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GROUP SPECIFICATION

Fifth Generation Fixed Network (F5G); Test Specification for 50G-PON Functionality and Performance

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Foreword

This Group Specification (GS) has been produced by ETSI Industry Specification Group (ISG) Fifth Generation Fixed Network (F5G).

Modal verbs terminology

In the present document "**shall**", "**shall not**", "**should**", "**should not**", "**may**", "**need not**", "**will**", "**will not**", "**can**" and "**cannot**" are to be interpreted as described in clause 3.2 of the ETSI Drafting Rules (Verbal forms for the expression of provisions).

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1 Scope

The present document specifies the testing methodology and criteria of the functionality and performance of 50G TDM PON as specified in Recommendation ITU-T G.9804.x series [3], [4] and [5]. Relevant standards of the Broadband Forum (BBF) are referenced or extended.

2 References

2.1 Normative references

References are either specific (identified by date of publication and/or edition number or version number) or non-specific. For specific references, only the cited version applies. For non-specific references, the latest version of the referenced document (including any amendments) applies.

Referenced documents which are not found to be publicly available in the expected location might be found in the ETSI docbox.

NOTE: While any hyperlinks included in this clause were valid at the time of publication, ETSI cannot guarantee their long-term validity.

The following referenced documents are necessary for the application of the present document.

[1] Recommendation ITU-T G.984.2 (2019): "Gigabit-capable Passive Optical Networks (G-PON): Physical Media Dependent (PMD) layer specification".

[2] Recommendation ITU-T G.987.2 (2023) Amd.2: "10-Gigabit-capable passive optical networks (XG-PON): Physical media dependent (PMD) layer specification".

[3] Recommendation ITU-T G.9804.1 (2019) Amd.2: "Higher speed passive optical networks – Requirements".

[4] Recommendation ITU-T G.9804.2 (2021) Amd.2: "Higher speed passive optical networks – Common transmission convergence layer specification".

[5] Recommendation ITU-T G.9804.3 (2021) Amd.2: "50-Gigabit-capable passive optical networks (50G-PON): Physical media dependent (PMD) layer specification".

[6] Recommendation ITU-T G.9807.1 (2023) Amd.1: "10-Gigabit-capable symmetric passive optical network (XGS-PON)".

[7] Recommendation ITU-T G.652 (08/2024): "Characteristics of a single-mode optical fibre and cable".

[8] Recommendation ITU-T G.657 (08/2024): "Characteristics of a bending-loss insensitive single-mode optical fibre and cable".

[9] IEEE 802.3ah-2004™: "IEEE Standard for Information technology-- Local and metropolitan area networks-- Part 3: CSMA/CD Access Method and Physical Layer Specifications Amendment: Media Access Control Parameters, Physical Layers, and Management Parameters for Subscriber Access Networks".

[10] IEEE 802.3av-2009™: "IEEE Standard for Information technology - Telecommunications and information exchange between systems - Local and metropolitan area networks - Specific requirements Part 3: Carrier Sense Multiple Access with Collision Detection (CSMA/CD) Access Method and Physical Layer Specifications Amendment 1: Physical Layer Specifications and Management Parameters for 10 Gb/s Passive Optical Networks".

[11] BBF TR-423 (August 2025 - Issue 3): "PON PMD Layer Conformance Test Plan".

[12] BBF TP-255 (Issue 2): "G-PON & XG-PON & XGS-PON Interoperability Test Plan".

2.2 Informative references

References are either specific (identified by date of publication and/or edition number or version number) or non-specific. For specific references, only the cited version applies. For non-specific references, the latest version of the referenced document (including any amendments) applies.

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The following referenced documents may be useful in implementing an ETSI deliverable or add to the reader's understanding, but are not required for conformance to the present document.

Not applicable.

3 Definition of terms, symbols and abbreviations

3.1 Terms

For the purposes of the present document, the following terms apply:

Dynamic Bandwidth Assignment (**DBA):** process by which the Optical Line Terminal (OLT) distributes upstream Passive Optical Network (PON) capacity between the traffic-bearing entities within Optical Network Units (ONUs), based on the dynamic indication of their traffic activity and their configured traffic contracts

ODN Optical Path Loss class (ODN class): categorization of an Optical Distribution Network (ODN) based on the predefined values of minimum and maximum optical path loss over all possible paths between the S/R [or S/Rm] and any of the R/S reference points and over all possible operating wavelengths of a specific PON system

Optical Distribution Network (ODN): Optical Distribution Network including the fibres, splitters and connectors

Optical Modulation Amplitude (OMA): absolute difference between the optical power of a logic one level and the optical power of a logic zero level

Optical Path Penalty (OPP): apparent degradation of receiver sensitivity due to impairments from fibre transmission and apparent increase in ODN loss due to Raman depletion. The optical path penalty accounts for the effects of reflections, inter-symbol interference, mode partition noise, fibre dispersion, and fibre non-linearities

Transmission Container (T-CONT): traffic-bearing object within an Optical Network Unit (ONU) that represents a group of logical connections, is managed via the ONU Management and Control Channel (OMCC), and, through its TC layer Alloc-ID, is treated as a single entity for the purpose of upstream bandwidth assignment on the Passive Optical Network (PON)

Transmitter and Dispersion Eye Closure (TDEC): TDEC is an optical transmitter quality metric derived using histograms extracted from the eye diagram

NOTE: The optical transmitter is measured using a waveform monitoring device in a set-up that emulates the worst-case channel, including fibre, reference receiver and equalizer.

3.2 Symbols

Void.

3.3 Abbreviations

For the purposes of the present document, the following abbreviations apply:

50G-PON 50 Gbit/s Passive Optical Network

CEx	Coexistence Element Type

NOTE: x(x = 1, 2, etc.).

DAW	Dedicated Activation Wavelength
DBA	Dynamic Bandwidth Assignment
DFB	Distributed Feedback
DUT	Device Under Test
EMS	Element Management System
EPON	Ethernet Passive Optical Network
FEC	Forward Error Correction
FP	Fabry-Perot
GE	Gigabit Ethernet
GPON	Gigabit Passive Optical Network
ID	IDentifier
IP	Internet Protocol
MAC	Media Access Control
MPM	Multi-PON Module
ODN	Optical Distribution Network
OLT	Optical Line Terminal
OMA	Optical Modulation Amplitude
OMCC	OMCI Communications Channel
ONU	Optical Network Unit
OPP	Optical Path Penalty
PON	Passive Optical Network
QoS	Quality of Service
SMSR	Side-Mode Suppression Ratio
SPM	Single-PON Module
TC	Transmission Convergence
T-CONT	Transmission Container
TDEC	Transmission and Dispersion Eye Closure
TDM	Time-Division Multiplexing
VLAN	Virtual Local Area Network
WDM	Wavelength Division Multiplexer
X/S	Crosstalk to Signal Ratio
XG	10-Gigabit
XG-PON	10-Gigabit-capable Passive Optical Network
XGS-PON	10-Gigabit-capable Symmetric Passive Optical Network

4 Test equipment and fibre requirement

4.1 Test equipment

The functions and requirements of the instruments used in testing are shown in Table 1.

Table 1: Test Equipment Functions and Requirements

Equipment	Function	Requirements
Optical Power Meter	Measures the optical power of optical transmitters or optical networks.	• Insertion loss: < 2,0 dB • Measurement accuracy: ≤ 0,1 dB
Network Analyzer	Transmits and receives Ethernet data packets, and performs statistical analysis of results.	• Each port shall be capable of transmitting more than 16 k independent streams and receiving/analysing 64 k independent streams • Able to arbitrarily configure the template for each stream (including bandwidth, frame size, and frame content)
Optical Attenuator	Provides adjustable attenuation of optical signals. Used for testing receiver sensitivity, receiver overload optical power, FEC functionality, etc.	• Insertion loss: < 2,0 dB • Adjustment accuracy: ≤ 0,1 dB • Wavelength range shall cover: – 1 260 nm ~ 1 310 nm – 1 340 nm ~ 1 344 nm – 1 560 nm ~ 1 581 nm
Oscilloscope	Tests the waveform characteristics of optical transmitter signals. Used for testing transmitter eye diagrams and extinction ratio.	• Wavelength range shall cover: 1 260 nm~1 310 nm, 1 340 nm~1 344 nm, 1 560 nm~1 581 nm • For test cases such as transmitter eye diagram and TDEC, shall be equipped with corresponding optical-to-electrical converter, fourth-order Bessel-Thomson filter, reference equalizer, and result analysis modules
Optical Spectrum Analyzer / Optical Wavelength Meter	Tests the optical spectrum of optical transmitters. Used for testing transmit wavelength and side mode suppression ratio.	• Wavelength accuracy: ±0,05 nm • Wavelength range shall cover: – 1 260 nm ~ 1 310 nm – 1 340 nm ~ 1 344 nm – 1 560 nm~1 581 nm • Supports testing and data acquisition for both FP lasers and DFB lasers

Other equipment requirements for BBF tests refer to BBF TR-423 [11].

4.2 Fibre requirement

Test procedures in the present document shall use the fibre described in Recommendation ITU-T G.652 [7]. Other fibre types may be compatible with these test procedures, e.g. Recommendation ITU-T G.657 [8].

5 PON interface test cases

5.1 OLT interface test cases

5.1.1 SPM: Optical parameter test cases

5.1.1.1 OLT transmit power of 49,7664 Gbit/s downstream direction test

This test case shall be performed as described in BBF TR-423 [11], section 8.2.1.

5.1.1.2 OLT SMSR test

This test case shall be performed as described in BBF TR-423 [11], section 8.2.7.

5.1.1.3 OLT transmitter wavelength of 49,7664 Gbit/s downstream direction test

This test case shall be performed as described in BBF TR-423 [11], section 8.2.6.

5.1.1.4 OLT transmit optical waveform (eye diagram)

This test case shall be performed as described in BBF TR-423 [11], section 8.2.4.

5.1.1.5 OLT extinction ratio test

This test case shall be performed as described in BBF TR-423 [11], section 8.2.6.

5.1.1.6 OLT receive sensitivity test

5.1.1.6.1 Test purpose

Verify that the OLT SPM PON interface receive sensitivity complies with the requirements of Recommendation ITU-T G.9804.3 [5].

5.1.1.6.2 Test configuration

For the receive sensitivity test of 24,8832 Gbit/s upstream direction, the configuration requirements for parameters such as the bit error rate reference threshold and transmitter extinction ratio shall comply with the requirements of Recommendation ITU-T G.9804.3 [5], Table 9-7.

For the receive sensitivity test of 49,7664 Gbit/s upstream direction, the configuration requirements for parameters such as the bit error rate reference threshold and transmitter extinction ratio shall comply with the requirements of Recommendation ITU-T G.9804.3 [5], Table 9-8.

Figure 1 shows the configuration of the test.

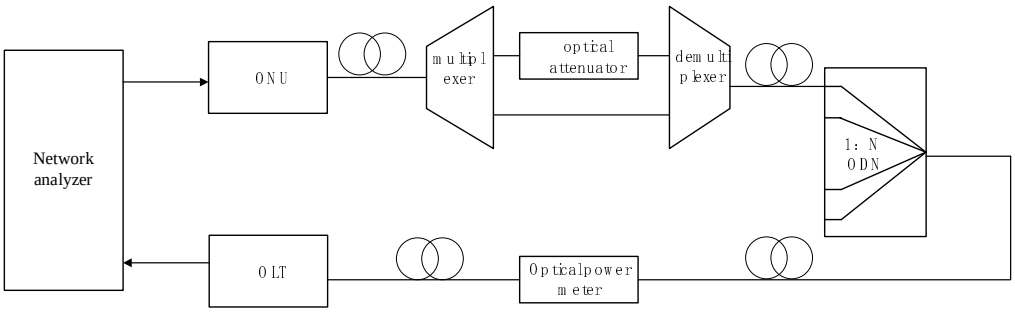

Figure 1: OLT transmitter receive sensitivity test environment

5.1.1.6.3 Test procedure

The test procedure shall be as follows:

1) Connect the optical paths between the equipment under test and the test instrument according to Figure 1, with upstream FEC enabled (the multiplexer/demultiplexer in Figure 1 is used to separate upstream and downstream wavelengths).

2) Send the test traffic from the network analyser to the ONU port.

3) Adjust the optical attenuator to gradually increase the attenuation until packet loss is detected by the network analyser, then slightly reduce the attenuation until packet loss disappears.

4) Measure the OLT PON interface received optical power.

5) Calculate the OMA sensitivity according to Appendix 1 of Recommendation ITU-T G.9804.3 [5], by combining the average transmitted optical power tested in section 5.1.1.1 and the extinction ratio tested in section 5.1.1.5.

5.1.1.6.4 Expected results

In step 4), the OLT PON interface receive sensitivity shall be within the requirements defined in Recommendation ITU-T G.9804.3 [5], Table 9-7 (for 24,8832 Gbit/s upstream direction) and Table 9-8 (for 49,7664 Gbit/s upstream direction).

In step 5), the OLT PON interface OMA sensitivity shall be within the requirements defined in Recommendation ITU-T G.9804.3 [5], Table 9-5 (for 49,7664 Gbit/s upstream direction).

5.1.1.7 OLT receive overload test

Take reference from BBF TR-423 [11], section 8.2.5.

5.1.1.8 OLT transmit optical waveform (TDEC) test

5.1.1.8.1 Test purpose

Verify that the OLT optical Transmitter and Dispersion Eye Closure (TDEC) complies with the requirements defined in the respective Recommendation ITU-T G.9804.3 [5] document.

5.1.1.8.2 Test configuration

Figure 2 shows the configuration of the test.

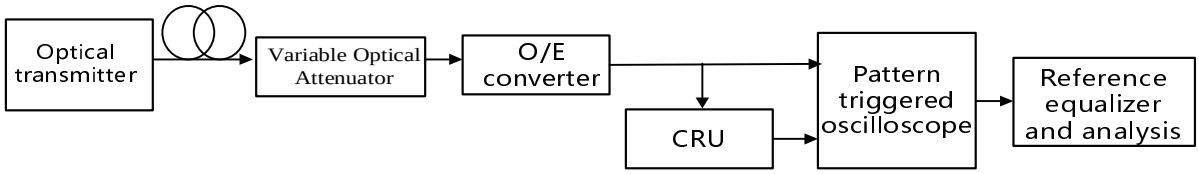

Figure 2: PON interface TDEC test environment

5.1.1.8.3 Test procedure

The test procedure shall be as follows:

1) Connect the test environment according to Figure 2. The setup of the oscilloscope is shown in Recommendation ITU-T G.9804.3 [5], section 9.2.7.8.

2) Insert a 20 km fibre between the OLT optical transmitter and the variable optical attenuator, adjusting the attenuator so that the output optical power is within the required range of the oscilloscope.

3) Measure the TDEC parameter of the 50G-PON OLT's PON interface under the condition of the 20 km fibre connected.

4) Insert a fibre not longer than 2 m between the OLT optical transmitter and the variable optical attenuator, adjusting the attenuator so that the output optical power is within the required range of the oscilloscope.

5) Measure the TDEC parameter of the 50G-PON OLT's PON interface under the condition of the 2 m fibre connected.

5.1.1.8.4 Expected results

In step 3) and step 5), The TDEC will pass if the result is within the requirements defined in Recommendation ITU-T G.9804.3 [5], Figure 9-5.

5.1.2 MPM: Optical parameter test cases

5.1.2.1 OLT transmit power

5.1.2.1.1 Test purpose

Verify that the OLT MPM PON optical interface transmit power shall be complies with the requirements of Recommendations ITU-T G.984.2 [1], G.987.2 [2], G.9807.1 [6] G.9804.3 [5], IEEE 802.3ah [9], and IEEE 802.3av [10].

5.1.2.1.2 Test configuration

This test case shall be performed as described in BBF TR-423 [11], section 8.2.1.

5.1.2.1.3 Test procedure

1) Insert PON power meter using fibre jumper between OLT and optical splitter; at OLT end. The jumper shall be between OLT and meter.

2) Record downstream power reading:

   2.1) When MPM module is used for connecting with the GPON ONU, verify the Mean Channel Launch Power is between levels indicated in Recommendation ITU-T G.984.2 [1] for specified ODN Class.

   2.2) When MPM module is used for connecting with the XG-PON ONU, verify the Mean Channel Launch Power is between levels indicated in Recommendation ITU-T G.987.2 [2] for specified ODN Class.

   2.3) When MPM module is used for connecting with the XGS-PON ONU, verify the Mean Channel Launch Power is between levels indicated in Recommendation ITU-T G.9807.1 [6] for specified ODN Class.

   2.4) When MPM module is used for connecting with the 50G-TDM-PON ONU, verify the Mean Channel Launch Power is between levels indicated in Recommendation ITU-T G.9804.3 [5] for specified ODN Class.

   2.5) When MPM module is used for connecting with the EPON series ONU, verify the Mean Channel Launch Power is between levels indicated in IEEE 802.3ah [9], and IEEE 802.3av [10] for specified ODN Class.

   2.6) When MPM module is used for connecting with the 10G-EPON series ONU, verify the Mean Channel Launch Power is between levels indicated in IEEE 802.3av [10] for specified ODN Class.

5.1.2.1.4 Expected results

In step 2), when MPM module is used for connecting the GPON series ONU, the Mean Channel Launch Power shall be between levels indicated in Recommendations ITU-T G.984.2 [1], G.987.2 [2], G.9807.1 [6] and G.9804.3 [5] for specified ODN Class.

In step 2), when MPM module is used for connecting the EPON series ONU, the Mean Channel Launch Power shall be between levels indicated in IEEE 802.3ah [9] and IEEE 802.3av [10] for specified ODN Class.

5.1.2.2 OLT transmitter wavelength

5.1.2.2.1 Test purpose

Verify that the OLT MPM PON optical interface transmitter wavelength shall be complies with the requirements of ITU-T G.984.2 [1], ITU-T G.987 [2], G.9807.1 [6], G.9804.3 [5], IEEE 802.3ah [9] and IEEE 802.3av [10].

5.1.2.2.2 Test configuration

This test case shall be performed as described in BBF TR-423 [11], section 8.2.6.

5.1.2.2.3 Test procedure

This test case shall be performed as described in BBF TR-423 3 [11], section 8.2.6.

5.1.2.2.4 Expected results

When MPM module is used for connecting with the GPON series ONU:

- For GPON: The OLT will pass if all the results are within the requirements defined in Recommendation ITU-T G.984.2 [1], Table 2c-2 Operating wavelength.
- For XG-PON: The OLT will pass if all the results are within the requirements defined in Recommendation ITU-T G.987.2 [2], Table 9-3 Operating wavelength.
- For XGS-PON: The OLT will pass if all the results are within the requirements defined in Recommendation ITU-T G.9807.1 [6], Table B.9-3 Operating wavelength.
- For 50G-TDM-PON: The OLT will pass if all the results are within the requirements defined in Recommendation ITU-T G.9804.3 [5], Table 9-7 Operating wavelength.

When MPM module is used for connecting with the EPON series ONU:

- For EPON: The OLT will pass if all the results are within the requirements defined in IEEE 802.3ah [9], Table 60-1.
- For 10G-EPON: The OLT will pass if all the results are within the requirements defined in IEEE 802.3av [10], Table 75-1.
- For 50G-TDM-PON: The OLT will pass if all the results are within the requirements defined in Recommendation ITU-T G.9804.3 [5], Table 9-7 Operating wavelength.

5.1.2.3 OLT transmit optical waveform (eye diagram)

5.1.2.3.1 Test Purpose

To test the transmitter eye diagram of the PON interface on the OLT service board (using MPM with built-in WDM function).

5.1.2.3.2 Test Configuration

The test configuration is shown in Figure 3.

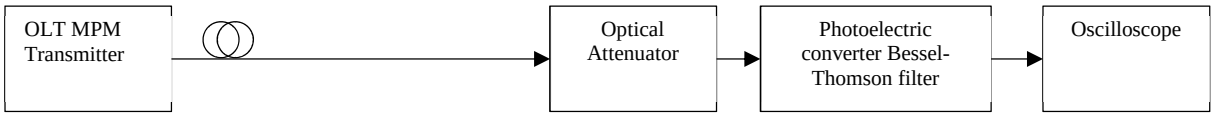

Figure 3: OLT Transmitter Eye Diagram Test Configuration

5.1.2.3.3 Test Procedure

1) Establish the test configuration as shown in Figure 3. Enable MPM module multi-channel, use a short fibre patch cord less than 2 m to connect devices under the test, the test equipment and the optical attenuator.
2) Carefully increase the attenuation keeping the photoelectric converter/optical power level within specified operational range.
3) Adjust the oscilloscope, select the corresponding template according to the line rate, and manually adjust or use the instrument to automatically align the waveform to achieve the optimal position between the waveform and the eye pattern template.
4) Check the eye diagram in the oscilloscope.

5.1.2.3.4 Expected Results

In step 4) for 50G-PON OLT coexisting with GPON systems:

- For GPON: GPON meets the requirements specified in Figure 2 and Table 2b of Recommendation ITU-T G.984.2 [1].
- For XG/XGS-PON: XG/XGS-PON meets the requirements specified in Table 9-5, Figure 9-2 of Recommendation ITU-T G.987.2 [2] and Table B.9-5 of Recommendation ITU-T G.9807.1 [6].
- For 50G-PON: 50G-PON meets the requirements specified in Figure 9-3, Table 9-9, and Figure 9-7 of Recommendation ITU-T G.9804.3 [5].

In step 4) for 50G-PON OLT coexisting with EPON systems:

- For EPON: EPON meets the requirements specified in Table 58-3, Table 58-5, and Figure 58-5 of IEEE 802.3ah [9].
- For 10G-EPON: 10G-EPON meets the requirements of IEEE 802.3av [10].
- For 50G-PON: 50G-PON meets the requirements specified in Figure 9-3, Table 9-9, and Figure 9-7 of Recommendation ITU-T G.9804.3 [5].

5.1.2.4 OLT extinction ratio test

5.1.2.4.1 Test purpose

Verify that the OLT MPM PON port extinction ratio complies with the requirements of Recommendations ITU-T G.984.2 [1], G.987.2 [2], G.9807.1 [6], G.9804.3 [5], IEEE 802.3ah [9], and IEEE 802.3av [10].

5.1.2.4.2 Test configuration

This test case shall be performed as described in BBF TR-423 [11], section 8.2.2.

5.1.2.4.3 Test procedure

This test case shall be performed as described in BBF TR-423 [11], section 8.2.2.

5.1.2.4.4 Expected results

The expected result depends on the test scenario (MPM module) and therefore one of the following results shall be met:

- For GPON, XG-PON and 50G-PON channel, the OLT PON port extinction ratio value will pass if the results are within the requirements defined in Recommendations ITU-T G.984.2 [1], G.987.2 [2], G.9807.1 [6], G.9804.3 [5].
- For EPON, 10G-EPON and 50G-PON channel, the OLT PON port extinction ratio value will pass if the results are within the requirements defined in IEEE 802.3ah [9], IEEE 802.3av [10] and Recommendation ITU-T G.9804.3 [5].

5.1.2.5 OLT SMSR test

5.1.2.5.1 Test purpose

Verify that the OLT PON interface minimum side mode suppression ratio shall be complying with the requirements defined in the Recommendations ITU-T G.984.2 [1], G.987.2 [2], G.9807.1 [6], G.9804.3 [5] and IEEE 802.3av [10].

5.1.2.5.2 Test configuration

This test case shall be performed as described in BBF TR-423 [11], section 8.2.7.

5.1.2.5.3 Test procedure

This test case shall be performed as described in BBF TR-423 [11], section 8.2.7.

5.1.2.5.4 Expected results

When MPM module is used for connecting with the GPON series ONU:

- For GPON: The OLT will pass if all the results are within the requirements defined in Recommendation ITU-T G.984.2 [1], Table 2c-2 Minimum side mode suppression ratio.
- For XG-PON: The OLT will pass if all the results are within the requirements defined in Recommendation ITU-T G.987.2 [2], Table 9-3. Minimum side mode suppression ratio.
- For XGS-PON: The OLT will pass if all the results are within the requirements defined in Recommendation ITU-T G.9807.1 [6], Table B.9-3 Minimum side mode suppression ratio.
- For 50G-TDM-PON: The OLT will pass if all the results are within the requirements defined in Recommendation ITU-T G.9804.3 [5], Table 9-7 Minimum side mode suppression ratio.

When MPM module is used for connecting with the EPON series ONU:

- For 10G-EPON: The OLT will pass if all the results are within the requirements defined in IEEE 802.3av [10], Table 91-5 Minimum side mode suppression ratio.
- For 50G-TDM-PON: The OLT will pass if all the results are within the requirements defined in Recommendation ITU-T G.9804.3 [5], Table 9-7 Minimum side mode suppression ratio.

5.1.2.6 OLT receive sensitivity test

5.1.2.6.1 Test purpose

Verify that the OLT MPM receiver meets sensitivity requirements complied with the requirements of relevant ITU-T and IEEE standard.

5.1.2.6.2 Test configuration

For the receive sensitivity test of 24,8832 Gbit/s upstream direction, the configuration requirements for parameters such as the bit error rate reference threshold and transmitter extinction ratio shall comply with the requirements of Recommendation ITU-T G.9804.3 [5], Table 9-7.

For the receive sensitivity test of 49,7664 Gbit/s upstream direction, the configuration requirements for parameters such as the bit error rate reference threshold and transmitter extinction ratio shall comply with the requirements of Recommendation ITU-T G.9804.3 [5], Table 9-8.

Figure 4 shows the configuration of the test.

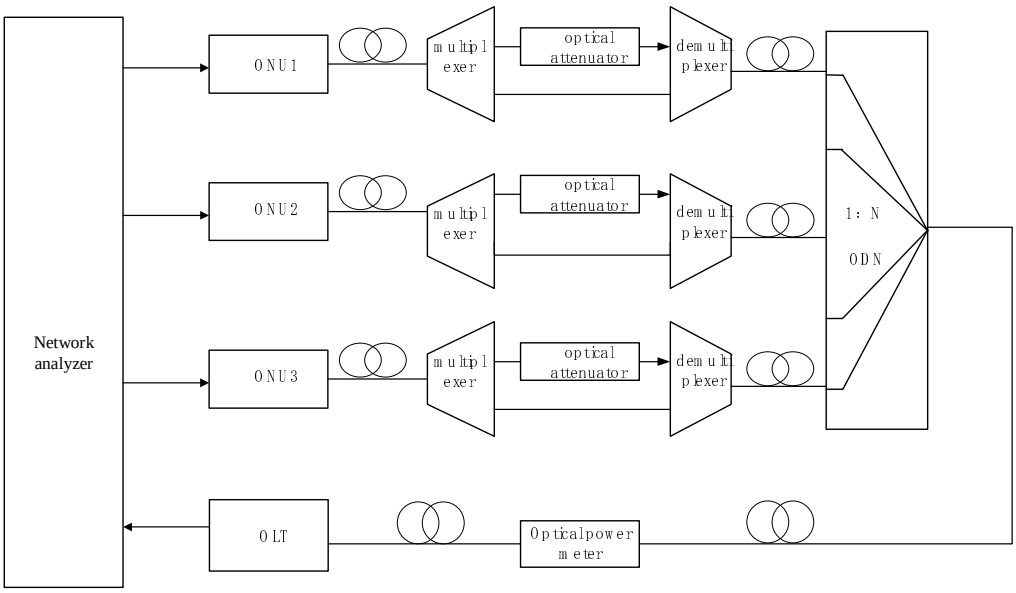

Figure 4: OLT transmitter receive sensitivity test environment

5.1.2.6.3 Test procedure

The test procedure shall be as follows:

1) Connect the optical paths between the equipment under test and the test instrument according to Figure 4, with upstream FEC enabled (the multiplexer/demultiplexer in Figure 4 is used to separate upstream and downstream wavelengths), ONUs are connected to the ODN and activated by the OLT. ONU1 is a 50G-PON ONU with 24,8832 Gbit/s in the upstream direction or 49,7664 Gbit/s in the upstream direction, ONU2 is working in GPON/EPON (narrowband with upstream a wavelength range of 1 260 nm ~ 1 280nm) mode and ONU3 is working in XG(s)-PON/10G-EPON mode. The power meter shall support burst signal measurement.

2) Send the test traffic from the network analyser to the ONU port.

3) Power on ONU1, power off ONU2 and ONU3.

4) Adjust the optical attenuator to gradually increase the attenuation until packet loss is detected by the network analyser, then slightly reduce the attenuation until packet loss disappears.

5) Measure the OLT PON interface received optical power in 50G-PON mode.

6) Calculate the OMA sensitivity according to Appendix 1 of Recommendation ITU-T G.9804.3 [5], by combining the average transmitted optical power tested in section 5.1.1.1 and the extinction ratio tested in section 5.1.1.3.

7) Power on ONU2 and ONU3 sequentially, while power off the other two ONUs.

8) Adjust the optical attenuator to gradually increase the attenuation until packet loss is detected by the network analyser, then slightly reduce the attenuation until packet loss disappears.

9) Measure the OLT PON interface received optical power when each of the other two modes operates individually.

10) Power on all the ONUs which including GPON, XG(s)PON and 50G-PON or EPON, 10G-EPON and 50G-PON.

11) Adjust the optical attenuator in each channel to gradually increase the attenuation until packet loss is detected by the network analyser, then slightly reduce the attenuation until packet loss disappears.

12) Measure the OLT PON interface received optical power when operating in all modes simultaneously.

5.1.2.6.4 Expected results

In step 5), the OLT PON interface receive sensitivity shall be within the requirements defined in ITU-T G.9804.3 [5], Table 9-7 (for 24,8832 Gbit/s upstream direction) and Table 9-8 (for 49,7664 Gbit/s upstream direction).

In step 6), the OLT PON interface OMA sensitivity shall be within the requirements defined in ITU-T G.9804.3 [5], Table 9-5 (for 49,7664 Gbit/s upstream direction).

In step 9), the OLT PON interface receive sensitivity shall be within the requirements defined in Recommendation ITU-T G.984.2 [1], Table 2c-2 for GPON ONU, Recommendation ITU-T G.987.2 [2], Table 9-3 for XG-PON ONU, Recommendation ITU-T G.9807.1 [6], Table B.9-3 for XG(s)-PON ONU, IEEE 802.3ah [9], Table 60-1 for EPON ONU and IEEE 802.3av [10], Table 75-1 for 10G-EPON ONU.

In step 12), the OLT PON interface receive sensitivity shall be all within the requirements defined in relevant ITU-T and IEEE standard.

5.1.2.7 OLT receive overload test

5.1.2.7.1 Test purpose

Verify that the OLT MPM receiver meets overload requirements defined in Recommendation ITU-T G.9804.3 [5] for optical path loss class.

5.1.2.7.2 Test configuration

Figure 4 shows the configuration of the test.

5.1.2.7.3 Test procedure

The test procedure shall be as follows:

1) Connect the optical paths between the equipment under test and the test instrument according to Figure 4, with upstream FEC enabled (the multiplexer/demultiplexer in Figure 4 is used to separate upstream and downstream wavelengths), ONUs are connected to the ODN and activated by the OLT. ONU1 is a 50G-PON ONU with 24,8832 Gbit/s upstream direction or 49,7664 Gbit/s upstream direction, ONU2 is working in GPON/EPON (narrowband with upstream wavelength range 1 260 nm ~ 1 280 nm) mode and ONU3 is working in XG(s)-PON/10G-EPON mode. The power meter shall support burst signal measurement.

2) Send the test traffic from the network analyser to the ONU port.

3) Power on ONU1, while power off ONU2 and ONU3.

4) Adjust the optical attenuator to gradually decrease the attenuation until packet loss is detected by the network analyser, then slightly reduce the attenuation until packet loss disappears. If the optical power meets the overload requirements of Recommendation ITU-T G.9804.3 [5] before packet loss occurs, there is no need to adjust the attenuation value of the optical attenuator.

5) Measure the OLT PON interface received optical power for ONU1.

6) Power on ONU2, while power off the other two ONUs.

7) Adjust the optical attenuator to gradually decrease the attenuation until packet loss is detected by the network analyser, then slightly reduce the attenuation until packet loss disappears. Before packet loss occurs, if the optical power meets the overload requirements of Recommendation ITU-T G.984.2 [1] for GPON, IEEE 802.3ah [9] for EPON, there is no need to adjust the attenuation value of the optical attenuator.

8) Measure the OLT PON interface received optical power.

9) Power on ONU3, while power off the other two ONUs.

10) Adjust the optical attenuator to gradually decrease the attenuation until packet loss is detected by the network analyser, then slightly reduce the attenuation until packet loss disappears. Before packet loss occurs, if the optical power meets the overload requirements of Recommendation ITU-T G.987.2 [2] and Recommendation ITU-T G.9807.1 [6] for XG(s)-PON ONU, IEEE 802.3av [10] for 10G-EPON ONU, there is no need to adjust the attenuation value of the optical attenuator.

11) Measure the OLT PON interface received optical power.

12) Power on all ONUs which including GPON, XG(s)PON and 50G-PON or EPON (narrowband with upstream wavelength range 1 260 nm ~ 1 280 nm), 10G-EPON and 50G-PON.

13) Adjust each optical attenuator to gradually decrease the attenuation until packet loss is detected by the network analyser in each traffic channel of ONUs, then slightly reduce the attenuation until packet loss of each traffic channel disappears. Before packet loss occurs, if the optical power meets the overload requirements of relevant ITU-T and IEEE standard.

14) Measure the OLT PON interface received overload power when operating in all modes simultaneously.

5.1.2.7.4 Expected results

In step 5), OLT PON receiver overload power shall be within the requirements defined in Recommendation ITU-T G.9804.3 [5], Table 9-7 (for 24,8832 Gbit/s upstream direction) and Table 9-8 (for 49,7664 Gbit/s upstream direction).

In step 8), OLT PON receiver overload power shall be within the requirements defined in Recommendation ITU-T G.984.2 [1], Table 2c-2 for GPON ONU, IEEE 802.3ah [9], Table 60-1 for EPON ONU.

In step 11), OLT PON receiver overload power shall be within the requirements defined in Recommendation ITU-T G.987.2 [2], Table 9-3 for XG-PON ONU, Recommendation ITU-T G.9807.1 [6], Table B.9-3 for XG(s)-PON ONU and IEEE 802.3av [10], Table 75-1 for 10G-EPON ONU.

In step 14), OLT PON receiver overload power of each channel shall be all within the requirements defined in relevant ITU-T and IEEE standard.

5.1.2.8 OLT transmit optical waveform (TDEC) test

5.1.2.8.1 Test purpose

Verify that the OLT optical transmitter and dispersion eye closure (TDEC) of MPM transmitter complies with the requirements defined in Recommendation ITU-T G.9804.3 [5].

5.1.2.8.2 Test configuration

Figure 5 shows the configuration of the test.

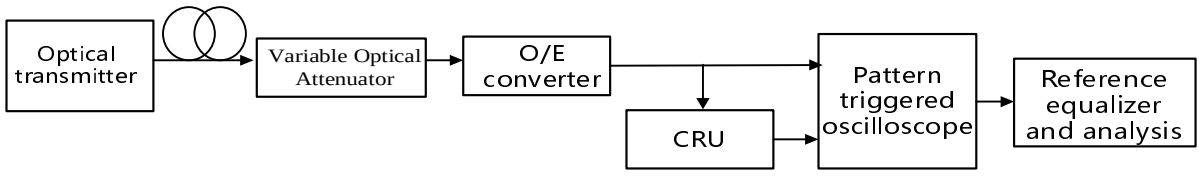

Figure 5: OLT MPM interface TDEC test environment

5.1.2.8.3 Test procedure

The test procedure shall be as follows:

1) Connect the test environment according to Figure 5. The setup of the oscilloscope is shown in Recommendation ITU-T G.9804.3 [5], section 9.2.7.8.

2) Configure OLT to enable only the 50G-PON channel, insert a 20 km fibre between the OLT MPM transmitter and the variable optical attenuator, and adjust the attenuator so that the output optical power is within the required range of the oscilloscope.

3) Measure the TDEC parameter of the 50G-PON OLT's PON interface under the condition of the 20 km fibre connected.

4) Insert a fibre not longer than 2m between the OLT optical transmitter and the variable optical attenuator, adjusting the attenuator so that the output optical power is within the required range of the oscilloscope.

5) Measure the TDEC parameter of the 50G-PON OLT's PON interface under the condition of the 2 m fibre connected.

6) Configure OLT to enable all the channels, repeat the steps 2 to 5.

5.1.2.8.4 Expected results

In step 3), step 5) and step 6), The TDEC will pass if the result is within the requirements defined in Recommendation ITU-T G.9804.3 [5], Figure 9-5.

5.2 ONU interface test cases

5.2.1 ONU transmit power

This test case shall be performed as described in BBF TR-423 [11], section 7.2.1.

5.2.2 ONU transmitter wavelength

This test case shall be performed as described in BBF TR-423 [11], section 7.2.2.

5.2.3 ONU transmit optical waveform (eye diagram)

This test case shall be performed as described in BBF TR-423 3 [11], section 7.2.2.

5.2.4 ONU extinction ratio

This test case shall be performed as described in BBF TR-423 [11], section 7.2.3.

5.2.5 ONU SMSR test

This test case shall be performed as described in BBF TR-423 [11], section 7.2.8.

5.2.6 ONU receive sensitivity test

5.2.6.1 Test purpose

Verify that the ONU PON optical interface receive sensitivity complies with the requirements of Recommendation ITU-T G.9804.3 [5].

5.2.6.2 Test configuration

For the receiver sensitivity test of 49,7664 Gbit/s downstream direction, the configuration requirements for parameters such as the bit error rate reference threshold and transmitter extinction ratio shall comply with the requirements of Recommendation ITU-T G.9804.3 [5], Table 9-5.

Figure 6 shows the configuration of the test.

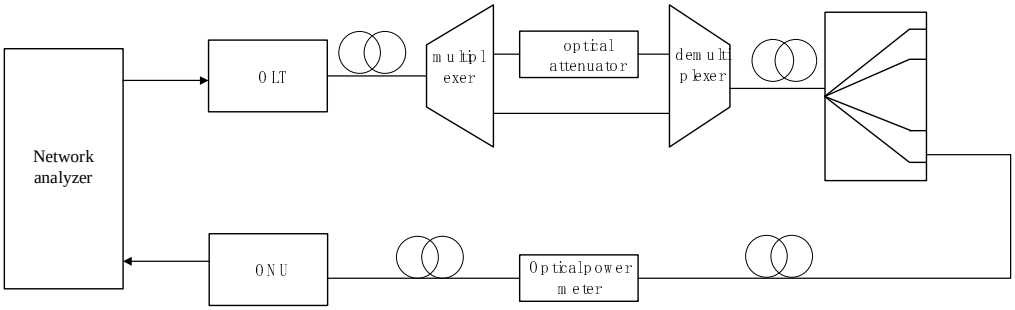

Figure 6: ONU transmitter receive sensitivity test environment

5.2.6.3 Test procedure

The test procedure shall be as follows:

1) Connect the optical paths between the equipment under test and the test instrument according to Figure 6, the multiplexer/demultiplexer in Figure 6 is used to separate upstream and downstream wavelengths.

2) Send the test traffic from the network analyser to the OLT port.

3) Adjust the optical attenuator to gradually increase the attenuation until packet loss is detected by the network analyser, then slightly reduce the attenuation until packet loss disappears.

4) Measure the ONU PON interface received optical power.

5) Calculate the OMA sensitivity according to Appendix 1 of Recommendation ITU-T G.9804.3 [5], by combining the average transmitted optical power tested in section 5.2.1 and the extinction ratio tested in section 5.2.4.

5.2.6.4 Expected results

In step 4), the ONU PON interface receive sensitivity shall be within the requirements defined in Recommendation ITU-T G.9804.3 [5], Table 9-5.

In step 5), the ONU PON interface OMA sensitivity shall be within the requirements defined in Recommendation ITU-T G.9804.3 [5], Table 9-5.

5.2.7 ONU receive overload test

This test case shall be performed as described in BBF TR-423 [11], section 7.2.7.

5.2.8 ONU Transmitter and Dispersion Eye Closure (TDEC) test

5.2.8.1 Test purpose

Verify that the ONU 49,7664Gbit/s upstream optical Transmitter and Dispersion Eye Closure (TDEC) complies with the requirements defined in the respective Recommendation ITU-T G.9804.3 [5] document.

5.2.8.2 Test configuration

Figure 7 shows the configuration of the test.

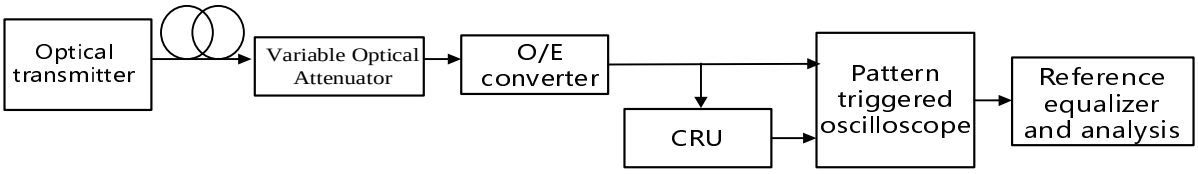

Figure 7: ONU PON interface TDEC test environment

5.2.8.3 Test procedure

The test procedure shall be as follows:

1) Connect the test environment according to Figure 7. The setup of the oscilloscope is shown in Recommendation ITU-T G.9804.3 [5], section 9.2.7.8.

2) Insert a 20 km fibre between the ONU optical transmitter and the variable optical attenuator, adjusting the attenuator so that the output optical power is within the required range of the oscilloscope.

3) Measure the TDEC parameter of the 50G-PON ONU's 49,7664 Gbit/s upstream PON interface under the condition of the 20 km fibre connected.

4) Insert a fibre not longer than 2m between the ONU optical transmitter and the variable optical attenuator, adjusting the attenuator so that the output optical power is within the required range of the oscilloscope.

5) Measure the TDEC parameter of the 50G-PON ONU's 49,7664 Gbit/s upstream PON interface under the condition of the 2 m fibre connected.

5.2.8.4 Expected results

In step 3) and step 5), The TDEC will pass if the result is within the requirements defined in Recommendation ITU-T G.9804.3 [5], Figure 9-8.

5.2.9 ONU X/S tolerance (optional)

This test case shall be performed as described in BBF TR-423 [11], section 7.2.6.

5.2.10 ONU Transmitter OPP (24,8832 Gbit/s Upstream) test

5.2.10.1 Test purpose

To test the transmitter Optical Path Penalty (OPP) of the 50G-PON ONU (24,8832 Gbit/s upstream).

5.2.10.2 Test Configuration

The test configuration is shown in Figure 8.

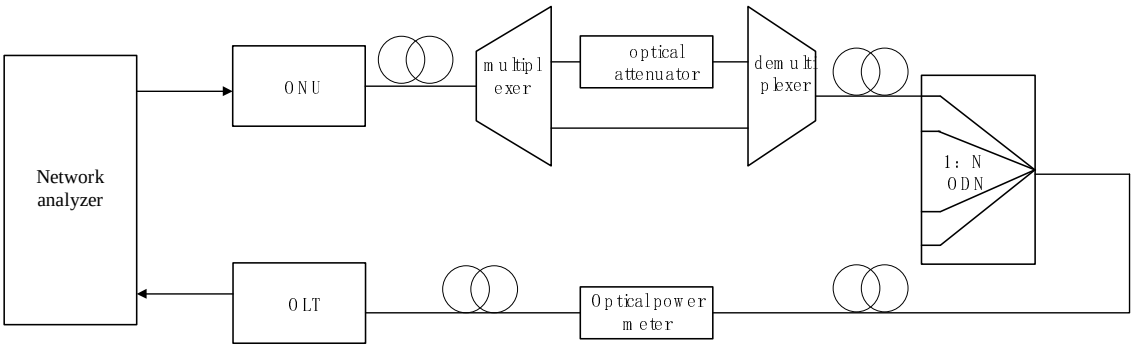

Figure 8: ONU Transmitter OPP test environment

If a Wavelength Division Multiplexer (WDM) corresponding to the 50G-PON system wavelength is not available, alternative devices such as circulators may be used to separate the upstream and downstream wavelengths.

5.2.10.3 Test Procedure

1) Connect the Device Under Test (DUT) and the test equipment according to the test configuration shown in Figure 8, where the optical fibre length shall not exceed 2 m, with upstream FEC enabled (the WDM in the figure is used to separate the upstream and downstream wavelengths).
2) Transmit test signals to the DUT through the network analyser.
3) Adjust the optical attenuator by gradually increasing the attenuation value until the network analyser detects packet loss, then adjust the optical attenuator back to the point where no packet loss occurs.
4) Measure the OLT received optical power $\boldsymbol{P_B}$ at this point (back-to-back receiver sensitivity).
5) Adjust the optical fibre length in step 1) to 20 km, with upstream FEC enabled (the WDM in the figure is used to separate the upstream and downstream wavelengths).
6) Transmit test signals to the DUT through the network analyser.
7) Adjust the optical attenuator by gradually increasing the attenuation value until the network analyser detects packet loss, then adjust the optical attenuator back to the point where no packet loss occurs.
8) Measure the OLT received optical power $\boldsymbol{P_{20km}}$ at this point (20 km receiver sensitivity).
9) Calculate the optical path penalty of the transmitter under test, which equals the 20 km receiver sensitivity measured in step 8) minus the back-to-back receiver sensitivity measured in step 4):

$$OPP = \boldsymbol{P_{20km}} - \boldsymbol{P_B} \quad (1)$$

5.2.10.4 Expected Results

The results shall comply with the requirements specified in Recommendation ITU-T G.9804.3 [5], Table 9-7.

6 PON basic function cases

6.1 Split ratio and fibre distance test

6.1.1 Split ratio and maximum fibre distance

6.1.1.1 Test purpose

This test case defines the function to verify whether the number of ONUs working simultaneously on one OLT PON interface meets the minimum requirements of Recommendation ITU-T G.9804.1 [3] for 50G TDM PON.

6.1.1.2 Test configuration

Figure 9 shows the configuration of the test.

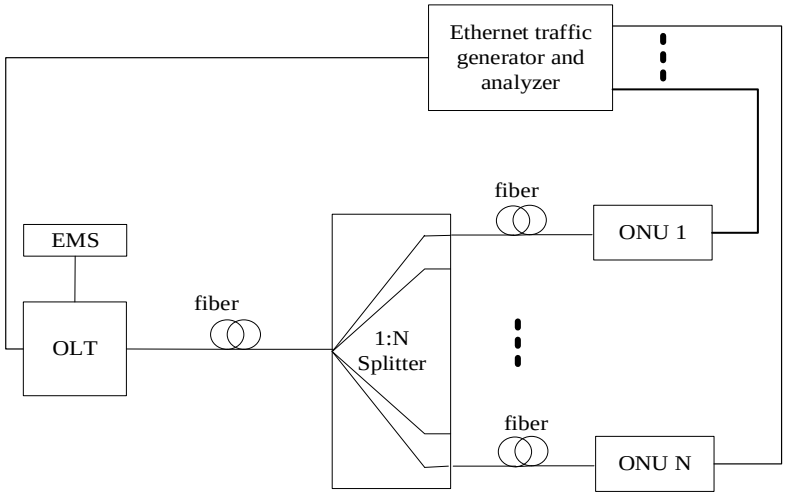

Figure 9: Split ratio of 50G TDM PON test environment

6.1.1.3 Test procedure

The test procedure shall be as follows:

1) Connect the test environment according to Figure 9.

2) Connect N ONUs to one OLT PON port of 50G TDM PON, where N is the maximum number of split ratio supported by the system.

3) Configure the fibre with a length of no less than 20 km between the OLT and the splitter, set up ONU, OLT, and network analyser. If necessary, connect the user ports of the ONU to the network analyser through an Ethernet switch, aggregating the Ethernet user ports of multiple ONUs to one port of the network analyser.

4) Activate OLT and ONU devices.

5) Verify whether all ONUs successfully registered with the OLT and data is transmitted with no packet loss and whether the maximum transmission distance of at least 20 km is supported.

6) Record the number of ONUs that are connected and transmitting data with no packet loss.

6.1.1.4 Expected results

In step 5), all ONUs shall successfully register and data transmission with no packet loss and the maximum transmission distance of at least 20 km shall be supported Recommendation ITU-T G.9804.1 [3].

In step 6), the number of ONUs shall be at least 64.

6.1.2 Maximum differential fibre distance

6.1.2.1 Test purpose

This test case defines the function to verify the maximum difference fibre distance between different ONUs connected to the same OLT PON port under normal data transmission meets the minimum requirements of Recommendation ITU-T G.9804.1 [3] for 50G TDM PON.

6.1.2.2 Test configuration

Figure 9 shows the configuration of the test.

6.1.2.3 Test procedure

The test procedure shall be as follows:

1) Connect the test environment according to Figure 9.
2) Connect 64 ONUs to one OLT PON port of 50G TDM PON.
3) Configure the fibre with a length of less than 5 m between the OLT and the splitter, no less than 20 km fibre between the ONU1 and the splitter, less than 5 m fibre between the remaining ONUs and splitters.
4) Set up ONU, OLT, and network analyser. If necessary, connect the user ports of the ONU to the network analyser through an Ethernet switch, aggregating the Ethernet user ports of multiple ONUs to one port of the network analyser.
5) Activate OLT and ONU devices.
6) Verify whether all ONUs successfully register with the OLT and data is transmitted with no packet loss, the maximum difference fibre distance of 20 km shall be supported Recommendation ITU-T G.9804.1 [3].

6.1.2.4 Expected results

In step 6) All ONUs shall successfully register and data transmission with no packet loss. Maximum difference fibre distance shall support at least 20 km.

6.2 Authentication/encryption test

6.2.1 ONU discovery and registration test

6.2.1.1 Test purpose

This test case is to verify the OLT ability to automatically discover and register ONUs when multiple ONUs are connected.

6.2.1.2 Test configuration

The test environment for 50G-PON ONU auto discovery and registration of 50G TDM PON system is shown in Figure 10.

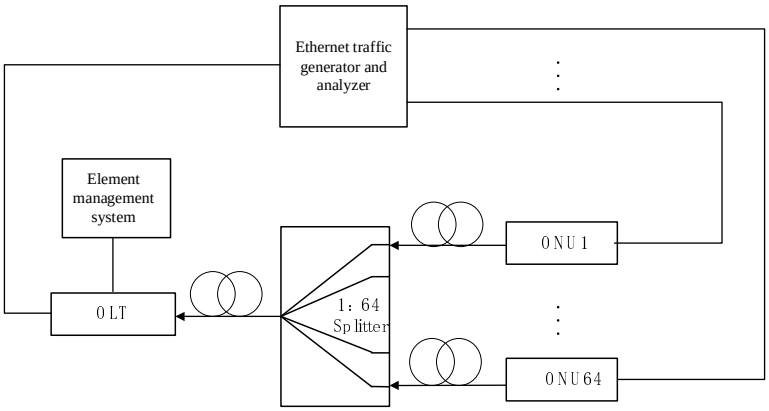

Figure 10: ONU auto discovery and registration of 50G TDM PON test environment

6.2.1.3 Test procedure

1) Connect the test environment according to Figure 10.
2) Configure 64 ONUs under the same OLT PON interface, with short-distance fibre (not longer than 5 m) between the OLT and the splitter, 20 km fibre between ONU1 and the splitter, short-distance fibre (not longer than 5 m) between the remaining ONUs and the splitter.
3) Turn on the power of all ONUs in sequence, and wait for the ONUs to successfully register.
4) Turn off and then turn on the power of any one ONU, and wait for that ONU to successfully register.
5) Disconnect the fibre from the OLT PON interface, then reconnect it, and wait for all ONUs to successfully register.
6) Disconnect the fibre from any ONU interface, then reconnect it, and wait for that ONU to successfully register.

6.2.1.4 Expected results

In steps 3), 4), 5) and 6), the ONUs shall register successfully, and the ONU status displayed on Element management system shall be consistent with the actual operating status of the ONUs.

6.3 ODN resilience and protection test

6.3.1 Backbone fibre protection switching test

6.3.1.1 Test purpose

Verify the service protection switching function supported by OLT (ODN Backbone fibre protection switching).

6.3.1.2 Test configuration

The test environment is shown in Figure 11.

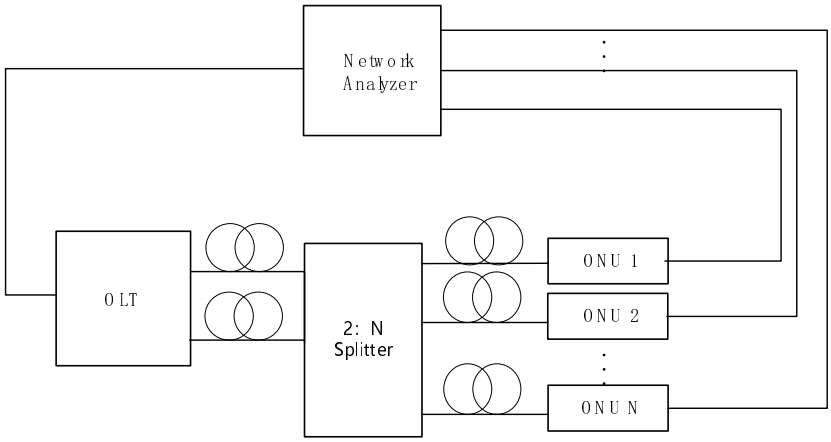

Figure 11: OLT service protection switching test environment

6.3.1.3 Test procedure

1) Connect the test environment according to Figure 11, the number of ONU shall be not less than 3, and each ONU work normally.
2) Allocate 100 Mbit/s or more upstream fixed bandwidth to each ONU.
3) The network analyser sends bidirectional traffic to each ONU from the OLT, with a sending packet rate of 10 000 per second and fixed packet lengths of 64 Byte, 128 Byte, 512 Byte, and 1 024 Byte.

4) Configure automatic service switching function and disconnect the backbone fibre or unplugging the OLT main optical module, observe the traffic transmission of network analyser and record the number of upstream and downstream packet losses generated during the entire protection switching process.

5) Restore the original configuration.

6) Configure forced service switching function and perform service switching operation on OLT, observe the traffic transmission of network analyser and record the number of upstream and downstream packet losses generated during the entire protection switching process.

7) Measure multiple times according to the requirements, and take the maximum value.

6.3.1.4 Expected results

In step 4) The traffic transmission is normal, and the service shall be able to automatically switching to the protection port. The service switching time shall be less than 50 ms (Recommendation ITU-T G.9804 [3]) (switching time= packet loss/10 000, the unit is second).

In step 6) The traffic transmission is normal, and the service shall be able to switch to the protection port. The service switching time shall be less than 50 ms (Recommendation ITU-T G.9804 [3]) (switching time= packet loss/10 000, the unit is second).

6.3.2 Full fibre protection switching test (optional)

6.3.2.1 Test purpose

Verify the service protection switching function supported by OLT and ONU device (ODN full fibre protection switching).

6.3.2.2 Test configuration

The test environment is shown in Figure 12.

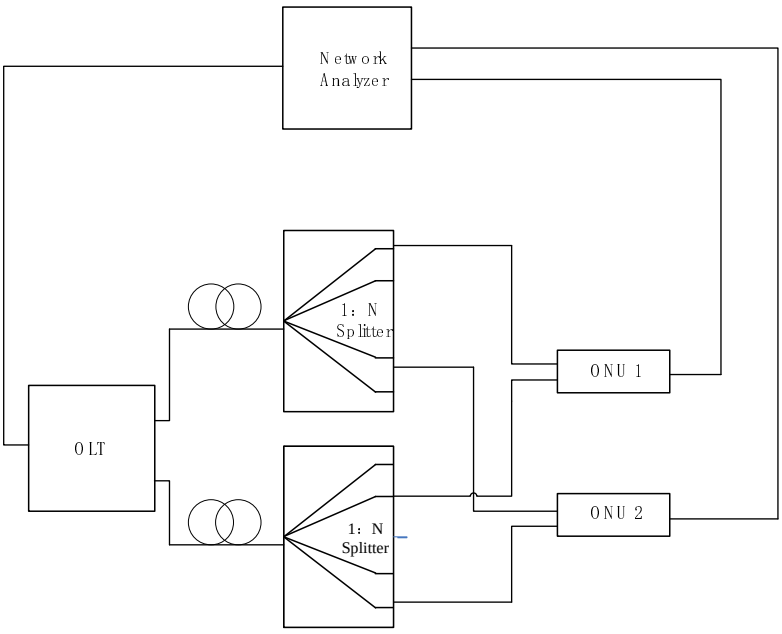

Figure 12: OLT and ONU service protection switching test environment

6.3.2.3 Test procedure

1) Connect the test environment according to Figure 12, check that each ONU works normally.
2) Allocate 100 Mbit/s or more upstream fixed bandwidth to each ONU.
3) The network analyser sends bidirectional traffic to each ONU from the OLT, with a sending packet rate of 10 000 per second and fixed packet lengths of 64 Byte, 128 Byte, 512 Byte, and 1 024 Byte.
4) Disconnect the backbone fibre, observe the traffic transmission of network analyser and record the number of upstream and downstream packet losses generated during the entire protection switching process.
5) Restore the connection of the backbone optical fibre and disconnect the main branch optical fibre of ONU1, observe the traffic transmission of network analyser and record the number of upstream and downstream packet losses generated during the protection switching to spare branch fibre.
6) Measure multiple times according to the requirements, and take the maximum value.

6.3.2.4 Expected results

In step 4) and step 5) the traffic transmission is normal, and the service shall be able to automatically switching to the protection port. The service switching time shall be less than 50 ms (Recommendation ITU-T G.9804.1 [3]) (switching time= packet loss/10 000, the unit is second).

6.4 Optical parameters reporting

This test case shall be performed as described in BBF TP-255 [12], section 6.12.3.

7 Ethernet/IP function test cases

7.1 VLAN and VLAN Stacking

This test case shall be performed as described in BBF TP-255 [12], section 6.1.

7.2 Multicast function

This test case shall be performed as described in BBF TP-255 [12], section 6.3.

7.3 OLT MAC address table depth

7.3.1 Test purpose

Test MAC address table depth of OLT.

7.3.2 Test configuration

The test environment is shown in Figure 13.

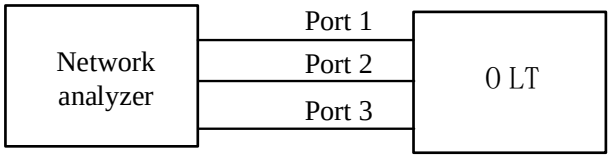

Figure 13: OLT MAC address table depth test environment

7.3.3 Test procedure

1) Connect the test environment according to Figure 13.
2) Add uplink ports 1, 2, and 3 of the OLT to the same VLAN.
3) Use the network analyser to transmit N frames (N is greater than the estimated depth of the OLT address table) to port 1 at the rate of 1 000 frames per second. The source MAC addresses are different. The destination MAC address is fixed to MAC address of the port 2.
4) Use the network analyser to transmit N frames to port 2 at the rate of 1 000 frames per second. The destination MAC addresses of the frames correspond to the source MAC addresses used in step 3.
5) Check the receiving results of ports 1 and 3.

7.3.4 Expected results

In step 5, when N exceeds the OLT's MAC address table depth, port 3 receives M frames from port 2.

The final value of N-M represents the OLT MAC address table depth

7.4 QoS function

This test case shall be performed as described in BBF TP-255 [12], section 6.2.

7.5 Security

This test case shall be performed as described in BBF TP-255 [12], section 6.5.

8 Performance test cases

8.1 Throughput test

8.1.1 Test purpose

Test the throughput of one PON port on 50G-TDM-PON OLT equipment.

8.1.2 Test configuration

Figure 14 shows the configuration of the test.

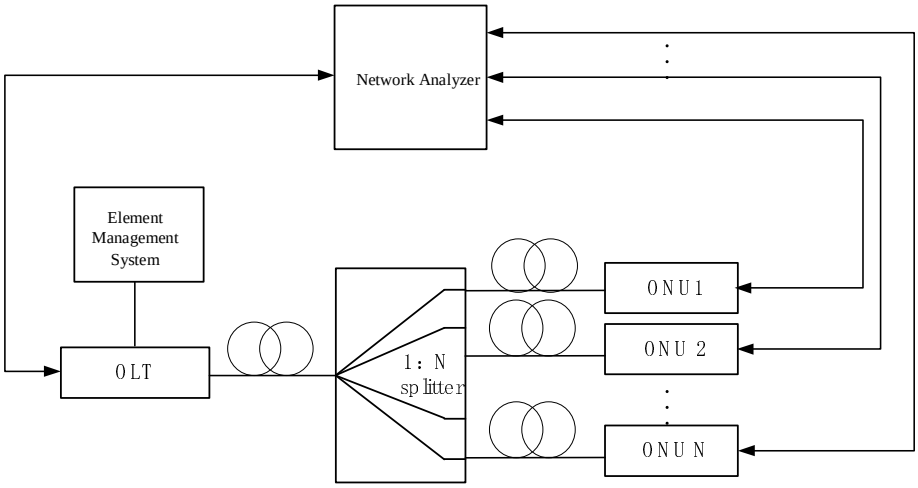

Figure 14: OLT single PON port throughput test environment

8.1.3 Test procedure

The test procedure shall be as follows:

1) Configure the test environment according to Figure 14. The number of ONUs shall be chosen such that the sum of the upstream and downstream throughput of N ONUs exceeds the throughput of a single OLT PON interface.

2) Configure each ONU to use the maximum data bandwidth, the FEC is enabled for both directions.

3) Send N downstream streams with VLAN tags from the network analyser to the OLT, corresponding to N ONUs, where the total bandwidth of the N streams exceeds the downstream bandwidth of the PON port.

4) Test the traffic received by each ONU user port when the downstream packet lengths are 68, 132, 260, 516, 1 028, 1 284, and 1 522 bytes, respectively, with a test duration of 20 seconds.

5) Send upstream traffic with VLAN tags from the network analyser to N ONU devices, where the total traffic exceeds the upstream bandwidth of the PON port.

6) Test the traffic received by the OLT uplink port for upstream packet lengths of 68, 132, 260, 516, 1 028, 1 284, and 1 522 bytes, with a test duration of 20 seconds.

NOTE: Testing instruments generally use a binary method for throughput testing, with the main principle as follows: the testing instrument first sends packets at 100 % of the traffic. If no packet loss is detected, the test is complete, and the throughput is the line speed. If packet loss is detected, the instrument then tests with ((100 % + 0) / 2) of the traffic. If no packet loss is found, it tests again with ((50 % + 100 %) / 2) of the traffic, and so on. Through this binary method, the maximum throughput of the device is ultimately determined.

8.1.4 Expected results

In step 4) and step 6), record the test results from the network analyser has successfully run the throughput test via binary method. The minimum throughput test results shall be as shown in Table 2.

Table 2: Minimum throughput test results for 50G-TDM-PON systems

	Asymmetric 50G-PON	Symmetric 50G-PON
Downstream (L2)	≥ 36 Gbps	≥ 36 Gbps
Upstream(L2)	≥ 18 Gbps	≥ 36 Gbps

NOTE: This test result applies to scenarios using 4 ONUs. If more ONUs are used in the test, the overall throughput will decrease due to increased overhead.

8.2 Latency and deterministic test

8.2.1 Latency and deterministic test based on multiple bursts per frame

8.2.1.1 Test purpose

To measure the 50G-PON latency and deterministic performances in both directions, and to verify the reduction of average and maximum latency, and also maximum jitter in upstream direction when multiple bursts per frame function is activated.

8.2.1.2 Test configuration

The test environment for latency and jitter test of 50G-PON in both directions is shown in Figure 15. The OLT uplink interface and every ONU are connected to the network analyser. The back-to-back configuration is adopted in this test case.

1) All the equipment and test instrument are connected according to the figure above, the ONU type could be either asymmetric or symmetric, the split ratio is 1:64, the length of the fibre shall not be longer than 3 m.

2) DBA model is added to the OLT.

3) Multiple ONUs are registered online, the number of ONU could be 2, 4, 8, 16; the number of T-CONT is 1 or 2 for each ONU.

4) The max allowed throughput for both directions were characterized.

8.2.1.3 Test procedure

The test procedure shall be as follows:

1) Prepare the test system as shown in Figure 15, and configure the service channel for each ONU.

2) Send data stream in both directions using Ethernet test centre, fix the total throughput to be 80 % of the max allowed throughput of the system, set the packet length to be 64 Byte, 512 Byte and 1 518 Byte.

3) Record the average and maximum latency in both directions, and the average and maximum jitter in both directions.

4) Activate the multiple bursts per frame function, the number of bursts of each ONU could be 2, 4 or 8.

5) Repeat step 2 (the max upstream throughput needs to be measured again).

6) Record the average and maximum latency in both directions, and the average and maximum jitter in both directions again.

8.2.1.4 Expected results

In step 3), for upstream direction, the average and maximum latency, and also maximum jitter are relatively large.

In step 6), the average and maximum latency, and also maximum jitter in upstream direction shall be reduced when the multiple bursts per frame function was activated. How much the reduction will be is for further study.

8.2.2 Latency and deterministic test based on disabling quiet window

8.2.2.1 Test purpose

According to Recommendation ITU-T G.9804.2 [4], Appendix IX, this test case defines a methodology to verify disabling quiet window function of the 50G-PON system.

8.2.2.2 Test configuration

Figure 15 shows the configuration of the test.

The Ethernet traffic generator and analyser are connected to the OLT and ONU via the 50G/10G/2.5G/GE Ethernet interface.

Registration information and service channels for ONU shall be configured through the EMS (Element Management System).

Enable the quiet window on the OLT PON port, configure the window size as maximum distance equal to maximum differential distance = 20 km, and set the window opening frequency to once every 5 seconds. It is recommended to use an optical split ratio of 1:32.

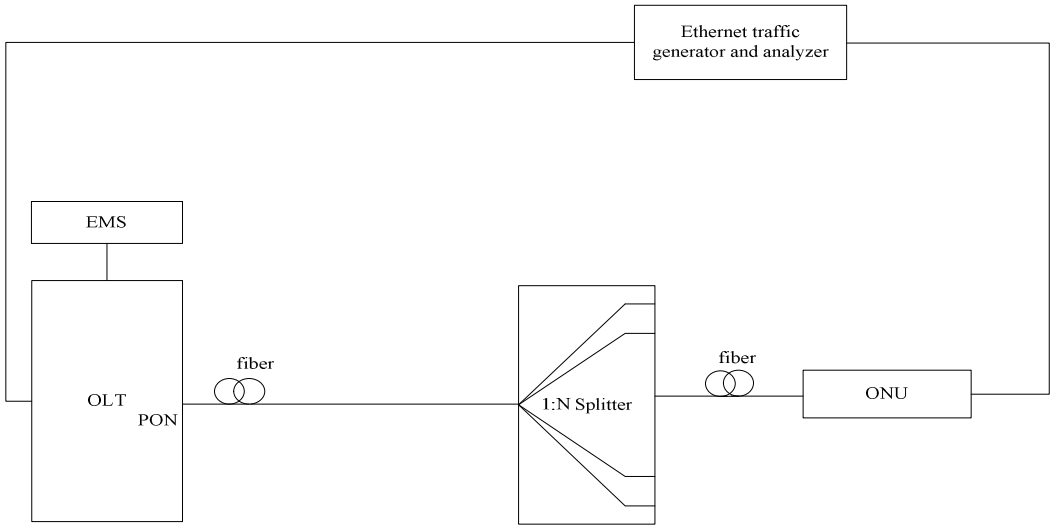

Figure 15: Latency and deterministic test based on disabling quiet window test environment

8.2.3.3 Test procedure

The test procedure shall be as follows:

1) Connect the test environment according to Figure 15.
2) Power on the ONU and complete its registration.
3) Send a continuous bidirectional traffic stream of 100 Mbps for 60 seconds between the OLT and the ONU using an Ethernet traffic generator and analyser.
4) Record the maximum upstream latency of the ONU.
5) Disable the quiet window on the OLT PON port.
6) Stop and restart the traffic streams in step 3, and refresh the maximum upstream latency.
7) Use the Ethernet traffic generator and analyser to measure the maximum upstream latency for the ONU within 60 seconds.

8.2.3.4 Expected results

In step 7), the maximum upstream delay for ONU shall be less than the value recorded in step 4).

In step 3) to 7), no packet loss shall occur.

8.2.3 Latency and deterministic test based on DAW (optional)

8.2.3.1 Test purpose

According to Recommendation ITU-T G.9804.2 [4], Appendix IX, a Dedicated Activation Wavelength (DAW) is introduced to eliminate quiet window during activation. This test case defines a methodology to verify DAW function of the 50G-PON system.

8.2.3.2 Test configuration

If both the OLT and ONU support DAW, configure the test environment according to Figure 16.

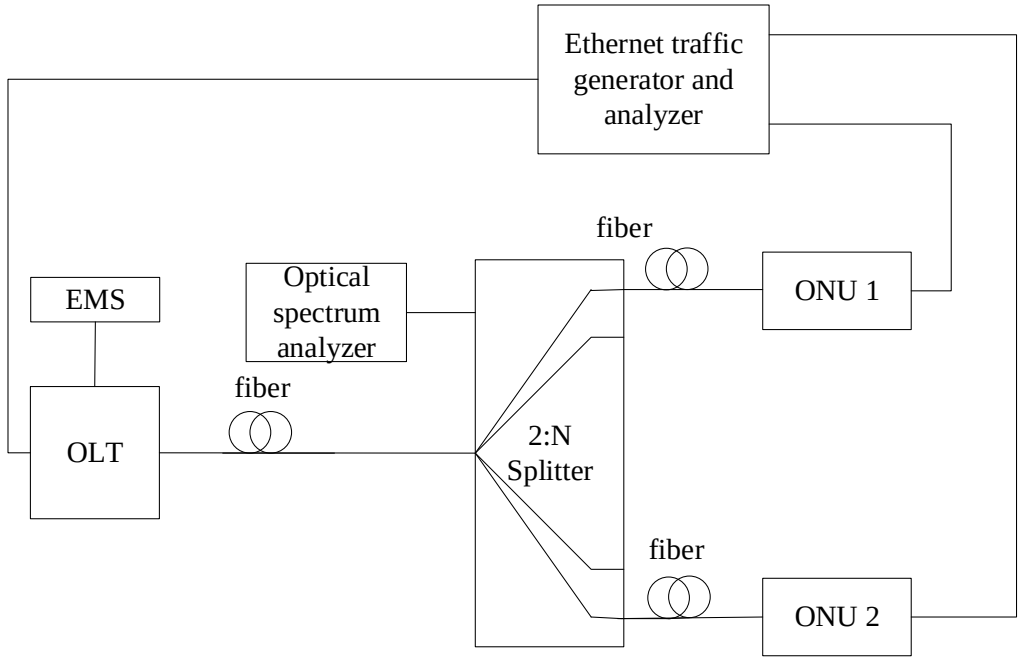

Figure 16: Latency and deterministic test based on DAW test environment

The Ethernet traffic generator and analyser shall be connected to the OLT and ONU via the 50G/10G/2.5G/GE Ethernet interface. The Optical spectrum analyser shall be connected to ONU2 via the optical interface. Registration information and service channels for each ONU shall be configured through the EMS (Element Management System).

NOTE: It is recommended to use an optical split ratio of 2:32.

8.2.3.3 Test procedure

The test procedure shall be as follows:

1) Connect the test environment according to Figure 16.
2) Power on the ONU1 and complete its registration.
3) Send a continuous bidirectional traffic stream of 100 Mbps between the OLT and ONU1 using Ethernet traffic generator and analyser.
4) Power on the ONU2 and complete its registration.
5) Observe whether the traffic stream on the ONU1 is interrupted and if the maximum latency increases.
6) Set up the Optical spectrum analyser to determine and record the value of the third wavelength.

8.2.3.4 Expected results

In step 5), the traffic stream shall be transmitted without packet loss and the maximum latency shall not increase significantly.

In step 6), the measurement results of the third wavelength will be referenced from Recommendation ITU-T G.9804.2 [4].

8.3 Synchronization test

8.3.1 Timing source selection test

8.3.1.1 Test purpose

Verify the timing source selection capability of OLT equipment.

8.3.1.2 Test configuration

The test environment is shown in Figure 17.

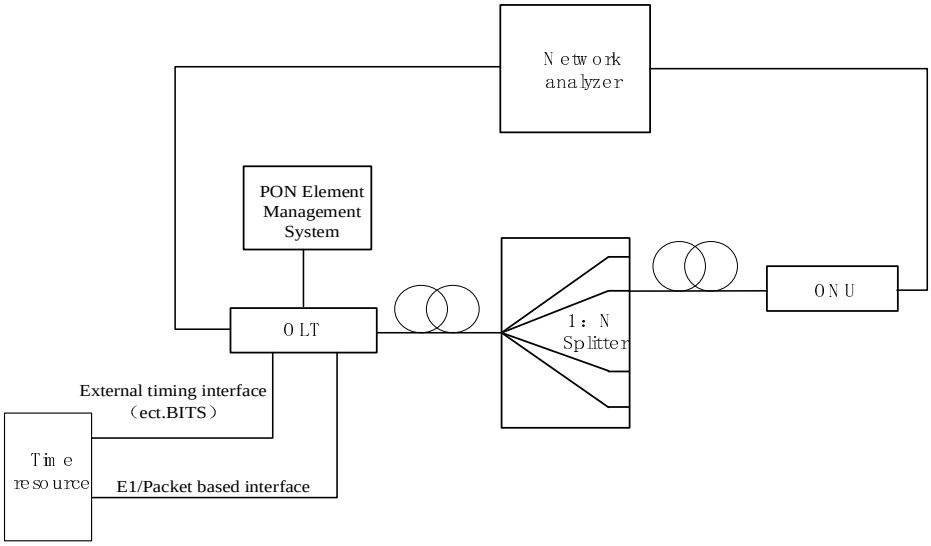

Figure 17: OLT timing source selection test environment

8.3.1.3 Test procedure

1) Connect the test environment according to Figure 17.
2) Send 1Gbit/s downstream data traffic and 1Gbit/s upstream data traffic to ONU through network analyser.
3) Observe the OLT timing source selection via the PON Element Management System.
4) Disconnect the external timing source interface and E1 or packet-based timing source interface in sequence.
5) Observe OLT timing source selection and switching from PON Element Management System.

8.3.1.4 Expected results

In step 3), the OLT timing sources will be selected to the external dedicated timing source interface.

In step 4), the OLT shall prioritize timing sources in the following order and use the selected source as the data transmission clock:

4.1) E1 interface or packet-based timing source interface.

4.2) Internal timing source.

In step 5), during the timing source switching process, the OLT device shall maintain normal data transmission without packet loss.

8.4 Stability test

8.4.1 Test purpose

Test the packet loss of 50G-TDM-PON within 24 hours period.

8.4.2 Test configuration

Figure 18 shows the configuration of the test.

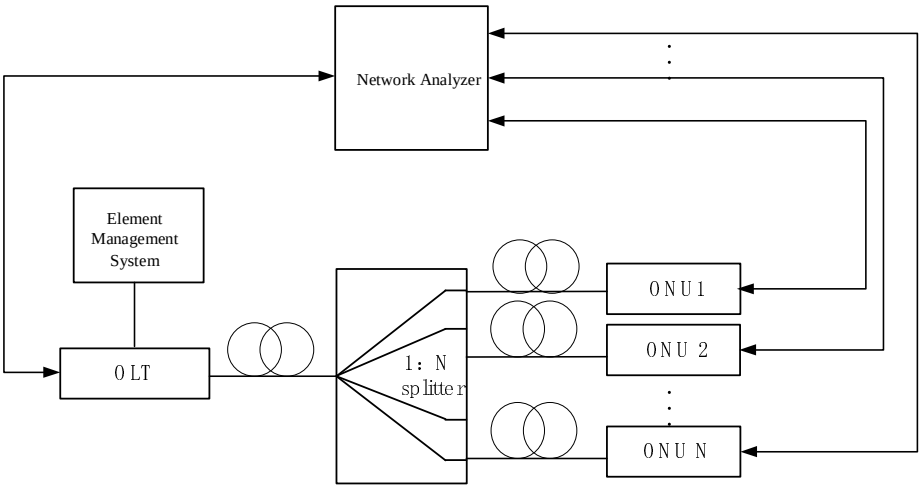

Figure 18: Stability test environment

8.4.3 Test procedure

The test procedure shall be as follows:

1) Configure the test environment according to Figure 18. The number of ONUs N shall ensure that the sum of the upstream and downstream throughput of N ONUs is greater than the throughput of one OLT PON interface.

2) Configure each ONU to the maximum bandwidth.

3) Use a network analyser to send upstream and downstream traffic streams with random packet lengths to all ONUs, so that the upstream and downstream traffic pass through the OLT PON port reaches 90 % of the PON port's throughput, which is tested in clause 8.1.

4) Observe the system packet loss rate for 24-hour.

8.4.4 Expected results

In step 4), there is no packet loss in both upstream and downstream data streams in 24 hours.

9 Coexistence test cases

9.1 Coexistence with CEx device

9.1.1 Single-mode coexistence

9.1.1.1 Coexistence of XG(S)-PON and 50G TDM PON

9.1.1.1.1 Test purpose

According to Recommendation ITU-T G.9804.1 [3], section 7.1, there are two ODN co-existence scenarios for coexistence of 50G-PON and legacy PON systems, as with CEx device and with multi-PON module.

This test case defines the configuration, procedure and expected results to verify the capability of XG(S)-PON and 50G-PON coexistence with CEx.

9.1.1.1.2 Test configuration

Figure 19 shows the configuration of the test.

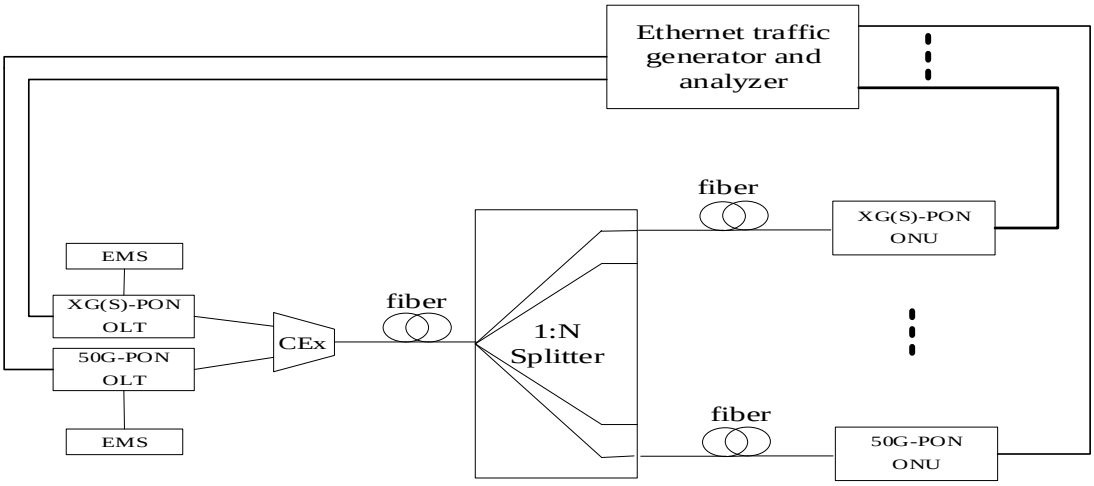

Figure 19: Coexistence test of XG(S)-PON and 50G-PON with CEx

9.1.1.1.3 Test procedure

The test procedure shall be as follows:

1) Connect the test environment according to Figure 19:

   1.1) This test configuration applied to both XG-PON and XGS-PON systems, the DUT should be chosen accordingly for either case, i.e. XG-PON OLT and XG-PON ONU, or XGS-PON OLT with XGS-PON ONU and/or XG-PON ONU.

   1.2) Connect the PON ports of the XG(S)-PON and 50G-PON OLTs to a CEx device.

   1.3) Connect the uplink ports of the XG(S)-PON and 50G-PON OLTs to an ethernet traffic generator and analyser.

2) Configure and bring all the ONUs online.

3) Using the Ethernet traffic generator and analyser to transmit L2 traffic in both upstream and downstream directions for all the ONUs, each traffic stream is configured to 100 Mbps in both direction.

9.1.1.1.4 Expected results

In step 2), all the ONUs shall be brought online.

In step 3), all the traffic streams shall be transmitted without losses of packets.

9.1.1.2 Coexistence of 10G-EPON and 50G TDM PON

9.1.1.2.1 Test purpose

According to Recommendation ITU-T G.9804.1 [3], section 7.1, there are two ODN co-existence scenarios for coexistence of 50G-PON and legacy PON systems, as with CEx device and with multi-PON module.

This test case defines the configuration, procedure and expected results to verify the capability of 10G-EPON and 50G-PON coexistence with CEx.

9.1.1.2.2 Test configuration

Figure 20 shows the configuration of the test.

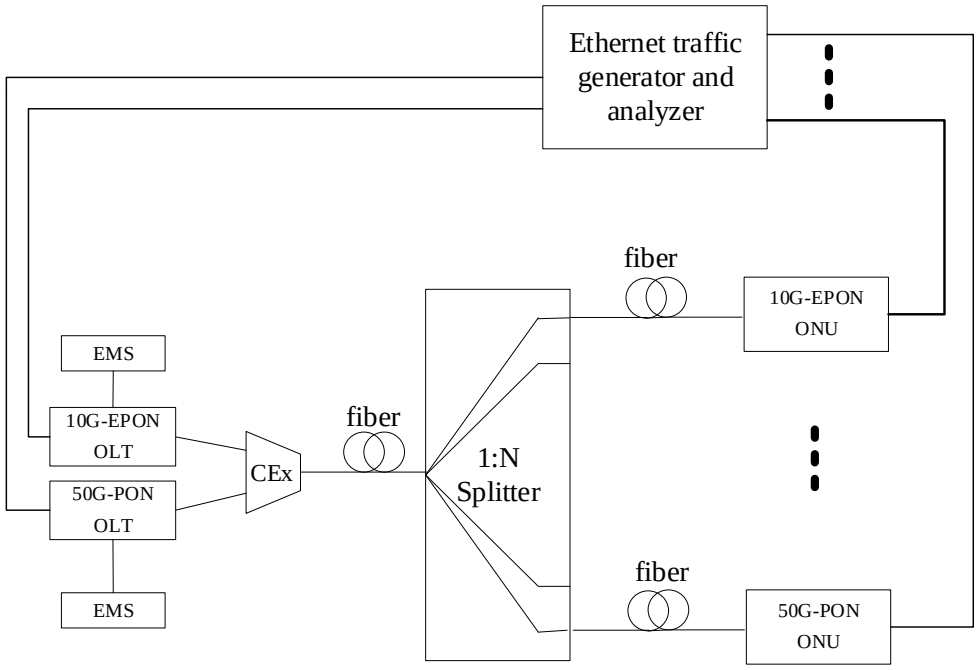

Figure 20: Coexistence test of 10G-EPON and 50G-PON with CEx

9.1.1.2.3 Test procedure

The test procedure shall be as follows:

1) Connect the test environment according to Figure 20:

   1.1) This test configuration is applied to both asymmetric and symmetric 10G-EPON systems, the DUT is chosen accordingly for either case, i.e. asymmetric 10G-EPON OLT and ONU, or symmetric 10G-EPON OLT with symmetric and/or asymmetric ONU.

   1.2) Connect the PON ports of the 10G-EPON and 50G-PON OLTs to a CEx device.

   1.3) Connect the uplink ports of the 10G-EPON and 50G-PON OLTs to an ethernet traffic generator and analyser.

2) Configure and bring all the ONUs online.

3) Using the ethernet traffic generator and analyser to transmit L2 traffic in both upstream and downstream directions for all the ONUs, each traffic stream is configured to 100 Mbps in either direction.

9.1.1.2.4 Expected results

In step 2), all the ONUs shall be brought online.

In step 3), all the traffic streams shall be transmitted without losses of packets.

9.1.2 Multi-mode coexistence

9.1.2.1 Coexistence of GPON, XG(S)-PON and 50G TDM PON

This test case shall be performed as described in BBF TR-423 [11], section 9.

9.2 Coexistence with MPM method

9.2.1 Single-mode coexistence

9.2.1.1 Coexistence with XG(S)-PON and 50G TDM PON

9.2.1.1.1 Test Purpose

To verify the coexistence of 50G-PON with XG(S)-PON on the same OLT service board based on the MPM mode.

9.2.1.1.2 Test Configuration

The test configuration is shown in Figure 21.

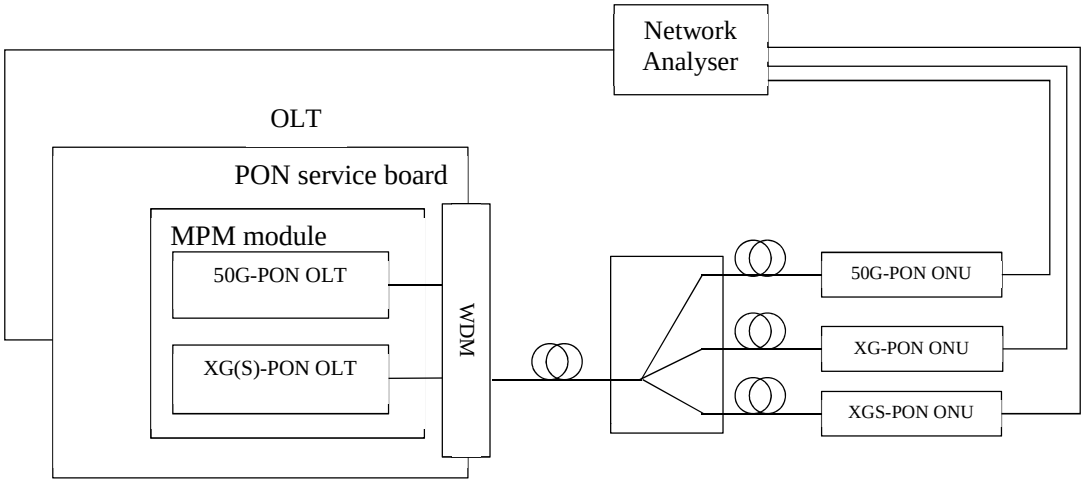

Figure 21: Coexistence of 50G-PON with XG(S)-PON test environment (via MPM Method)

9.2.1.1.3 Test Procedure

1) Connect the test environment according to Figure 21.

2) Configure service board with MPM module on the OLT, and connect one 50G-PON ONU, one XG-PON ONU, and one XGS-PON ONU to the same PON port of one service board.

3) Configure each ONU to use the maximum bandwidth.

4) Use the network analyser and configure the data traffic as following:

   4.1) 5Gbps upstream and downstream data traffic to the 50G-PON ONU.

   4.2) 1Gbps upstream and downstream data traffic to each of the XG-PON ONU and XGS-PON ONU.

   4.3) The test duration is at least 5 minutes.

5) Observe the coexistence of upstream and downstream traffic for the 50G-PON and XG(S)-PON ONUs.

9.2.1.1.4 Expected Results

In step 5), the upstream and downstream data traffic of the 50G-PON ONU, XG-PON ONU and XGS-PON ONU are transmitting without packets losses.

9.2.1.2 Coexistence of 10G-EPON and 50G TDM PON

9.2.1.2.1 Test Purpose

To verify the coexistence of 50G-PON and 10G-EPON on the same OLT service board based on the MPM mode.

9.2.1.2.2 Test Configuration

The test configuration is shown in Figure 22.

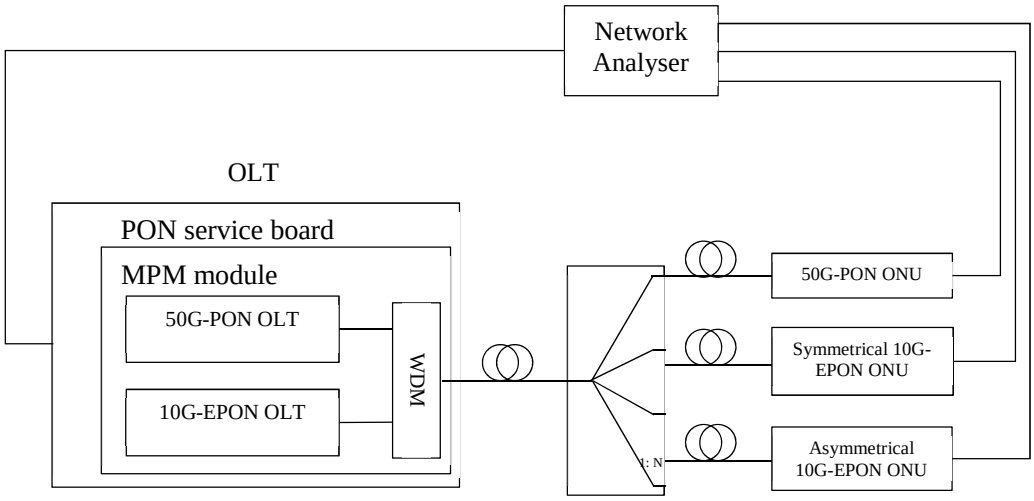

Figure 22: Coexistence of 50G-PON with 10G-EPON test environment (via MPM Method)

9.2.1.2.3 Test Procedure

1) Connect the test environment according to Figure 22.

2) Configure the service board with the MPM module on the OLT, and connect one 50G-PON ONU, one symmetric 10G-EPON ONU, and one asymmetric 10G-EPON ONU (narrowband with upstream wavelength range 1 260 nm ~ 1 280 nm) [3] to the same PON port of the service board.

3) Configure each ONU to use the maximum bandwidth.

4) Use the network analyser and configure the data traffic as following:

   4.1) 5 Gbps upstream and downstream data traffic to the 50G-PON ONU.

   4.2) 1 Gbps upstream and downstream data traffic to each symmetric 10G-EPON ONU and the asymmetric 10G-EPON ONU.

   4.3) The test duration is at least 5 minutes.

5) Observe the coexistence of upstream and downstream data traffic for the 50G-PON, asymmetric 10G-EPON ONU and symmetric 10G-EPON ONU.

9.2.1.2.4 Expected Results

In step 5), the upstream and downstream data traffic of the 50G-PON ONU, asymmetric 10G-EPON ONU and symmetric 10G-EPON ONU are transmitting without packet loss.

9.2.2 Multi-mode coexistence

9.2.2.1 Coexistence of GPON, XG(S)-PON and 50G TDM PON

9.2.2.1.1 Test Purpose

To verify the coexistence of 50G-PON with XG-PON/XGS-PON and GPON on the same OLT service board based on the MPM mode.

9.2.2.1.2 Test Configuration

The test configuration is shown in Figure 23.

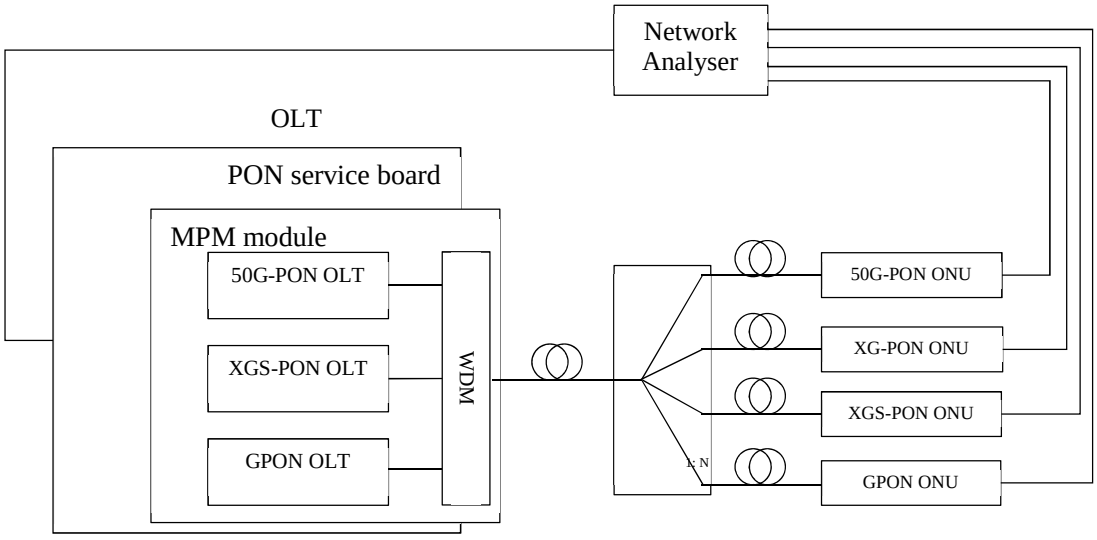

Figure 23: Coexistence of 50G-PON with XG-PON/XGS-PON and GPON test environment (via MPM Method)

9.2.2.1.3 Test Procedure

1) Connect the test environment according to Figure 23.

2) Configure service board with MPM module on the OLT, and connect one 50G-PON ONU, one GPON ONU, one XG-PON ONU, and one XGS-PON ONU to the same PON port of one service board.

3) Configure each ONU to use the maximum bandwidth.

4) Use the network analyser and configure the data traffic as following:

   4.1) 5 Gbps upstream and downstream data traffic to the 50G-PON ONU.

   4.2) 1 Gbps upstream and downstream data traffic to each of the XG-PON ONU and XGS-PON ONU.

   4.3) 100 Mbps upstream and downstream data traffic to the GPON ONU.

   4.4) The test duration is at least 5 minutes.

5) Observe the coexistence of upstream and downstream traffic for the 50G-PON, GPON, XG-PON and XGS-PON ONUs.

9.2.2.1.4 Expected Results

In step 5), the upstream and downstream traffic for the 50G-PON, GPON, XG-PON, and XGS-PON ONUs are transmitting without packet loss.

9.2.2.2 Coexistence of EPON, 10G-EPON and 50G TDM PON

9.2.2.2.1 Test Purpose

To verify the coexistence of 50G-PON with 10G-EPON and EPON (Narrow band) on the same OLT service board based on the MPM mode.

9.2.2.2.2 Test Configuration

The test configuration is shown in Figure 24.

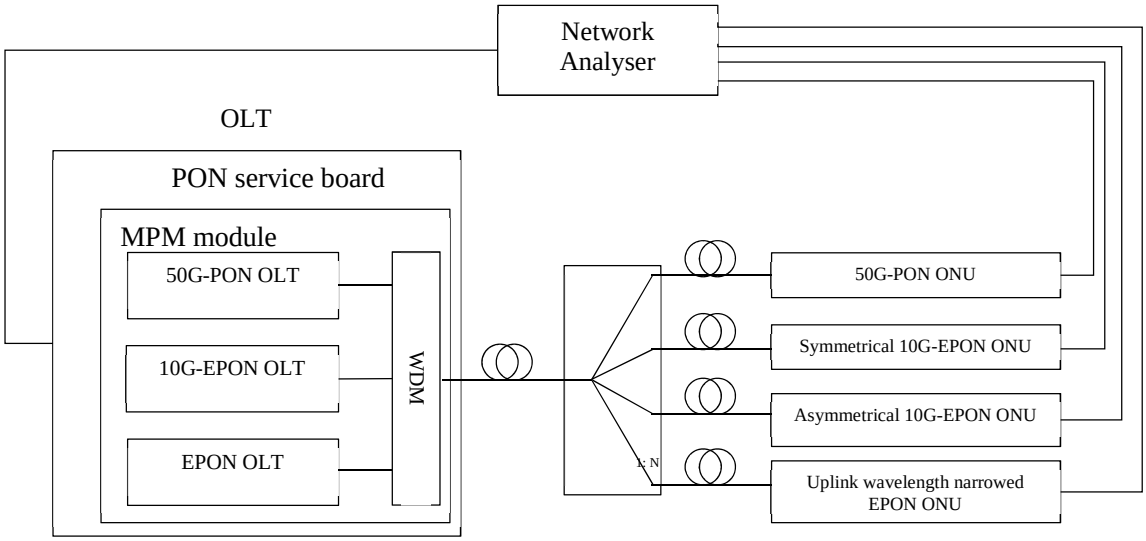

Figure 24: Coexistence of 50G-PON with 10G-EPON and EPON (Narrow band) test environment (via MPM Method)

9.2.2.2.3 Test Procedure

1) Connect the test configuration as shown in Figure 24.

2) Configure service board MPM module on the OLT, and connect one 50G-PON ONU, one symmetric 10G-EPON ONU, one asymmetric 10G-EPON ONU (narrowband with upstream wavelength range 1 260 nm ~ 1 280 nm) (Recommendation ITU-T G.9804.1 [3]), and one EPON ONU (narrowband with upstream wavelength range 1 290 nm ~ 1 330 nm) (Recommendation ITU-T G.9804.1 [3]) to the same PON port of the service board.

3) Configure each ONU to use the maximum bandwidth.

4) Use the network analyser and configure the data traffic as following:

   4.1) 5Gbps upstream and downstream data traffic to the 50G-PON ONU.

   4.2) 1Gbps upstream and downstream data traffic to each symmetric 10G-EPON ONU and asymmetric 10G-EPON ONU.

   4.3) 100 Mbps upstream and downstream data traffic to the EPON ONU.

4.4) The test duration is at least 5 minutes.

5) Observe the coexistence of upstream and downstream data traffic for the 50G-PON, EPON ONU (narrowband), asymmetric 10G-EPON ONU (narrowband), and symmetric 10G-EPON ONU.

9.2.2.2.4 Expected Results

In step 5), the upstream and downstream data traffic of the 50G-PON ONU, EPON ONU (narrowband), asymmetric 10G-EPON ONU (narrowband), and symmetric 10G-EPON ONU are transmitting without packet loss.

History

Version	Date	Status
V1.1.1	April 2026	Publication