile index 2, channel profile pertains to another channel, ignore downstream descriptor, ignore upstream descriptor) • Channel profile version: 0001 0000 • PON-ID: 0xAAAAAAA2 • Downstream line rate: 0 (9.95328 Gbit/s) or 1 (2.48832 Gbit/s), as applicable – not supported by ONU to generate error condition • Downstream line code: 0001 (invalid) • CPI: 0xB • Default response channel: 0xAAAAAAA2 • UWLCH ID: 2 • Upstream frequency: 195.1 • Optical link type: 0000 0001 (type A not supported, type B supported), or as applicable to generate error condition • Upstream rate: 0000 0001 (9.95328 Gbit/s not supported, 2.48832 Gbit/s supported), or as applicable to generate error condition • Other fields: at the discretion of the OLT. Parameters for channel profile #3 – TWDM channel B on target OLT CT: • Control octet: 0010 0100 (channel profile index 2, channel profile pertains to this channel, valid downstream descriptor, valid upstream descriptor) • Channel profile version: 0010 0000 • PON-ID: 0xAAAAAAA2 • Downstream line rate: 0 (9.95328 Gbit/s) or 1 (2.48832 Gbit/s), as applicable • Downstream line code: 0000 (NRZ) • CPI: 0xA • Default response channel: 0xAAAAAAA1 • UWLCH ID: 2 • Upstream frequency: 195.5 • Optical link type: 0000 0010 (type A supported, type B not supported), or as applicable • Upstream rate: 0000 0010 (9.95328 Gbit/s supported, 2.48832 Gbit/s not supported), or as applicable • Other fields: at the discretion of the OLT. Parameters for channel profile #4 – TWDM channel B on target OLT CT (for ROLLBACK tests): • Control octet: 0010 0101 (channel profile index 2, channel profile pertains to this channel, downstream descriptor valid, ignore upstream descriptor) • Channel profile version: 0011 0000 • PON-ID: 0xAAAAAAA2 • Downstream line rate: 0 (9.95328 Gbit/s) or 1 (2.48832 Gbit/s), as applicable • Downstream line code: 0001 (invalid) • CPI: 0xA • Default response channel: 0xAAAAAAA2 • UWLCH ID: 2 • Upstream frequency: 195.1 • Optical link type: 0000 0001 (type A not supported, type B supported), or as applicable to generate error condition • Upstream rate: 0000 0001 (9.95328 Gbit/s not supported, 2.48832 Gbit/s supported), or as

	applicable to generate error condition • Other fields: at the discretion of the OLT. Parameters for tuning control (Request) message #1 (for NACK tests): • Operation code: 0x0 (Request) • Scheduled SFC: current SFC • Rollback flag: 0 (no rollback available when tuning fails) • Target downstream PON-ID: 0xAAAAAAA2 • Target upstream PON-ID: 0xAAAAAAA2 • Calibration flag: 1 (execute tuning if no calibration information for target wavelength channel) Parameters for tuning control (Request) message #2 (for ROLLBACK tests): • Operation code: 0x0 (Request) • Scheduled SFC: current SFC + 65535 • Rollback flag: 1 (rollback available when tuning fails) • Target downstream PON-ID: 0xAAAAAAA2 • Target upstream PON-ID: 0xAAAAAAA2 • Calibration flag: 1 (execute tuning if no calibration information for target wavelength channel) Parameters for tuning response (ACK) message: • Operation code: 0x0 (ACK) • Response code: 0x0 Parameters for tuning response (NACK) message: • Operation code: 0x1 (NACK) • Response code: 0x0001 (INT_SFC), 0x0002 (DS_ALBL), 0x0004 (DS_VOID), 0x0008 (DS_PART), 0x0010 (DS_TUNR), 0x0020 (DS_LNRT), 0x0040 (DS_LNCD), 0x0080 (US_ALBL), 0x0100 (US_VOID), 0x0200 (US_TUNR), 0x0400 (US_CLBR), 0x0800 (US_LKTP), 0x1000 (US_LNRT), 0x2000 (US_LNCD). Parameters for tuning response (ROLLBACK) message: • Operation code: 0x4 (ROLLBACK) • Response code: 0x0001 (COM_DS), 0x0002 (DS_ALBL), 0x0004 (DS_LKTP), 0x0008 (US_ALBL), 0x0010 (US_VOID), 0x0020 (US_TUNR), 0x0040 (US_LKTP), 0x0080 (US_LNRT), 0x0100 (US_LNCD). Parameters for tuning response (Complete_u) message: • Operation code: 0x3 (Complete_u) • Response code: 0x0 Parameters for tuning control (Complete_d) message:

	• Operation code: 0x1 (Complete_d) Parameters for OLT timers: • Tsource: 10 seconds • Ttarget: 10 seconds Parameters for ONU timers: • TO4: 1 second • TO5: 1 second	
G	**Test procedure**	
	User Action	**Expected reaction and message timeline**
1	Configure source OLT CT to send channel profile #1, target OLT CT to send channel profile #2.	1. ONU scans and achieves DSYNC on one of the TWDM channels, learns both channel profiles (#1 and #2). 2. ONU achieves DSYNC on PON-ID of channel profile #1. 3. OLT CT discovers and activates the ONU. 4. Show ONU serial number from OLT CT. Find out which channel is active (source), which channel is target. 5. If active OLT CT is on PON-ID 0xAAAAAAA2, perform test procedure 9.2.1 to switch active (source) OLT CT to 0xAAAAAAA1.
2	Issue source OLT command to tune ONU to target OLT CT's downstream and upstream PON-IDs. Tuning control (Request) message #1.	1. ICTP:Tune-Out and ICTP:Tune-In are issued on source and target OLT CTs. 2. Source OLT CT sends tuning control (Request) message. Source and target OLT CT send periodic PLOAMu grants.
3	Capture downstream and upstream PLOAMs with protocol analyzer.	1. ONU sends tuning response with Opcode: NACK, Response code: INT_SFC | DS_VOID | DS_PART | DS_TUNR | DS_LNRT | DS_LNCD | US_VOID | US_TUNR | US_LKTP | US_LNRT | US_LNCD 2. Source OLT CTsends ICTP:abort to target OLT CT, stops Tsource and returns to HOSTING state. 3. Target OLT CT stops sending PLOAMu grants and stops Ttarget after receiving ICTP:abort. Target OLT returns to UNAWARE state. 4. ONU stays in O5.1 state.
4	Configure traffic generator to generate upstream and downstream traffic on source OLT CT and ONU.	1. Upstream traffic and downstream traffic should go through. No error in received traffic.
5	Configure target	1. ONU learns the new channel profile (profiles #1 and #3 are made active).

	OLT CT to send channel profile #3.	
6	Issue source OLT command to tune ONU to target OLT CT's downstream and upstream PON-IDs. Tuning control (Request) message #2.	1. ICTP:Tune-Out and ICTP:Tune-In are issued on source and target OLT CTs. 2. Source OLT CT sends tuning control (Request) message. 3. Source and target OLT CT send periodic PLOAMu grants. 4. ONU sends a tuning response (ACK) message to source OLT CT.
7	Configure target OLT CT to send channel profile #4.	1. ONU learns the new channel profile (profiles #1 and #4 are made active).
8	Capture downstream and upstream PLOAMs with protocol analyzer.	1. ONU waits until the specified SFC (16 least significant bits), transitions to state O8.1, starts tuning its transceiver to target upstream and downstream PON-IDs and starts timer TO4. 2. ONU achieve DSYNC with target OLT CT before TO4 expires. 3. ONU learns and checks parameters in channel profile from target OLT CT. 4. ONU detects invalid parameters in channel profile #4. 5. ONU tunes its transceiver back to source OLT CT and restarts timer TO4. 6. ONU achieves DSYNC with source OLT CT before TO4 expires. 7. ONU receives PLOAMu grants from source OLT CT, and sends tuning response (ROLLBACK), Response code: DS_LKTP | US_VOID | US_TUNR | US_LKTP | US_LNRT | US_LNCD. 8. ONU stops timer TO4, transitions to state O9 and starts timer TO5. 9. Source OLT CT stops Tsource, sends ICTP:abort to target OLT CT, sends tuning control (Complete_d) to ONU and returns to HOSTING state. 10. ONU receives tuning control (Complete_d), stops TO5 and transitions to state O5.1.
9	Configure traffic generator to generate upstream and downstream traffic on source OLT CT and ONU.	1. Upstream traffic and downstream traffic should go through. No error in received traffic.
H	**Pass/fail criteria**	
	1. Step 2: Use protocol analyzer to check all parameters in tuning control (Request) PLOAM. 2. Step 3: Use protocol analyzer to check all parameters in tuning response (NACK) PLOAM. 3. Step 4: No error in received traffic. 4. Step 6: Use protocol analyzer to check all parameters in tuning control (Request) PLOAM. 5. Step 8: Use protocol analyzer to check all parameters in tuning response (ROLLBACK) PLOAM.	

	6. Step 9: No error in received traffic.
I	**Remarks**
	• None

9.3 ONU Calibration and Wavelength Drift Control

9.3.1 ONU Calibration Status Reporting

A	**Test Status**	Refer to Section 6.
B	**Reference Documents**	ITU-T G.989.3 [7], Sections 11.3.4.1, 11.3.4.6 and 17.4.
C	**Test Objective**	Verify the ONU generates proper calibration reporting.
D	**Test setup**	As shown in Section **5.6**.
E	**Pre-test 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.
F	**Test Configuration**	
	Profiles from the ONU discovery test (**7.1.1**) are used in this test. Parameters for tuning control (Request) message: • Operation code: 0x0 (Request) • Scheduled SFC: current SFC + 1000 • Rollback flag: 0 (no rollback available when tuning fails) • Target downstream PON-ID: 0xAAAAAAB2 • Target upstream PON-ID: 0xAAAAAAB2 • Calibration flag: 1 (execute tuning if no calibration information for target wavelength channel)	
G	**Test procedure**	
	User Action	**Expected reaction and message timeline**
1	OLT issues serial number grant	1. ONU responds with Serial_Number_ONU. 2. This PLOAM message is captured.
2	OLT initiates a wavelength channel handover	1. ONU sends Tuning_Response to confirm operation. 2. This PLOAM message is captured.
H	**Pass/fail criteria**	
	1. For both the Serial_Number_ONU message and the Tuning_Response message, the following fields must have the proper format and content: • Calibration record status (8 octets) • Tuning granularity (8 bits) • One-step tuning time (8 bits) • Upstream line rate (2 bits) • Attenuation (4 bits) • Power leveling (7 bits)	
I	**Remarks**	
	• None	

9.3.2 Wavelength Drift Control

A	**Test Status**	Refer to Section 6.
B	**Reference Documents**	ITU-T G.989.3 [7], Sections 11.3.3.11 and 17.4.
C	**Test Objective**	Test upstream TX fine tuning.
D	**Test setup**	As shown in Section **5.6**.
E	**Pre-test 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.
F	**Test Configuration**	
	Profiles from the ONU discovery test (**7.1.1**) are used in this test. Parameters for Adjust_Tx_Wavelength message: • ONU_ID: o If addressing via ONU-ID, then this field set to the ONU-ID of the ONU under test o Else if addressing via Vendor ID, then this field set to 0x3FF • Vendor_ID, VSSN: o If addressing via ONU-ID, then Vendor_ID and VSSN set to zero o Else if addressing via Vendor ID, then Vendor_ID and VSSN set to Vendor ID of the ONU • Current_PON_ID: identity of the CT which currently terminates this ONU • Frequency adjustment direction: 0 or 1 to adjust to a lower or higher frequency, respectively • Frequency adjustment size: Amount of frequency adjustment in units of 0.1 GHz	
G	**Test procedure**	
	User Action	**Expected reaction and message timeline**
1	OLT issues Adjust_ Tx_Wavelength PLOAM message	1. ONU adjusts transmission frequency as instructed by OLT. 2. OLT collects optical signal quality statistics.
H	**Pass/fail criteria**	
	1. After F+N*T+6 PHY frames (N = Tuning granularity, T = One-step tuning time), upstream optical signal statistics must indicate that tuning is complete. 2. An optical spectrum analyzer can be used to confirm that the requested tuning amount was implemented.	
I	**Remarks**	
	• None	

9.4 Lambda Type Protection

9.4.1 Protection Channel Not Configured, Default TO2

A	**Test Status**	Refer to Section 6.
B	**Reference Documents**	ITU-T G.989.3 [7], Section 18.
C	**Test Objective**	Verify the proper ONU behavior when protection channel is not configured on the ONU and that the TO2 value is set to the default value.
D	**Test setup**	As shown in Section **5.6**.
E	**Pre-test conditions**	1. The ONU should be reset to factory default settings. 2. Four TWDM channels should be active in the test environment. 3. Testing is performed with only a single ONU in the system. 4. All PLOAM channels should offer serial number grants in high frequency (1 per 100ms). 5. All TWDM channels should be configured to support service restoration for the ONU service under test. This allows the tester to validate the time it takes to restore service with the current testing configuration.
F	**Test Configuration**	
	ONU Setup Parameters: • Upstream FEC: on • Primary TWDM Channel: 1 • Protection TWDM Channel: Undefined • TO2: Default (expected to be 1 second) Subscriber Service provisioning: • S-VLAN: 101 (default service VLAN for testing) • C-VLAN: 1 (default service VLAN for testing) • Service Type: Data only • Data Rate: 1Gbps symmetrical • IGMP & other values: Default	
G	**Test procedure**	
	User Action	**Expected reaction and message timeline**
1	Power-up the ONU and attach the PON fiber	1. ONU is at state O1.1 until downstream frame synchronization is attained. It then transitions to states O1.2 and 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.

2	Activate the ONU on Channel 1 with the configuration prescribed in F above.	1. ONU provisioning is applied on the ONU. 2. ONU transitions from default channel to channel 1.
3	Apply subscriber service provisioning.	1. Data traffic should pass to the test set. The test set should be able to measure total outage time.
4	Disable channel 1 at the OLT by pulling fiber (not by removing).	1. The ONU should lose service. 2. After some period of time (expected to be 1 second), the ONU should begin searching for a viable channel. 3. When connected to a new channel, the ONU should notify OLT of its presence and wait for instructions. 4. All TWDM channels should be configured to support service restoration for the ONU service under test. This allows the tester to validate the time it takes to restore service with the current testing configuration.
H	**Pass/fail criteria**	
	1. Upon failure, the ONU should wait the prescribed period of time (default TO2 value) before searching for restoration options. 2. When transitioning to a new channel, the ONU should land on the next viable channel (should be channel 2).	
I	**Remarks**	
	• None	

9.4.2 Protection Channel Not Configured, Large Configured TO2

A	**Test Status**	Refer to Section 6 (Conditionally Mandatory if ONU TO2 value can be configured).
B	**Reference Documents**	ITU-T G.989.3 [7], Section 18.
C	**Test Objective**	Verify the proper ONU behavior when protection channel is not configured on the ONU and that the TO2 value is set to high value.
D	**Test setup**	As shown in Section **5.6**.
E	**Pre-test conditions**	1. The ONU should be reset to factory default settings. 2. Four TWDM channels should be active in the test environment. 3. Testing is performed with only a single ONU in the system. 4. All PLOAM channels should offer serial number grants in high frequency (1 per 100ms). 5. All TWDM channels should be configured to support service restoration for the ONU service under test. This allows the tester to validate the time it takes to restore service with the current testing configuration.

F	**Test Configuration**	
	ONU Setup Parameters: • Upstream FEC: on • Primary TWDM Channel: 1 • Protection TWDM Channel: Undefined • TO2: 30 seconds Subscriber Service provisioning: • S-VLAN: 101 (default service VLAN for testing) • C-VLAN: 1 (default service VLAN for testing) • Service Type: Data only • Data Rate: 1Gbps symmetrical • IGMP & other values: Default	
G	**Test procedure**	
	User Action	**Expected reaction and message timeline**
1	Power-up the ONU and attach the PON fiber	1. ONU is at state O1.1 until downstream frame synchronization is attained. It then transitions to states O1.2 and 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.
2	Activate the ONU on Channel 1 with the configuration prescribed in F above.	1. ONU provisioning is applied on the ONU. 2. ONU transitions from default channel to channel 1.
3	Apply subscriber service provisioning.	1. Data traffic should pass to the test set. The test set should be able to measure total outage time.
4	Disable channel 1 at the OLT.	1. The ONU should lose communication to the OLT. By default, the ONU should not transition to a protection channel. **Note**: ONU protection behavior should have been provisioned to the ONU during activation process and does not rely on subscriber service provisioning. 2. After some period of time (expected to be 30 seconds), the ONU should begin searching for a viable channel. 3. When connected to a new channel, the ONU should notify OLT of its presence and wait for instructions.
H	**Pass/fail criteria**	
	1. Upon failure, the ONU should wait the prescribed period of time (30 seconds) before searching for alternative channels. 2. When transitioning to a new channel, the ONU should tune to the next viable channel (should be channel 2).	

I	Remarks
	• None

9.4.3 Protection Switching

A	Test Status	Refer to Section 6.
B	Reference Documents	ITU-T G.989.3 [7], Sections 11.3.3.15 and 18.
C	Test Objective	Verify the proper ONU behavior when protection channel is configured.
D	Test setup	As shown in Section **5.6**.
E	Pre-test conditions	1. The ONU should be reset to factory default settings. 2. Four TWDM channels should be active in the test environment. 3. Testing is performed with only a single ONU in the system.
F	Test Configuration	
	ONU Setup Parameters: • Upstream FEC: on • Primary TWDM Channel: 1 • Protection TWDM Channel: 3 • TO3: 5 seconds Subscriber Service provisioning: • S-VLAN: 101 (default service VLAN for testing) • C-VLAN: 1 (default service VLAN for testing) • Service Type: Data only • Data Rate: 1Gbps symmetrical • IGMP & other values: Default	
G	Test procedure	
X	User Action	Expected reaction and message timeline
1	Power-up the ONU and attach the PON fiber	1. ONU is at state O1.1 until downstream frame synchronization is attained. It then transitions to states O1.2 and 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.
2	Activate the ONU on Channel 1 with the configuration prescribed in F above.	1. ONU provisioning is applied on the ONU. 2. ONU transitions from default channel to channel 1.

3	Apply subscriber service provisioning.	1. Data traffic should pass to the test set. The test set should be able to measure total outage time.
4	Disable channel 1 by removing the fiber at the OLT.	1. The ONU should lose communication to OLT. By default, the ONU should wait 5 seconds before transitioning to a protection channel. **Note**: ONU protection behavior should have been provisioned to the ONU during activation process and does not rely on subscriber service provisioning. 2. After 5 seconds, the ONU should transition to its predefined protection channel (i.e. channel 3).
H	**Pass/fail criteria**	
	1. Upon failure, the ONU should wait the prescribed period of time (5 seconds) before tuning to the predefined channel. 2. Total outage time measured on the test set should be range 5 - 5.050 seconds or less.	
I	**Remarks**	
	• None	

9.4.4 Protection Channel Unavailable

A	**Test Status**	Refer to Section 6.
B	**Reference Documents**	ITU-T G.989.3 [7], Sections 11.3.3.15 and 18.
C	**Test Objective**	Verify the proper ONU behavior when protection channel is configured but is not available.
D	**Test setup**	As shown in Section **5.6**.
E	**Pre-test conditions**	1. The ONU should be reset to factory default settings. 2. Four TWDM channels should be active in the test environment. 3. Testing is performed with only a single ONU in the system. 4. All PLOAM channels should offer serial number grants in high frequency (1 per 100ms). 5. All TWDM channels should be configured to support service restoration for the ONU service under test. This allows the tester to validate the time it takes to restore service with the current testing configuration.
F	**Test Configuration**	
	ONU Setup Parameters: • Upstream FEC: on • Primary TWDM Channel: 1 • Protection TWDM Channel: 3 • TO3: 5 seconds • Protection Channel: Default	

	Subscriber Service provisioning: • S-VLAN: 101 (default service VLAN for testing) • C-VLAN: 1 (default service VLAN for testing) • Service Type: Data only • Data Rate: 1Gbps symmetrical • IGMP & other values: Default	
G	**Test procedure**	
	User Action	**Expected reaction and message timeline**
1	Power-up the ONU and attach the PON fiber	1. ONU is at state O1.1 until downstream frame synchronization is attained. It then transitions to states O1.2 and 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.
2	Activate the ONU on Channel 1 with the configuration prescribed in F above.	1. ONU provisioning is applied on the ONU. 2. ONU transitions from default channel to channel 1.
3	Apply subscriber service provisioning.	1. Data traffic should pass to the test set. The test set should be able to measure total outage time.
4	Disable channel 3 by disconnecting the Channel 3 fiber at the OLT.	1. Service should not be impacted on the ONU under test.
5	Disable channel 1 by removing the fiber at the OLT.	1. The ONU should lose communication to OLT. By default, the ONU should wait 5 seconds before transitioning to a protection channel. **Note**: ONU protection behavior should have been provisioned to the ONU during activation process and does not rely on subscriber service provisioning. 2. After 5 seconds, the ONU should transition to its predefined protection channel (i.e. channel 3), which is not present. 3. Upon discovering protection channel is missing, ONU should begin searching for alternative channel to restore on. 4. When connected to a new channel, the ONU should notify OLT of its presence and wait for instructions.
H	**Pass/fail criteria**	
	1. Upon failure, the ONU should wait the prescribed period of time (5 seconds) before transitioning to the protection channel. 2. ONU will begin a channel sweep when protection channel is found to not be present. Channel sweep will continue until the ONU discovers a viable channel. Service should be restored in no	

	less than 5 seconds.
I	**Remarks**
	• None

9.4.5 Protection Switching – Multiple ONUs

A	**Test Status**	Refer to Section 6.
B	**Reference Documents**	ITU-T G.989.3 [7], Sections 11.3.3.15 and 18.
C	**Test Objective**	Verify the proper ONU protection switching behavior when multiple ONUs are present and configured with different values.
D	**Test setup**	As shown in Section **5.6**.
E	**Pre-test conditions**	1. The ONUs should be reset to factory default settings. 2. Four TWDM channels should be active in the test environment. 3. Testing is performed with multiple ONU in the system.
F	**Test Configuration**	

ONU Setup Parameters:

Table 9-1 – ONU Setup Parameters

Parameter	ONU 1	ONU 2	ONU 3	ONU 4
Upstream FEC	On	On	On	On
Primary TWDM Channel	1	1	1	1
TO3	1 sec	1 sec	1 sec	1 sec
Protection TWDM Channel	Null	2	3	4

Subscriber Service provisioning:

Table 9-2 – Subscriber Service provisioning

Parameter	ONU 1	ONU 2	ONU 3	ONU 4
S-VLAN	101	101	101	101
C-VLAN	1	2	3	4
Service Type	Data	Data	Data	Data
Data Rate	1Gbps	1Gbps	1Gbps	1Gbps
Other Values	Default	Default	Default	Default

G	**Test procedure**

	User Action	Expected reaction and message timeline
1	Power-up and attach all ONUs to the PON fiber.	1. Each ONU is at state O1.1 until downstream frame synchronization is attained. It then transitions to states O1.2 and 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.
2	Activate each of the ONUs with the configuration prescribed in F above.	1. ONU provisioning is applied on the ONU. 2. ONUs transition from default channel to channel 1.
3	Apply subscriber service provisioning to all ONUs.	1. Data traffic should pass to the test set. The test set should be able to measure total outage time. This test can be performed with a single test set by repeating the test while monitoring a new ONU.
4	Disable channel 1 by disconnecting the fiber at the OLT.	1. The ONUs should lose communication to OLT. By default, each of the ONUs should wait 1 second before transitioning to a protection channel. 2. After 1 second, each ONU should transition to its predefined protection channel.
H	**Pass/fail criteria**	
	1. Upon failure, the ONU should wait the prescribed period of time (1 second) before searching for alternative channels. 2. Total outage time measured on the test set for ONUs 2-4 should be 1.050 seconds or less. Service on restoration for ONU 1 should take longer than 1 second with no pre-determined restoration time.	
I	**Remarks**	
	• None	

9.4.6 Protection Switching – Multiple ONUs, Different TO3 Values

A	**Test Status**	Refer to Section 6.
B	**Reference Documents**	ITU-T G.989.3 [7], Sections 11.3.3.15 and 18.
C	**Test Objective**	Verify the proper ONU protection switching behavior with multiple ONUs and varying TO3 values.
D	**Test setup**	As shown in Section **5.6**.
E	**Pre-test conditions**	1. The ONUs should be reset to factory default settings. 2. Four TWDM channels should be active in the test environment.

<table>
<tr><td></td><td></td><td>3. Testing is performed with multiple ONU in the system.</td></tr>
<tr><td>F</td><td colspan="2">Test Configuration</td></tr>
<tr><td></td><td colspan="2">ONU Setup Parameters:
Table 9-3 – ONU Setup Parameters
<table>
<tr><th>Parameter</th><th>ONU 1</th><th>ONU 2</th><th>ONU 3</th><th>ONU 4</th></tr>
<tr><td>Upstream FEC</td><td>On</td><td>On</td><td>On</td><td>On</td></tr>
<tr><td>Primary TWDM Channel</td><td>1</td><td>1</td><td>1</td><td>1</td></tr>
<tr><td>TO3</td><td>1 sec</td><td>5 sec</td><td>30 sec</td><td>1 min</td></tr>
<tr><td>Protection TWDM Channel</td><td>3</td><td>3</td><td>3</td><td>3</td></tr>
</table>
Subscriber Service provisioning:
Table 9-4 – Subscriber Service provisioning
<table>
<tr><th>Parameter</th><th>ONU 1</th><th>ONU 2</th><th>ONU 3</th><th>ONU 4</th></tr>
<tr><td>S-VLAN</td><td>101</td><td>101</td><td>101</td><td>101</td></tr>
<tr><td>C-VLAN</td><td>1</td><td>2</td><td>3</td><td>4</td></tr>
<tr><td>Service Type</td><td>Data</td><td>Data</td><td>Data</td><td>Data</td></tr>
<tr><td>Data Rate</td><td>1Gbps</td><td>1Gbps</td><td>1Gbps</td><td>1Gbps</td></tr>
<tr><td>Other Values</td><td>Default</td><td>Default</td><td>Default</td><td>Default</td></tr>
</table></td></tr>
<tr><td>G</td><td colspan="2">Test procedure</td></tr>
<tr><td></td><td>User Action</td><td>Expected reaction and message timeline</td></tr>
<tr><td>1</td><td>Power-up and attach all ONUs to the PON fiber.</td><td>1. Each ONU is at state O1.1 until downstream frame synchronization is attained. It then transitions to states O1.2 and 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.</td></tr>
<tr><td>2</td><td>Activate each of the ONUs with the configuration prescribed in F above.</td><td>1. ONU provisioning is applied on the ONU.
2. ONUs transition from default channel to channel 1.</td></tr>
<tr><td>3</td><td>Apply subscriber service provisioning to all ONUs.</td><td>1. Data traffic should pass to the test set. The test set should be able to measure total outage time. This test can be performed with a single test set by repeating the test while monitoring a new ONU.</td></tr>
</table>

4	Disable channel 1 by disconnecting the fiber at the OLT.	1. The ONUs should lose communication to OLT. By default, each of the ONUs should wait the prescribed period of time transitioning to a protection channel. 2. Then, each ONU should transition to its predefined protection channel (i.e. channel 3).
H	**Pass/fail criteria**	
	1. Upon failure, each of the ONUs should wait the prescribed period of time before transitioning to the protection channel or searching for alternative channels. 2. ONUs should be restored in the order of their TO3 values. Total outage time measured on the test set for ONUs 2-4 should correspond to their TO3 values. ONUs should restore within 50ms of their TO3 value.	
I	**Remarks**	
	• None	

9.5 System Misconfiguration Detection

9.5.1 Transmitter Parameter Mismatch

A	**Test Status**	Refer to Section 6.
B	**Reference Documents**	ITU-T G.989.3 [7], Section 11.3.3.13.
C	**Test Objective**	Verify that the ONU refuses operation in the channel when the specified upstream transmitter parameters do not match the ONUs capabilities. This test case can be executed on a single fixed channel pair.
D	**Test setup**	As shown in Section **5.6**. Two OLT CTs, single ONU.
E	**Pre-test conditions**	The OLT CTs powered up, connected to ODN. The cold ONU (CPI = 0000) powered up, disconnected from ODN.
F	**Test Configuration**	
	• OLT CT A periodically transmits System profile PLOAM message with the default parameters. • OLT CT A periodically transmits Channel profile PLOAM message with the default parameters and Channel Partition Index set to 0000. • OLT CT A periodically transmits Burst profile messages with the default parameters. • OLT CT B periodically transmits System profile PLOAM message with the default parameters. • OLT CT B periodically transmits Channel profile PLOAM message with the default parameters and Channel Partition Index set to 0000. • OLT CT B periodically transmits Burst profile messages with the default parameters. • The OLT CT offers In-band Serial number grants.	
G	**Test procedure**	
	User Action	**Expected reaction and message timeline**
1	Connect the ONU to the PON fiber; wait for activation to be completed.	An OLT CT discovers and activates the ONU. Without loss of generality, assume this is OLT CT A.
2	Disconnect the ONU; change the Channel Spacing parameter of the System_Profile message to an unsupported value; reconnect the ONU to the PON fiber; wait for activation to be completed.	ONU fails to activate. Urgent snapshot record made.

3	Disconnect the ONU; change the Upstream MSE parameter of the System_Profile message to an unsupported value; reconnect the ONU to the PON fiber; wait for activation to be completed.	ONU fails to activate. Urgent snapshot record made.
4	Disconnect the ONU; restore the default parameter of the System_Profile PLOAM.	OLT CT discovers and activates the ONU.
H	**Pass/fail criteria**	
	1. Step 1: ONU is activated successfully. 2. Step 2: ONU fails to activate, stops responding to serial number grants. 3. Step 3: ONU fails to activate, stops responding to serial number grants. 4. Step 4: ONU is activated successfully.	
I	**Remarks**	
	• None	

9.5.2 NG2SYS ID Mismatch

A	**Test Status**	Refer to Section 6.
B	**Reference Documents**	ITU-T G.989.3 [7], Section 11.3.3.13.
C	**Test Objective**	Verify that the ONU treats gracefully a situation with distinct NG2SYS IDs on an NG-PON2 system. This test case requires multiple channel pairs.
D	**Test setup**	As shown in Section **5.6**. Two OLT CTs, single ONU.
E	**Pre-test conditions**	The OLT CTs powered up, connected to ODN. The cold ONU (CPI = 0000) powered up, disconnected from ODN.
F	**Test Configuration**	
	• OLT CTs A and B periodically transmit System profile PLOAM message with the default parameters. • OLT CTs A and B periodically transmit Channel profile PLOAM message with the default parameters and Channel Partition Index set to 0000. • OLT CTs A and B periodically transmit Burst profile messages with the default parameters. • The OLT CTs offer In-band Serial number grants.	
G	**Test procedure**	
	User Action	**Expected reaction and message timeline**
1	Connect the ONU to the PON fiber; wait for activation to be completed.	An OLT CT discovers and activates the ONU. Without loss of generality, assume this is OLT CT A.
2	Disconnect the ONU; change the NG2SYS ID parameter of the System_Profile message sent by OLT CT A to a different value; reconnect the ONU to the PON fiber; wait for activation to be completed.	ONU activates successfully. Urgent snapshot record made.
H	**Pass/fail criteria**	
	1. Step 1: ONU is activated successfully. 2. Step 2: ONU is activated successfully; makes a record of different NG2SYS IDs on the same NG-PON2 system.	
I	**Remarks**	
	• None	

9.5.3 PON-ID Mismatch – In Channel

A	**Test Status**	Refer to Section 6.
B	**Reference Documents**	ITU-T G.989.3 [7], Sections 10.1.1.1, 11.3.3.13.
C	**Test Objective**	Verify that the ONU refuses operation in a channel with PON-ID in the PSBd structure not matching the PON_ID in the Channel_profile PLOAM message for this channel. This test case can be executed on a single fixed channel pair.
D	**Test setup**	As shown in Section **5.6**. Two OLT CTs, single ONU.
E	**Pre-test conditions**	The OLT CTs powered up, connected to ODN. The cold ONU (CPI = 0000) powered up, disconnected from ODN.
F	**Test Configuration**	
	• OLT CTs A and B periodically transmit System profile PLOAM message with default parameters. • OLT CTs A and B periodically transmit Channel profile PLOAM message with the default parameters and Channel Partition Index set to 0000. • OLT CTs A and B periodically transmit Burst profile messages with the default parameters. • The OLT CTs offer In-band Serial number grants.	
G	**Test procedure**	
	User Action	**Expected reaction and message timeline**
1	Connect the ONU to the PON fiber; wait for activation to be completed.	An OLT CT discovers and activates the ONU. Without loss of generality, assume this is OLT CT A.
2	Disconnect the ONU; change the Administrative label sent within then PSBd so that it differs from the Administrative label of System_Profile message for the same channel. Reconnect the ONU to the PON fiber; wait for activation to be completed.	ONU fails to activate. Urgent snapshot record made.
H	**Pass/fail criteria**	
	1. Step 1: ONU is activated successfully. 2. Step 2: ONU fails to activate, stops responding to serial number grants.	
I	**Remarks**	
	• None	

9.5.4 PON-ID Mismatch – Cross Channel

A	**Test Status**	Refer to Section 6.
B	**Reference Documents**	ITU-T G.989.3 [7], Sections 10.1.1.1, 11.3.3.13.
C	**Test Objective**	Verify that the ONU treats gracefully the situation when the PON-ID of another channel pair does not match the PON-ID of that channel reported within a Channel_Profile message. This test case requires multiple channel pairs.
D	**Test setup**	As shown in Section **5.6**. Two OLT CTs, single ONU.
E	**Pre-test conditions**	The OLT CTs powered up, connected to ODN. The cold ONU (CPI = 0000) powered up, disconnected from ODN.
F	**Test Configuration**	
	• OLT CTs A and B periodically transmit System profile PLOAM message with the default parameters. • OLT CTs A and B periodically transmit Channel profile PLOAM message with the default parameters and Channel Partition Index set to 0000. • OLT CTs A and B periodically transmit Burst profile messages with the default parameters. • The OLT CTs offer In-band Serial number grants.	
G	**Test procedure**	
	User Action	**Expected reaction and message timeline**
1	Connect the ONU to the PON fiber; wait for activation to be completed.	An OLT CT discovers and activates the ONU. Without loss of generality, assume this is OLT CT A.
2	Disconnect the ONU; change the Administrative label sent within the PSBd and block configuration information sharing by the OLT CTs. Reconnect the ONU to the PON fiber; wait for activation to be completed.	ONU activates successfully. Urgent snapshot record made.
H	**Pass/fail criteria**	
	1. Step 1: ONU is activated successfully. 2. Step 2: ONU is activated successfully; makes a record of PON-IDs mismatch.	
I	**Remarks**	
	• None	

9.6 Auxiliary Management and Control Channel (AMCC)

This section intentionally left blank (for further study).

End of Broadband Forum Technical Report TR-426