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

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# G-PON interoperability test plan between optical line terminations and optical network units

ITU-T G-series Recommendations – Supplement 46

ITU-T G-SERIES RECOMMENDATIONS

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**Supplement 46 to ITU-T G-series Recommendations**

# G-PON interoperability test plan between optical line terminations and optical network units


**Summary**

Supplement 46 to ITU-T G-series Recommendations defines a test plan whose purpose is to verify interoperability between a G-PON OLT and ONU. Emphasis is placed on test cases that address the G-PON physical layer (ITU-T G.984.2), the TC layer (ITU-T G.984.3) and low-level components of the management layer (ITU-T G.984.4).

Service layer test cases are out of scope for this supplement.

Interoperability testing is conducted by or on behalf of four interests: the OLT vendor, the ONU vendor, one or more network operators who are potential customers, and possibly a third-party testing lab.

For each test case, the supplement provides detailed information on:

- purpose;
- reference standard;
- preconditions and dependencies;
- test set-up;
- test equipment;
- test procedure;
- pass – fail criteria.



**Source**

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## Introduction

This supplement defines a test plan whose purpose is to verify interoperability between a G-PON OLT and ONU. Emphasis is placed on test cases that address the G-PON physical layer (ITU-T G.984.2), the TC layer (ITU-T G.984.3) and low-level components of the management layer (ITU-T G.984.4).

In this supplement, the OLT is regarded as the baseline equipment, against which the ONU is evaluated. This is not to be understood as an assertion that the OLT is necessarily right in the event of incompatibility, merely to reflect the reality that a network operator is likely to have OLTs in place and is interested in qualifying additional ONUs for use on these OLTs. From this perspective, the unit under test is an ONU.

Interoperability testing is conducted by or on behalf of four interests: the OLT vendor, the ONU vendor, one or more network operators who are potential customers, and possibly a third-party testing lab. As a preliminary to an interoperability testing campaign, all interests are expected to agree on features, functions and configurations. Only the features supported by both OLT and ONU need be tested but all test cases need to be addressed with either a test result or an indication why there is no result (not supported, etc.). As to test configurations, the vendors may be requested to supply equipment (of a given vintage), and the network operator may be interested in testing in the presence of other ONU makes and models, or with particular ODN characteristics. The testing lab needs to have the necessary power, space, test equipment and expertise for the agreed campaign.

In this supplement, the manufacturers are referred to as the OLT vendor and the ONU vendor respectively, while tests are deemed to be conducted by a test operator. The term *ONU* includes ONTs as well, and the term *OLT* includes the entire network element at the head end of the PON, not just the G.984 interface.

**Supplement 46 to ITU-T G-series Recommendations**

# G-PON interoperability test plan between optical line terminations and optical network units

## 1 Scope

This clause describes the scope of G-PON interoperability testing. It is important to understand what an interoperability test plan is not, as well as what it is.

- An interoperability test project includes only features and capabilities that are claimed to be supported by both the OLT and the ONU. To apply a single interoperability test plan to all equipment combinations, the test report lists features and capabilities that are not claimed to be supported by one or both of the equipments, but tests of such cases are not to be regarded as failures. The reader of the test report determines the importance of a not-supported feature.
- An interoperability test plan evaluates the ability of an OLT and an ONU to deliver subscriber services. Services are standardized to a greater or lesser extent; the definition of a DS1 leaves very little to the imagination. However, services frequently have performance aspects that are more suitable for characterization than for Pass/fail results. An example might be the sustainable throughput of an Ethernet port or the echo performance of a voice channel. This supplement is based on ITU-T G.984.x-series of Recommendations and other standards. It expects that deviations from standards be recorded in the test results. Many test cases also characterize the quality or performance of service delivery. Compliance with standards is neither wholly necessary nor sufficient to guarantee that an OLT-ONU combination is suitable for a network provider's needs.
- An interoperability test plan confirms that a given ONU functions properly when installed on an ODN with other ONUs. In general, the other ONUs can differ arbitrarily in make, model and capability from the ONU under test. The vendors and the test lab should agree in advance on a representative population of ONUs.
- An interoperability test plan verifies that an ONU can be fully managed through the OLT, within the scope of capabilities it claims to support. This includes all pertinent FCAPS functions, for example initialization, provisioning, testing, fault isolation and maintenance, PM, backup, restoration and software upgrade.
- An interoperability test plan is not a gauge of standards compliance. A proprietary combination of OLT and ONU could well be completely interoperable. However, the standards form the basis of the interoperability test plan, in the expectation that they will closely describe most OLTs and ONUs.
- An interoperability test plan assumes a black-box view of the OLT-ONU combination. Information visible only through mechanisms such as debug ports is not valid as a test criterion. From a black-box perspective, some tests are clearly not possible, for example the ability for the OLT to controllably inject faults such as bit errors or send invalid PLOAM messages. Some of the test cases are nevertheless written to use such capabilities, if they exist. If the equipments do not expose such specialized mechanisms, it may be simply impossible to perform the test cases, and there is to be no implication that somehow it should have been possible.
- Ancillary equipment such as an uninterruptible power supply (UPS) or a DSL modem is not intrinsically within the scope of an OLT-ONU interoperability test plan. However, if a vendor always recommends a given ancillary equipment for use with an ONU or OLT, the ancillary equipment can be included by agreement. The test is not intended to resolve to a level as to isolate the operability of ancillary equipment or the OLT-ONU.
- With the exception of stress testing, in which the purpose of the test case is to oversubscribe resources of the network under test, any test case can fail if the test causes disruption to services that are not part of the test case.
- For the purpose of interoperability testing, it is assumed that all testing is performed with the temperature in the range of 60 to 80ºF (16 to 27ºC) and the relative humidity in the range of 20% to 60%. If testing is performed under different environmental conditions, then any such deviations should be clearly noted in the resulting test report. If different environmental conditions are required for a specific test case within this supplement, then these conditions will be explicitly stated in the test case.

## 2 Unlabelled

This clause intentionally left blank.

## 3 Interoperability guidelines

### 3.1 Overview

In preparation for interoperability test cycles, this clause provides ONU and OLT vendors with implementation guidelines created to enable multi-vendor interoperability. Interoperability testing between the ONU and OLT uses the ITU-T G.984.x-series Recommendations as the guidelines for all tests. This clause identifies the functionality to be implemented based on these specifications. Both vendors should complete PICS documents for [ITU-T G.984.2], [ITU-T G.984.3] and [ITU-T G.984.4] as a first step in planning the test campaign.

### 3.2 PON initialization and management

#### 3.2.1 PON initialization

An ONU must be able to successfully initialize with the OLT using the activation method described in [ITU-T G.984.3].

#### 3.2.2 Support of equipment management entities

The ONU/OLT should support OMCI and the managed entities defined in [ITU-T G.984.4]. The test plan assumes that OMCI is supported.

#### 3.2.3 Downstream encryption

Downstream encryption is an integral part of the security of the system. It is evaluated to verify that it does not adversely affect service.

## 4 Test configuration and equipment

### 4.1 Network configuration

Figure 1 shows the test configuration for the interoperability testing of the OLT and ONU.

While data service interoperability is out of scope for this test plan, several test cases do rely on the ability to establish a basic data traffic flow between the OLT and ONU. The OLT and ONU vendors will be expected to work together to support this pre-condition. Data test sets should be available for each side of the network.

Temperature and humidity within the laboratory work spaces should be monitored using calibrated temperature and humidity indicators, and should be recorded throughout the testing.

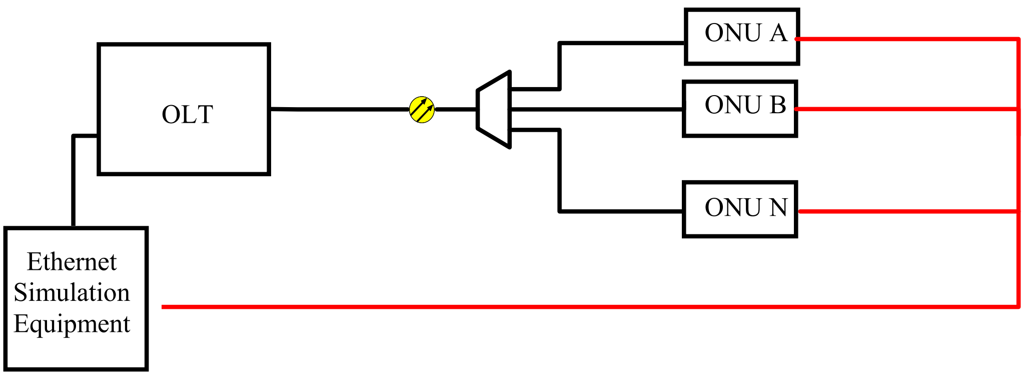


**Figure 1 – Interoperability test configuration**

## 4.2 Equipment requirements

The following test equipment is required:

**Data test equipment – A single test unit with two interfaces should be available**

**ONU** – At least three systems should be available to complete testing. Additional ONUs may be desired to fully build out the capacity of an OLT. The number of ONUs would be dependent upon the type of ONU.

**OLT** – Only one OLT is required for testing. Management must be provided with the OLT. The OLT vendor will be responsible for providing the management interface. Two examples of such a management interface are (1) a craft terminal with a description of all commands needed to perform the test cases in this supplement and (2) EMS access. It is at the discretion of the lab performing the test plan to have a pre-condition requiring that EMS be used to perform all relevant test cases.

**Video** – EDFA, optical combiner, with ability to present the required optical signal level to the ONU. These are only required if test cases involving the RF overlay will be executed.

## 4.3 Network equipment matrix

This matrix should be completed with all lab/test equipment used in the execution of the test plan.

| Equipment type | Quantity | Manufacturer | Model | Software version | Hardware Rev. | Hardware serial number |
|---|---|---|---|---|---|---|
| Data traffic generator | 1 | | | | | |
| OLT | 1 | | | | | |
| ONU | 3 | | | | | |
| Video EDFA (optional) | | | | | | |

## 4.4 Vendor features comparison matrix

G-PON ONU and OLT vendors are encouraged to complete an implementation conformance statement (ICS) showing supported features. A comparison of the statements from both vendors will help identify the portions of this test plan that should be executed for a given OLT-ONU combination. The comparison will identify what optional and conditional G.984 features and functions are in common between the OLT and ONU implementations, in addition to the mandatory features and functions that both implementations must support. PICS (*protocol implementation conformance statement*) documents for G-PON are for future study (FFS) and are not included in this supplement.

# 5 Physical layer compatibility verification

The tests in this area verify fundamental PMD layer conformance to [ITU-T G.984.2] to ensure that subsequent interoperability test results are not biased by physical layer issues or non-conformances of the EUT. Generally speaking, the test procedures are the same as those used in conformance testing (possibly including the insertion of variable reflectance generators to simulate operation over a worst-case ODN), although the EUT is connected to the baseline OLT (and not to an OLT emulator).

## 5.1 Mean launch power

This clause provides test cases for measuring the OLT and ONU transmitter launch power as specified in [ITU-T G.984.2].

### 5.1.1 ONU mean launch power – TX off

**Test case** # 5.10

**Purpose**:

To determine the ONU output power with no input to the transmitter (i.e., transmitter "off"), but powered on. Measurements are made for two states:

1) ONU ranged; and
2) ONU un-ranged.

This test case helps ensure that a powered ONU does not generate excessive optical signal leakage on the ODN when not transmitting (i.e., when waiting for a bandwidth allocation from the OLT or for the start of the ranging process (if un-ranged)).

**Standard (criteria)**: Clause 8.2.6.3 of [ITU-T G.984.2], clause III.3 of [ITU-T G.984.2] Amendment 1, and Appendix V of [ITU-T G.984.2] Amendment 2.

**Preconditions and dependencies**:

The test described in this clause is directly applicable to the ONU. However, it can only be performed if the appropriate equipment is available; e.g., an oscilloscope with sufficient sensitivity to determine conformance to the applicable specification (i.e., –33 to –43 dBm, depending on the particular bit rate, class and whether or not power levelling is supported), or an optical filter to isolate the oscilloscope from the OLT transmitter.

**Test set-up**:

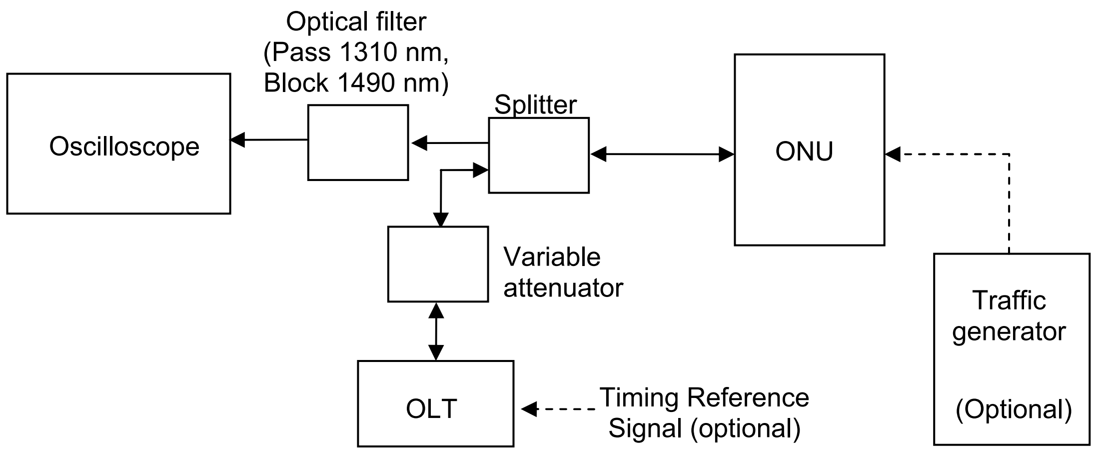


**Figure 2 – ONU mean launched power test configuration – *ONU ranged, TX off***

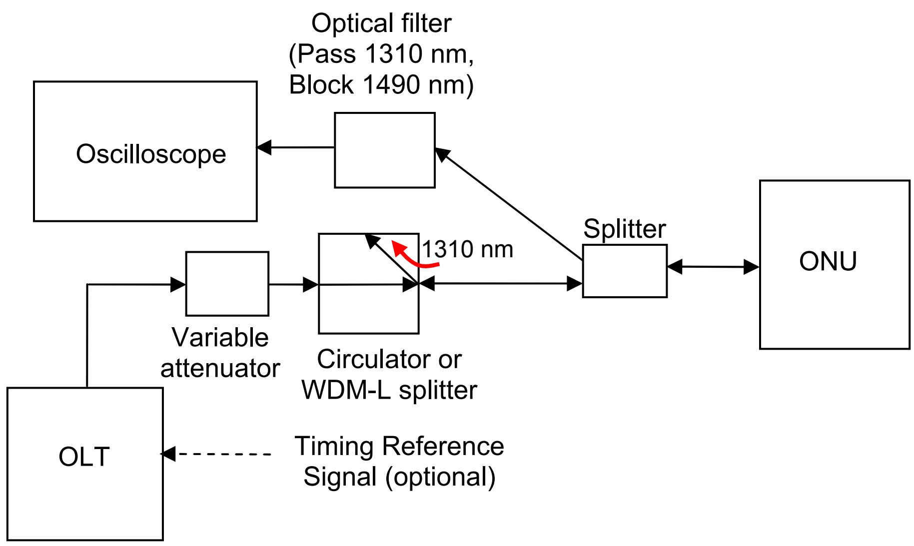


**Figure 3 – Disabled ONU mean launched power test configuration – *ONU Un-ranged***

1) Follow local procedures for cleaning all fibre connectors before making any fibre connections, and configure the system as shown in Figure 3.

2) Note that the configuration of the traffic generator shown in Figure 3 is not of particular importance, and could be omitted entirely, instead relying on (scrambled) idle data in the upstream.

3) Several correction factors will need to be determined for use in calculating the actual output power level from the measured value. These include:

- The insertion loss of the splitter for the output fibre connected to the oscilloscope (i.e., the difference between the input optical power to the splitter and the output power from that output fibre).
- The insertion loss (in the 1310-nm region) of the optical filter used to isolate the oscilloscope from the 1490-nm signal transmitted by the OLT[1].
- The level displayed on the oscilloscope when there is no input signal.

The first two of these correction factors (the optical path loss factors) can be determined using a transmitter that transmits continuously at a wavelength approximately equal to that of the ONU transmitter (i.e., 1310 nm), and can be expressed in units of dB so that they can simply be added to the measured power level when it is expressed in dBm. The third correction factor (the oscilloscope offset factor) can be obtained by disconnecting (from the optical filter's output port or fibre) the fibre jumper that provides the input signal to the oscilloscope, capping the end of that fibre so that no ambient light can enter the fibre and reach the oscilloscope, configuring the oscilloscope to trigger on some other source (e.g., "internal"), and measuring any offset between the zero/ground level and the "no light" trace. Unlike the first two correction factors, this value should be a constant in linear units (rather than in dB), and therefore must be subtracted from the measured power level when it is expressed in linear units (e.g., microwatts).

**Test equipment**:

1) Oscilloscope.
2) Optical splitters.
3) Optical filter.
4) Optical attenuator.
5) Optical circulator or WDM-L splitter.
6) Optical power meter.

**Test procedure**:

1) Adjust the variable attenuator such that the power of the signal reaching the ONU receiver is slightly greater than the minimum level that results in essentially error-free operation of that receiver.

   NOTE – For an ONU that supports the power levelling mechanism defined in [ITU-T G.984.2], this should also result in the power of the signal reaching the OLT to be close to its minimum specified level, causing the OLT to instruct the ONU to operate in Mode 0 (no attenuation).

2) Configure the oscilloscope to display at least several divisions of the transmitter signal received prior to the trigger event, and to trigger on the start of the burst signal transmitted by the ONU.
3) Record, in Table 1, the power level of the "no signal" portion of the trace as measured on the oscilloscope.
4) Apply any applicable correction factors and compare the results to the applicable specification (see pass/fail criteria below).
5) If it appears that the ONU does not meet the specification, decrease the attenuation provided by the variable attenuator to verify that the portion of signal reaching the oscilloscope that originates at the OLT transmitter is negligible. If it is not negligible (e.g., if the measured power level increases significantly when the attenuation is decreased by 3 dB), then the results should be discarded or corrected to account for the presence of the OLT's signal.
6) Disconnect the ONU from the test ODN and power off the ONU.
7) Insert a circulator between the variable attenuator and the splitter so that the configuration is as shown in Figure 3 and the ONU's output signal will *not* reach the OLT. Reconnect the ONU to the test ODN as shown in Figure 3 and power on the ONU.
8) If supported by the G-PON OLT, configure the OLT to set the default ONU transmit power level to "normal" (via the *Upstream_Overhead* PLOAM message transmitted by the OLT). Configure the OLT to periodically generate *Serial_Number Request* events, allowing ONU to respond in an attempt to join the PON.
9) Repeat steps 2 through 5.

---

[1] While the optical splitter provides isolation of the oscilloscope from the 1490 nm OLT downstream signal, further isolation is provided by the optical filter to avoid adversely affecting the ONU transmitter disabled power measurement.

**Table 1 – ONU mean launched power results**

| Status | Measured output power (µW) | Oscilloscope offset correction factor (µW) | Optical path loss correction factors (dB) | Corrected output power (dBm) | Pass/ fail result (Note) |
|---|---|---|---|---|---|
| Ranged ONU Tx-Off | | | | | |
| Un-ranged ONU Tx-Disabled | | | | | |
| NOTE – See pass/fail criteria below. | | | | | |

**Pass/fail criteria**:

Allowable ONU output power levels with no input to the transmitter are a function of minimum OLT receiver sensitivity and:

- the OLT-ONU system line rate being considered in the test campaign;
- the ODN Class(es) (e.g., A, B, B+, or C) operation being considered in the test campaign;
- whether video wavelength overlay is being considered in the test campaign.

ONU output power levels with no input to the transmitter are specified in [ITU-T G.984.2] and its Amendment 1. The maximum ONU output power level with no input to the transmitter is the minimum OLT receiver sensitivity, less 10 dB. These values for G-PON ONUs are shown below:

| Upstream rate | Class A | Class B/B+ | Class C | Class C+ (Note) |
|---|---|---|---|---|
| 1244 Mb/s (w/o power levelling) | –34 or possibly –38 dBm (if APD-based OLT RX) | –38 dBm | –39 dBm | –38 dBm |
| 1244 Mb/s (w/ power levelling | –33 dBm or possibly –38 dBm (if APD-based OLT RX) | –38 dBm | –39 dBm | –38 dBm |
| NOTE – Appendix V of [ITU-T G.984.2] states that "the ONU specifications should be achievable with ONU optics that are substantially similar to those described in Appendix III, except for the difference in upstream wavelength (described in [ITU-T G.984.5]) and operation with FEC (described in [ITU-T G.984.3])". Hence, this Class C+ ONU parameter is assumed to be the same as that for a Class B+ ONU. | | | | |

### 5.1.2 ONU mean launch power – TX enabled

**Test case** # 5.20

**Purpose**:

To determine the mean launched power level of the ONU transmitter when it is in the transmit-enabled state and in the presence of the specified worst-case reflection. (Note that if the ONU transmitter can be externally controlled to transmit continuously, the procedure described in clause 5.1.3 may be used instead.)

**Standard (criteria)**: Clause 8.2.6.3 of [ITU-T G.984.2], clause III.3 of [ITU-T G.984.2] Amd.1, and Appendix V of [ITU-T G.984.2] Amendment 2.

**Preconditions and dependencies**:

The ONU-OLT combination needs to be able to successfully activate, and a data port (e.g., Ethernet) must be provisioned on the ONU for connection of a traffic generator.

This test is directly applicable in cases where a calibrated optical power meter or oscilloscope with sufficient wavelength and input power ranges to measure the ONU output optical signal is available. If the maximum input power level of the power meter or oscilloscope is less than the ONU output power level, then an optical attenuator with a known insertion loss must be inserted between the transmitter and the power meter.

In addition, the splitters (or other optical equipment) that are used to (1) extract the signal transmitted by the ONU from the optical fibre carrying the bidirectional traffic between the OLT and the ONU, (2) isolate the variable reflection generator from the downstream path and (3) isolate ONU-to-power-measurement-equipment optical paths must have minimal polarization dependent loss and be calibrated at a wavelength approximately equal to that of the ONU's output (or have minimal wavelength dependence).

**Test set-up**:

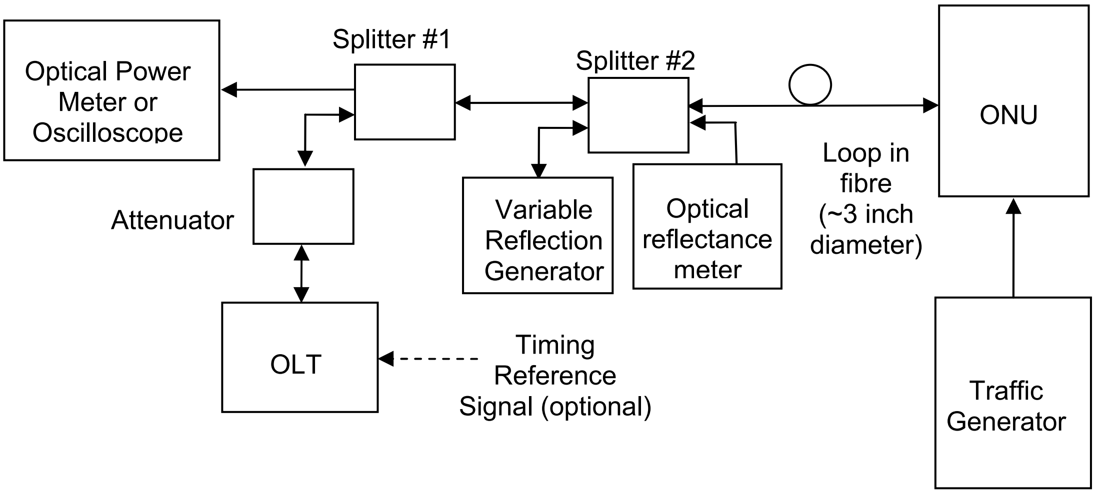


**Figure 4 – ONU mean launched power test configuration**[2]

1) Follow local procedures for cleaning all fibre connectors before making any fibre connections.

2) Configure the system as shown in Figure 4, and set the variable reflection generator so the ORL as seen at the transmitter under test is approximately 15 dB.

   NOTE – In general, the ORL must be verified using a separate configuration (e.g., a configuration similar to that shown in Figure 4 with the OLT replaced by a laser having a central wavelength in the 1310-nm range).

3) Adjust the attenuator in the downstream path to ensure ONU is operating within the attenuation range of the ODN class of interest (e.g., class A, B, B+, C).

4) For a G-PON ONU transmitting at 1244 or 2488 Mb/s, [ITU-T G.984.2] defines a power levelling mechanism that may or may not be supported by the OLT. If such a mechanism is supported, the attenuator shown in Figure 4 must be adjusted so that the level of the signal reaching the OLT ensures the ONU is operating in mode 0 (normal power – *no attenuation*)[3].

5) Note that although the data pattern for this test is specified to be pseudo random, the scrambling process provided at the TC layer should minimize the dependence of the results on the particular pattern that is used. On the other hand, if the system utilizes dynamic bandwidth allocation (DBA), then the traffic generator shown in Figure 4 will generally need to be configured to insert traffic at an appropriate rate (e.g., at a rate that maximizes the duration of the ONU's bursts).

***Power meter vs. oscilloscope considerations***: In general, it is necessary to first determine whether a power meter (or spectrum analyser with power averaging) can be used to measure the power, or whether an oscilloscope is required. In particular:

- If the ONU can be made to transmit for a consistent portion of the available time (and the power meter's measurement time is long compared to the burst length and repetition rate so that each measurement covers multiple periods (e.g., 100) during which a signal is or is not present), then a power meter can be used.
- If the ONU cannot be made to transmit for a consistent portion of the available time, then an oscilloscope must be used (assuming the optical signal can be displayed and the relationship between the trace amplitude and the power level can be established at the wavelength of interest).

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[2] The loop in the fibre connecting the ONU to the test ODN is included in the test set-up so that any optical power that gets launched into the cladding of the fibre (rather than the core) is dissipated before reaching the measurement equipment. This is important for the output power measurement because that power is not useful in a real-world situation (i.e., it leaks away before the signal gets to the receiver), but might otherwise make it through the short fibre used in the test and make the transmitter look hotter than it effectively is.

[3] This may require knowledge of the OLT power levelling threshold(s) or that the ONU provides a local mechanism to determine its power mode (0, 1, 2) upon completion of the activation process.

In the latter case, the approximate average optical power level can be calculated as:

$$P \approx 10 \times \log[(P_1 + P_0)/2] \text{ dBm}$$

- where $P_1$ is the average power in milliwatts for the central 20% of a logic '1' pulse period (i.e., the average "high" level) and $P_0$ is the average power in milliwatts for the central 20% of a logic '0' pulse period (i.e., the average "low" level).

***Correction factors***: One or more correction factors must be determined to calculate the actual output power levels from the measured values. These include:

- The insertion loss of the splitters for the output fibres that are in the ONU-to-power-measurement-equipment optical path (i.e., the difference between the input optical power to splitter #2 and the output power on the appropriate output fibre from splitter #1), which can be determined using a transmitter that transmits continuously at a wavelength approximately equal to that of the ONU transmitter.
- If the ONU transmits for a consistent portion of the available time and the measurement is going to be made using a power meter, then the ratio of the times during which transmission is enabled and disabled (which should be able to be determined using an oscilloscope configured for a relatively slow sweep rate to monitor the optical output signal).

Both of these correction factors can be expressed in units of dB so that they can simply be added to the measured power level (which in turn can be measured directly in units of dBm, or measured in linear units and converted to dBm). For example, if the ONU transmits for X out of every Y µs, the corresponding correction factor for the power measured at a power meter would be:

$$\Delta P_{On/Off} = -10 \times \log(X/Y) \text{ dB}$$

**Test equipment**:

1) Optical power meter or oscilloscope.
2) Optical splitters.
3) Optical attenuator.
4) Variable reflection generator.
5) Traffic generator.
6) Optical reflectance meter.

**Test procedure**:

1) Record the power measured by the power meter or calculated from the high and low levels measured on the oscilloscope, as illustrated in Table 2.
2) Disconnect, clean and reconnect the fibre at the ONU's input/output connector, and repeat these steps until 5 values have been recorded[4].
3) Add any applicable correction factors, calculate the average output optical power, and compare the individual and average power results to the applicable specification.
4) *Optional – this is applicable only for ONU which supports power levelling.* Reduce the attenuation provided by the attenuator shown in Figure 4 so that the OLT instructs the ONU to operate in mode 1 (3 dB of attenuation), and repeat the preceding steps.
5) *Optional – this is applicable only for ONU which supports power levelling.* Reduce the attenuation provided by the attenuator shown in Figure 4 so that the OLT instructs the ONU to operate in mode 2 (6 dB of attenuation), and repeat the preceding steps.

A test results table is provided in Table 2, as a tabular illustration of the measurement steps described in the test procedure.

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[4] The primary purpose of making multiple measurements of the output optical power is to verify the reproducibility of the connection between the equipment under test and the optical fibre. Significant variations in the measured power level could indicate a low-quality or damaged connector. In addition, any single measurement that is greater than the maximum power allowed by the specification would indicate a non-conformance to that specification (even if the average of the five measurements is within the specified range).

**Table 2 – ONU mean launched power test results**

| Trial | Mode <G-PON-only> | Measured output power (dBm) | Correction factors (dB) | Corrected output power (dBm) | Max. and average output power (dBm) | Pass/ fail result (Note) |
|---|---|---|---|---|---|---|
| 1<br>2<br>3<br>4<br>5 | N/A or 0 | | | | | |
| 1<br>2<br>… | 1 | | | | | |
| 1<br>2<br>… | 2 | | | | | |
| NOTE – See pass/fail criteria below. | | | | | | |

**Pass/fail criteria**:

Allowable transmit power levels are a function of:

- the OLT-ONU system line rate considered in the test campaign;
- the ODN class(es) (e.g., A, B, B+, or C) operation considered in the test campaign;
- whether video wavelength overlay is considered in the test campaign.

Average output power levels are specified in clauses 8.2.6, III.3 and Appendix V of [ITU-T G.984.2]. The ONU mean launched power specifications for 1244 Mb/s are as shown below:

| Rate | Mode | Class A | Class B | Class B+/C+ (Note) | Class C |
|---|---|---|---|---|---|
| 1244 Mb/s | N/A | –3 to +2 dBm | –2 to +3 dBm | +0.5 to +5 dBm | +2 to +7 dBm |
| 1244 Mb/s | 0 | –3 to +2 dBm | –2 to +3 dBm | +0.5 to +5 dBm | +2 to +7 dBm |
| 1244 Mb/s | 1 | –6 to –1 dBm | –5 to 0 dBm | –2.5 to +2 dBm | –1 to +4 dBm |
| 1244 Mb/s | 2 | –9 to –4 dBm | –8 to –1 dBm | –5.5 to –1 dBm | –4 to +1 dBm |
| NOTE – Appendix V of [ITU-T G.984.2] states that "the ONU specifications should be achievable with ONU optics that are substantially similar to those described in Appendix III, except for the difference in upstream wavelength (described in [ITU-T G.984.5]) and operation with FEC (described in [ITU-T G.984.3])", Hence this Class C+ ONU parameter is assumed to be the same as that for a Class B+ ONU. | | | | | |

**Test report**: Pass _____Fail _____Not supported _____

**Observation**:

**Last modified**: August 18, 2008.

### 5.1.3 OLT mean launch power

Per the introductory remarks, the equipment under test is considered to be an ONU, with the OLT considered as the baseline equipment. An OLT power measurement test case is provided to allow the organization executing the interoperability tests to verify that the reference OLT is operating within an acceptable range of previously benchmarked values. If results vary from the previously benchmarked values by more than an acceptable deviation (e.g., 2 dB), then investigative/corrective action should be undertaken by the test operator to resolve the discrepancy before proceeding with additional testing.

This OLT measurement can be considered an in-service quality verification check of the OLT, the OLT against which the ONU equipment under test interoperability will be assessed. This measurement should be considered a part of the lab's overall ISO/IEC 17025 quality program.

**Test case** # 5.30

**Purpose**:

To determine the mean launched power level of the OLT optical transmitter in the presence of the specified worst-case reflection. (Note that this procedure can also be used to determine the mean launched power level of an ONU transmitter if that transmitter can be externally controlled to transmit continuously (i.e., placed in a special test mode). Otherwise, see clause 5.1.2 for the ONU mean launch power test procedure.)

In the context of an ONU-centric interoperability test plan, measuring OLT transmit power is an in-service quality verification check.

**Standard (criteria)**: Clauses 8.2.6, III.3 and Appendix V of [ITU-T G.984.2].

**Preconditions and dependencies**:

This test is directly applicable in cases where a calibrated optical power meter with sufficient wavelength and input power ranges to measure the OLT output optical signal is available. If the maximum input power level of the power meter is less than the OLT output power level, then an optical attenuator with a known insertion loss will need to be inserted between the transmitter and the power meter.

**Test set-up**:

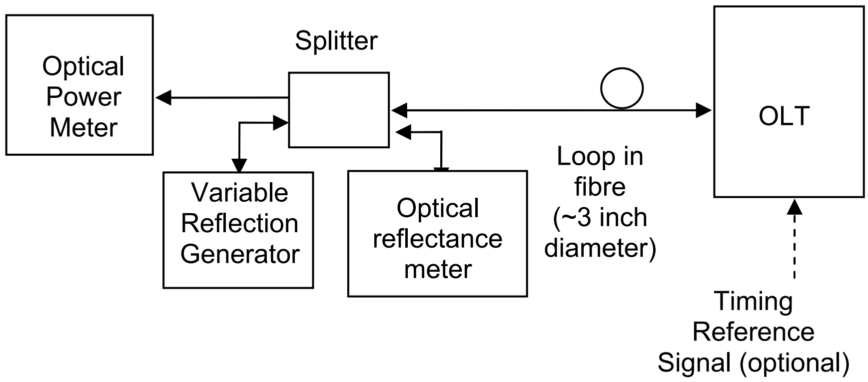


**Figure 5 – OLT mean launched power test configuration**

1) Follow local procedures for cleaning all fibre connectors before making any fibre connections.
2) Configure the system as shown in Figure 5, and set the variable reflection generator so the ORL as seen at the transmitter is approximately 15 dB[5]. In general, the ORL can be verified by inserting a reflection meter between the splitter and the transmitter under test.
3) Determine the insertion loss of the splitter for the output fibre connected to the power meter (i.e., the difference between the input optical power to the splitter and the output power from that output fibre) for use in correcting the power measurements obtained during the tests.
4) Although the data pattern for this test is specified in ITU-T G.984.x series of Recommendations to be pseudo random, the scrambling process provided at the TC layer should provide a sufficiently randomized pattern, even when the OLT is primarily transmitting idle data.

**Test equipment**:

1) Optical reflectance meter.
2) Optical power meter.
3) Optical splitter.
4) Variable reflection generator.

[5] A transmitter has to meet its output power, spectral characteristics, and eye-related specifications in the presence of a –15 dB reflectance (placed immediately downstream from the input/output connector), per clause 8.2.6.7 of [ITU-T G.984.2].

**Test procedure**:

1) Record the power measured by the power meter, as illustrated in Table 3.
2) Disconnect, clean and reconnect the fibre at the OLT's input/output connector, and repeat these steps until 5 values have been recorded[6].
3) Add any applicable correction factors, calculate the average output optical power, and compare the individual and average power results to the applicable specification.

**Table 3 – OLT mean launched power test results**

| Tx | Trial | Measured output power (dBm) | Correction factors (dB) | Corrected output power (dBm) | Pass/ fail result (Note) |
|---|---|---|---|---|---|
| OLT #1 | 1<br>2<br>3<br>4<br>5 | | | | |
| NOTE – See pass/fail criteria below. | | | | | |

**Pass/fail criteria**:

In the context of an ONU-centric interoperability test plan, measuring OLT transmit power is an in-service quality verification check. As such the measurement results are compared to transmit power levels previously collected during the laboratory benchmarking of the baseline OLT. Deviations greater than 2 dB from the benchmark transmit power levels are effectively a "fail" and indicate that investigative/corrective action should be undertaken to resolve the discrepancy before proceeding with additional testing.

Generally speaking, OLTs are expected to comply with the transmit power specifications of [ITU-T G.984.2] and its associated amendments.

**Test report**: Pass _____Fail _____ Not supported _____

**Observation**:

**Last modified**: July 25, 2006.

## 5.2 Receiver sensitivity

This clause provides test cases for assessing ONU and OLT receiver sensitivity. OLT assessment is performed in the context of an in-service quality check.

### 5.2.1 ONU receiver sensitivity

**Test case #** 5.40

**Purpose**:

This test case assesses whether the ONU is able to operate at a bit error ratio (BER) at or below $10^{-10}$ when the received signal is at the minimum acceptable average power specified in ITU-T G.984.x series of Recommendation. The specified procedure measures BER at levels in excess of $10^{-10}$ (e.g., starting at $10^{-7}$) and then uses these measurement results to estimate the receiver power level at which a $10^{-10}$ BER is likely to be achieved.

NOTE – This extrapolation technique has been used for many years with SONET/SDH-based systems, applies to receivers whose performance is thermal noise limited, and helps reduce overall testing times relative to procedures that attempt to directly assess receiver performance at a $10^{-10}$ BER. The extrapolation technique is based on that technique described in step 4.9 of [TIA-526.3], "OFSTP-3 "Fibre optic terminal equipment receiver sensitivity and maximum receiver input".

Examining physical layer transmission performance (BER) helps ensure the underlying PON physical layer transport mechanism is sound before assessing service-level performance.

**Standard (criteria)**: Clauses 8.2.6, III.3 and Appendix V of [ITU-T G.984.2].

[6] The primary purpose of making multiple measurements of the output optical power is to verify the reproducibility of the connection between the equipment under test and the optical fibre. Significant variations in the measured power level could indicate a low-quality or damaged connector.

**Preconditions and dependencies**:

This measurement requires that the OLT-ONU combination be activated and that a data port be provisioned at both the ONU (customer facing interface) and OLT ("V" interface). If estimated ONU receiver BER performance data is available at the OLT (based on the ONU's REI PLOAM messages), then it may be more efficient to use this data in assessing the ONU receiver sensitivity rather than using external test equipment to estimate the BER. Accessing this data typically requires OLT management system or craft interface access. Additionally, any correction factors that need to be applied in order to calculate the power level at the ONU receiver from the power level measured at the power meter or oscilloscope must be determined in advance.

**Test set-up**:

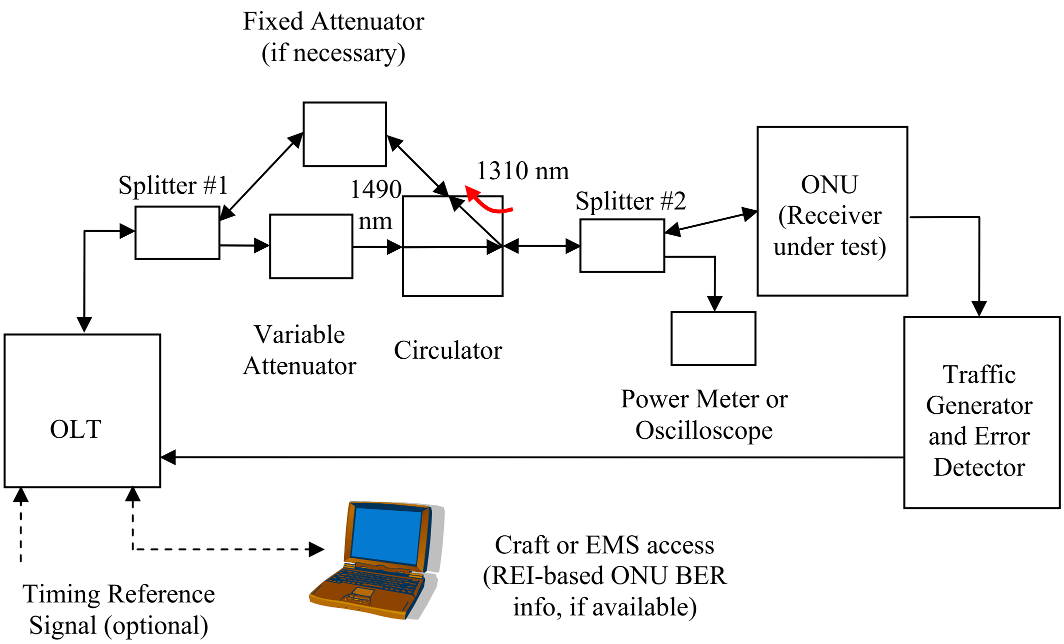


**Figure 6 – Receiver sensitivity test configuration**

1) Follow local procedures for cleaning all fibre connectors before making any fibre connections.
2) Configure the system as shown in Figure 6 and select the fixed attenuator so that the power of the signal reaching the OLT receiver (travelling in the non-test direction) is well within its specified limits, and set the variable attenuator such that the power of the signal reaching the ONU receiver is within that receiver's limits.
3) While a circulator is required, one optimized for operation at 1490 nm should be used if available. The circulator provides an ODN with an asymmetrical attenuation characteristic that helps ensure that degradations in the non-test direction of transmission (i.e., ONU => OLT) do not affect the test results.
4) Configure the traffic generator to insert packets for transmission from the OLT to the ONU.

***Reflectance issues*** – It is important that the directivity of "Splitter #2" and the reflectance characteristics of the circulator (and any connectors located between those two components) be such that the portion of the ONU's optical output signal that reaches the power meter or oscilloscope is negligible. If it is not negligible, then it will be necessary to correct the various power measurements for the returned/reflected power, or to move Splitter #2 such that it is located on the other side of the circulator. (In the latter case, in order to determine the power of the signal reaching the ONU's receiver, it will be necessary to adjust the power levels measured at the power meter or oscilloscope by the loss that occurs through the circulator.)

***Traffic capacity and error measurement issues*** – To reduce the time required to perform this test, the traffic generator should be set to transmit packets (i.e., frames or cells) at a rate that is *slightly* less than the maximum rate that can be continuously supported by the system.

In those cases when PLOAM-based REI messages from the ONU are not used to estimate ONU bit error performance, then the packet loss may need to be measured in lieu of bit errors. Direct measurement of bit errors may not be possible as packets that are errored during transmission may be discarded by the ONU, rather than being passed downstream to the UNI (error detector). In such cases the traffic generator and error detector would need to be configured such that the number of packets sent to the OLT (for transmission through the system) can be compared to the number of packets received from the ONU (packet loss). A technique to estimate bit errors from the number of lost packets is described below.

***BER calculation issues*** – This BER calculation discussion is applicable in those cases when PLOAM-based REI messages from the ONU are *not* used to estimate ONU bit error performance, in which case packet loss will be used to estimate ONU bit error performance.

The BER can be approximated by dividing the number of packets that were errored (or lost) by the product of the number of packets transmitted and the number of bits ("N") per packet that, if errored, would cause the packet to be detected as errored (or discarded).

$$\text{BER} \sim \text{PL} / [\text{PT} \times \text{N}], \text{where}$$

PL = Packets Lost.

PT = Packets Transmitted.

N = # of bits within a packet that, if errored, would result in a lost packet.

"N" typically will not include the GEM header, as that portion of the signal is required to be protected against errors via a header error correction (HEC) function.

As an example, for a 512 byte Ethernet frame with no FEC:

N = 8 bits/byte × 512 bytes = 4096 bits.

This formula is derived by expressing the packet loss probability, P(PL), as a function of the bit error probability, P(B). Specifically, P(PL) = N × P(B). P(L) can be approximated by PL/PT (# lost packets / # packets transmitted). Hence, PL/PT ≈ N × BER and BER ≈ PL / (PT × N).

***Power measurement issues*** – In receiver sensitivity tests, it is generally recommended (and in some cases, essential) that the test set-up include equipment that allows a signal whose power level is proportional to the power of the signal reaching the receiver to be continuously monitored (e.g., to detect optical power fluctuations, either random or as a result of the power levelling function, that could have a significant impact on the short-term BER). In the test set-up shown in Figure 6, this function is provided by "Splitter #2" and the "Power meter or oscilloscope". In the ideal case, the signal would be continuously present (so that its power level could be measured directly with a power meter), and the power of the signal reaching the receiver under test would be equal to the power of the signal reaching the power meter. However, in practice at least one correction factor, to account for the difference in the powers of the signals appearing on the splitter's output fibres, typically needs to be applied.

**Test equipment**: See Figure 6.

**Test procedure**:

Depending on the type of traffic and the test set used to generate and detect errors or lost packets on that traffic, the test set may display the BER directly. Also, estimated ONU receiver BER performance data may be available at the OLT (estimated via received REI PLOAM messages). In such cases, it will generally not be necessary to record and calculate certain values as described in this procedure.

1) Ensure that downstream FEC is disabled.
2) Gradually increase the attenuation until bit errors begin to occur at a significant rate (e.g., at a BER of approximately $10^{-7}$) and the measured power is at a convenient level for plotting purposes. This is the starting point for a series of BER measurements.
3) Clear the error or transmitted and received packet counters, and cause the traffic generator to send a known number of packets in the test direction.
4) Record the power level displayed by the optical power meter (or oscilloscope), the BER estimate retrieved from the OLT (if supported), or the number of packets transmitted and the number of packets errored (or lost) during transmission (if OLT-based retrieval of ONU BER performance data is not available)[7].
5) Calculate the power level of the signal at the ONU receiver and (if OLT-based retrieval of ONU BER performance data is not available) the approximate BER at that power level.

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[7] It is recommended that the BER measurement at any particular power level be continued until at least 10 (or better yet, 100) errors have been detected. However, due to transmitter output stability issues and traffic capacity and time limitations, this may not be possible in some situations. Data collected during shorter test periods should be carefully evaluated.

6) If any packets were errored (or lost) at the test power level (or REI data received by the OLT), decrease the attenuation by approximately 0.5 dB (or if desired 0.25 dB) and return to step 5. Continue this process of decreasing the attenuation until *at least* five RX power/BER data points have been recorded. If no errors are encountered before five data points have been collected, then repeat steps 4 through 8, this time decreasing the attenuation in smaller steps.

7) Plot the recorded BER versus received power data on graph paper equivalent to that shown in Figure 7. (Note that the y-axis scale used for this graph paper is not a standard linear or log scale. Instead, it is a scale that is based on the complementary error ("Q") function and is specifically derived for plotting BER versus received power data for typical optical receivers per [TIA-526.3].)

8) Fit a line through the data points and determine the power level at which that line crosses the BER level of $10^{-10}$.

9) Compare the result to the applicable criteria or specifications for that receiver. In general, the measured sensitivity for a new receiver should be several dB better than the value given in the criteria, to allow for the effects of aging. (see ITU-T G.957 Amendment 2 for more on aging effects).

10) If the OLT supports FEC encoding, then enable downstream FEC encoding at the OLT.

    a) If the ONU EUT does not support FEC decoding, simply spot-check several of the previously recorded (BER, RX) power data points (recorded when OLT FEC encoding = was set to OFF) to verify no ONU RX performance change is evident (the ONU is expected to ignore the OLT-insert FEC parity inserted by the OLT and operate with the same RX performance as with OLT FEC encoding OFF).

    b) If the ONU EUT supports FEC decoding, repeat steps 4 through 10. In step 4 the likely observable non-zero BER will be closer to $10^{-3}$. As attenuation is decreased from the starting point measurement, select an appropriate attenuation step granularity to produce enough BER versus received power data points to fit a line to, per step 10 (the line is likely to be very steep). Also, fluctuations in the power received by the ONU (for a given attenuation) should be very carefully monitored to ensure that power variations do not skew the BER data. (When the BER versus received power line is very steep, a relatively short period in which the received power is less than the setpoint can cause a large increase in the average BER.)

A test results table is provided in Table 4 as a tabular illustration of the measurement steps described in the test procedure. In cases where FEC encoding (and possibly decoding) is supported, results tables should be completed for each case tested.

**Table 4 – Receiver sensitivity test results**

| Measured power (dBm) | Correction factors (dB) | Received power (dBm) | Packets sent | Packets errored or lost | BER (Note 1) | Calc. Sens. (dBm) and pass/fail results (Note 2) |
|---|---|---|---|---|---|---|
| | | | | | | |
| NOTE 1 – The number of bits per packet (for use in the denominator of the BER calculation) is _______. (See the discussion in the "set-up" paragraph above regarding the determination of the appropriate value.)<br>NOTE 2 – See pass/fail criteria paragraph below. | | | | | | |

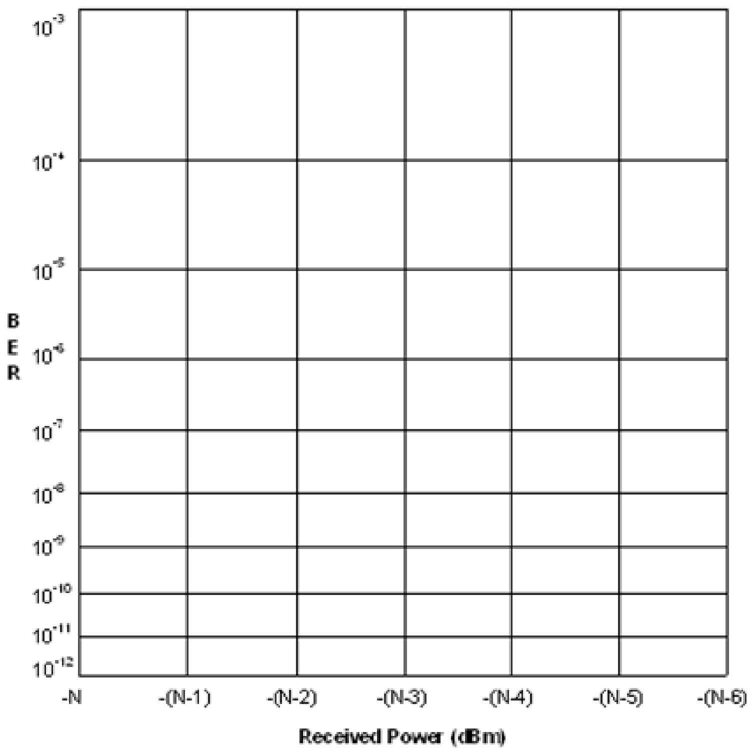



**Figure 7 – BER Versus Received Power Plotting Paper**

**Pass/fail criteria**:

The receiver sensitivity specifications are that the BER must be $1\times10^{-10}$ or better when the power at the ONU receiver is as shown below. Receivers are expected to display several dB of margin to allow for the effects of aging, the use of a transmitter with a better than worst-case extinction ratio and pulse rise and fall times, and the absence of the worst-case ORL at the transmitter.

ONU receiver sensitivity criteria are specified in Table 2c, Table III.1 and Table V.1 of [ITU-T G.984.2].

| Downstream rate | Class A | Class B | Class B+ | Class C | Class C+ (Note) |
|---|---|---|---|---|---|
| 2488 Mb/s | –21 dBm | –21 dBm | –27 dBm | –28 dBm | –30 dBm |
| NOTE – Appendix V of [ITU-T G.984.2] states "The ONU sensitivity assumes the use of the optional RS(255,239) FEC capability of the G-PON TC layer with the current class B+ ONU detector technology". A pre-FEC Bit error ratio of $10^{-4}$ is specified. | | | | | |

**Test report**: Pass _____Fail _____ Not supported _____

**Observation**:

**Last modified**: August 18, 2008.

### 5.2.2 OLT receiver sensitivity

**Test case** # 5.50

**Purpose**: This OLT measurement can be considered an in-service quality verification check of the OLT, helping to ensure that no unexpected degradations have occurred in the OLT, against which ONU interoperability is assessed. In addition, this measurement may highlight unexpected upstream transmission performance issues related to the specific characteristics of the ONU's transmitted signal.

**Standard**: Clauses 8.2.6, III.3 and Appendix V of [ITU-T G.984.2].

**Preconditions and dependencies**: The measurement requires that the OLT-ONU combination be activated and that a data port be provisioned at both the ONU (customer facing) and OLT ("V" interface).

**Test set-up**: See Figure 6 with the OLT now in the position of the receiver under test and a circulator optimized for operation at 1310 nm. Configure the traffic generator to insert packets for transmission from the ONU to the OLT.

**Test procedure**: See ONU test case procedure of clause 5.2.1, with OLT substituted for ONU. Note that the power correction factor equivalent to $\Delta P_{On/Off}$ (see clause 5.1.2) will also need to be applied when measuring the received power (ONU upstream burst) at the OLT using an optical power meter. OLT receiver performance data may be directly accessible via a craft/EMS terminal, in which case the use of an external error counter at the SNI is not required.

If the OLT and ONU support FEC, then initially perform the test with upstream FEC encoding OFF (disabled). Then repeat the test with upstream FEC ON. The downstream FEC encoding status is inconsequential as this is the non-test direction, with relatively modest attenuation present.

**Pass fail criteria**: In the context of an ONU-centric interoperability test plan, measuring OLT receiver sensitivity is an in-service quality verification check. As such the measurement results are compared to receiver sensitivity previously collected during the benchmarking of the baseline OLT. Degradations greater than 2 dB from the benchmark receiver sensitivity are effectively a fail, and indicate that investigative/corrective action should be undertaken before proceeding with additional testing.

Generally speaking, OLTs are expected to comply with the receiver sensitivity specifications of clause 8.2.8 of [ITU-T G.984.2].

The OLT receiver sensitivity criteria are (see clause 8.2.8 of [ITU-T G.984.2]:

| Upstream rate | Class A | Class B | Class B+ | Class C | Class C+ (Note) |
|---|---|---|---|---|---|
| 1244 Mb/s | –24 dBm | –28 dBm | –28 dBm | –29 dBm | –32 dBm |
| NOTE – Appendix V of [ITU-T G.984.2] states "The OLT sensitivity assumes the use of the optional RS(255,239) FEC capability of the G-PON TC layer, as well as intrinsic detector technology improvements, e.g., SOA preamplification". A pre-FEC Bit error ratio of $10^{-4}$ is specified. | | | | | |

**Test report**: Pass _____Fail _____ Not supported _____

**Observation:**

**Last modified**: August 18, 2008.

## 5.3 Receiver overload

This clause provides test cases for assessing ONU and OLT receiver overload. The test cases seek to determine the maximum average received power levels at which the OLT and ONU receivers are able to operate (i.e., maintain a BER of $10^{-10}$ or better). OLT assessment is performed in the context of an in-service quality check.

Receiver overload is measured against a signal with worst-case G.984 extinction ratio and pulse rise and fall times. For the purpose of interoperability testing, however, receiver overload is measured when the incoming signal is from a real OLT (or ONU) implementation (i.e., not using a test transmitter with controlled transmitted signal characteristics). This implies the transmitter may have better-than-worst-case extinction ratio. While one might consider applying a correction factor for measurements made with transmitters with better-than-worst-case extinction ratio, this is deemed difficult or impossible because of the complicated relationship between the eye diagram degradations (which result in errors at the receiver) and the power and extinction ratio of a high-power input signal.

**COMMENT**: Due to the very steep slope of the BER versus received power line in the high power region for most receivers, some believe that FEC encoding/decoding will not have a significant impact on the receiver overload test results. Therefore, no discussions of FEC or FEC-related steps have been added to receiver overload procedures. If such steps are desired, they can be based on the steps that have been added to the receiver sensitivity test case. Some minor editorial changes are, however, suggested below.

### 5.3.1 ONU receiver overload

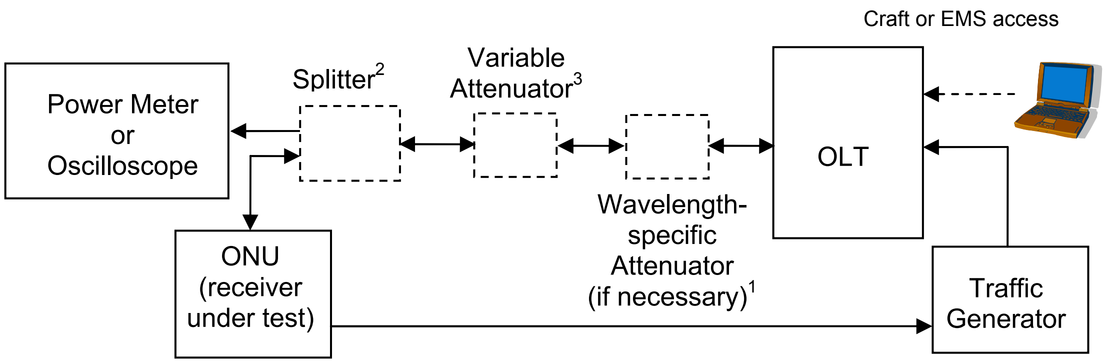
**Test case** # 5.60

**Purpose**: To determine the maximum average received power level at which the ONU receiver is able to operate (i.e., maintain a BER of $10^{-10}$ or better) when receiving a signal from the baseline OLT transmitter.

**Standard**: Clauses 8.2.6, III.3 and Appendix V of [ITU-T G.984.2].

**Preconditions and dependencies**: The measurement requires that the OLT-ONU combination successfully activate, and that a data port be successfully provisioned at both the ONU (customer facing interface) and OLT ("V" interface). If estimated ONU receiver BER performance data is available at the OLT (based on the ONU's REI PLOAM messages), then it may be more efficient to use this data in assessing the ONU receiver overload rather than using external test equipment to estimate the BER. Accessing this data typically requires OLT management system or craft interface access.

**Test set-up**:




NOTE 1 – The purpose of the wavelength-specific attenuator (or equivalent equipment such as an optical filter or a fixed attenuator located between a pair of circulators) is to reduce the power of the 1310-nm signal generated by the ONU to a level that can be tolerated by the OLT receiver (non-test direction), while simultaneously allowing the 1490 nm signal generated by the OLT to pass through with minimal attenuation.

NOTE 2 – If the test equipment insertion losses are such that the power level of a minimally attenuated signal is less than that at which overload occurs (or the minimum specified overload power level), then it may be necessary to perform the BER and power measurements separately using different test configurations. For example, each BER measurement could be made with the splitter removed from the set-up, and then the splitter could be inserted for the corresponding power measurement (which would then need to be corrected for the splitter's insertion loss).

NOTE 3 – If after removing the splitter (Note 2) the power level is still insufficient for completion of the test (and an unattenuated signal will not cause damage to the receiver), then the variable attenuator can also be removed.

**Figure 8 – Receiver overload test configuration**

1) Follow local procedures for cleaning all fibre connectors before making any fibre connections.
2) Configure the system as shown in Figure 8 and set the variable attenuator such that the power of the signal reaching the ONU receiver is within that receiver's limits. If necessary, the (1310 nm) wavelength specific attenuator (or functional equivalent) should be configured such that the power of the signal reaching the OLT receiver (in the non-test direction) is kept within that receiver's limits through the expected range of the variable attenuator adjustments.

**Traffic capacity and error measurement, BER calculation, and power measurement issues** – See clause 5.2.1, ONU receiver sensitivity.

**Test equipment**: See Figure 8.

**Test procedure**:

Depending on the type of traffic and the test set used to generate and detect errors or lost packets on that traffic, the test set may display the BER directly. Also, estimated ONU receiver BER performance data may be available at the OLT (estimated via received REI PLOAM messages). In such cases, it will generally not be necessary to record and calculate certain values as described in this procedure.

1) Determine the correction factors that must be applied in order to calculate the power level at the ONU receiver from the power level measured at the power meter or oscilloscope.
2) Configure the traffic generator to insert packets for transmission from the OLT to the ONU.
3) Gradually decrease the attenuation until bit errors begin to occur at a significant rate (e.g., at a BER of approximately $10^{-7}$) and the measured power is at a convenient level for plotting purposes. This is the starting point for a series of BER measurements.
4) Clear the error or transmitted and received packet counters, and cause the traffic generator to send a known number of packets in the test direction.
5) Record the power level displayed by the optical power meter (or oscilloscope), the BER estimate retrieved from the OLT (if supported), or the number of packets transmitted and the number of packets

errored (or lost) during transmission (if OLT-based retrieval of ONU BER performance data is not available)[8].

6) Calculate the power level of the signal at the ONU receiver and (if OLT-based retrieval of ONU BER performance data is not available) the approximate BER at that power level.

7) If any packets were errored (or lost) at the test power level (or REI data received by the OLT indicated that errors occurred), increase the attenuation by approximately 0.2 dB and return to step 4. (Note that for most receivers the BER versus received power curve is expected to be very steep at high power levels, and therefore it may be necessary to utilize small changes in the received power. In addition, it may not be necessary to plot the results as indicated in the following step.)

8) Plot the recorded BER versus received power data on graph paper equivalent to that shown in Figure 7. (Note that the y-axis scale used for this graph paper is not a standard linear or log scale. Instead, it is a scale that is based on the complementary error function and is specifically derived for plotting BER versus received power data for typical optical receivers (per [TIA-526.3]).)

9) Fit a curve through the data points and determine the power level at which that curve crosses the BER level of $10^{-10}$.

**Table 5 – Receiver overload test results**

| Measured power (dBm) | Correction factors (dB) | Received power (dBm) | Packets sent | Packets errored or lost | BER (Note 1) | Calc. Sens. (dBm) and pass/fail results (Note 2) |
|---|---|---|---|---|---|---|
| | | | | | | |
| NOTE 1 – The number of bits per packet (for use in the denominator of the BER calculation) is _________. (See the discussion in the "Set-up" paragraph of clause 5.2.1, *ONU receiver sensitivity* above regarding the determination of the appropriate value.)<br>NOTE 2 – See pass/fail criteria paragraph below. | | | | | | |

**Pass/fail criteria**:

The receiver overload specifications are that the BER must be $10^{-10}$ or better when the power at the ONU receiver is as shown below.

G-PON receiver overload criteria are specified in clause 8.2.8 of [ITU-T G.984.2].

| Downstream rate | Class A | Class B | Class B+ | Class C | Class C+ (Note) |
|---|---|---|---|---|---|
| 2488 Mb/s | –1 dBm | –1 dBm | –8 dBm | –8 dBm | –8 dBm |
| NOTE – ITU-T G.984.2, Appendix V states "The ONU overload is set at –8 dBm to be common with the class B+ value, even though in this application –10 dBm is sufficient". | | | | | |

**Test report**: Pass _____Fail _____ Not supported _____

**Observation**:

**Last modified**: August 18, 2008.

### 5.3.2 OLT receiver overload

**Test case** # 5.70

**Purpose**: This OLT measurement can be considered an in-service quality verification check of the OLT, helping to ensure that no unexpected degradations have occurred in the OLT, against which the ONU equipment under test interoperability is assessed. In addition, this measurement may highlight unexpected upstream transmission performance issues related to the specific characteristics of the ONU's transmitted signal (e.g., pulse characteristics and extinction ratio).

**Standard (criteria)**: Clauses 8.2.6, III.3 and Appendix V of [ITU-T G.984.2].

[8] In almost all cases it is recommended that the BER measurement at any particular power level be continued until at least 10 (or better yet, 100) errors have been detected. However, due to transmitter output stability issues and traffic capacity and time limitations, this may not be possible in some situations. Data collected during shorter test periods should be carefully evaluated.

**Preconditions and dependencies**: The measurement requires that the OLT-ONU combination successfully activate, and that a data port be successfully provisioned at both the ONU (customer facing) and OLT ("V" interface).

**Test set-up**: See Figure 8 with the OLT now in the position of the receiver under test and a 1490-nm wavelength-specific attenuator.

**Test equipment**: See Figure 8.

**Test procedure**: See ONU test case procedure of clause 5.3.1, with OLT substituted for ONU.

**Pass/fail criteria**: In the context of an ONU-centric interoperability test plan, measuring OLT receiver overload is an in-service quality verification check. As such the measurement results are compared to receiver overload previously collected during the benchmarking of the baseline OLT. Degradations greater than 2 dB from the benchmark receiver overload are effectively a "fail" and indicate that investigative/corrective action should be undertaken before proceeding with additional testing.

Generally speaking, OLTs are expected to comply with the receiver overload specifications of clause 8.2.8 of [ITU-T G.984.2].

The receiver overload specifications based on clauses 8.2.6, III.3 and Appendix V of [ITU-T G.984.2] are shown below.

| Upstream rate | Class A | Class B | Class B+ | Class C | Class C+ |
|---|---|---|---|---|---|
| 1244 Mb/s | –3 dBm | –7 dBm | –8 dBm | –8 dBm | –12 dBm |

**Test report**: Pass _____Fail _____ Not supported _____

**Observation**:

**Last modified**: August 18, 2008.

## 5.4 OLT and ONU emission wavelengths

This clause provides test cases for measuring the nominal OLT and ONU emission wavelengths as specified in [ITU-T G.984.2]. Nominal wavelengths are those observed at the environmental test conditions specified in clause 1.

### 5.4.1 Nominal OLT emission wavelength

**Test case** # 5.80

**Purpose**:

To measure the OLT emission wavelength for each PON interface of the OLT. In the context of an ONU-centric interoperability test plan, measuring OLT emission wavelength is a quality verification check, since the OLT does serve as the reference source for the ONU receiver test cases. As such, this test case serves as a preliminary/reference test to verify that the OLT emission wavelength meets the G.984.2 specifications.

**Standard (criteria)**: Table 2c of [ITU-T G.984.2].

**Preconditions and dependencies**:

The test described in this clause is directly applicable to the OLT. Each equipment used for this measurement has to work in the ideal conditions (temperature, power) recommended by the provider (equipment specifications).

**Test set-up**:

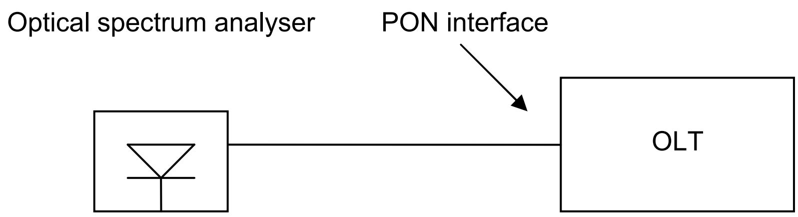



**Figure 9 – OLT emission wavelength test configuration**

**Test equipment**:

1) Optical spectrum analyser.

**Test procedure**:

1) Activate OLT PON interface.
2) Establish an optical connection between OLT and optical spectrum analyser via Input connector.
3) Record the wavelength measured by the analyser, as illustrated in Figure 9.
4) Disconnect, clean and reconnect the fibre at the OLT's input/output connector, and repeat these steps until 5 values have been recorded.

**Table 6 – OLT emission wavelength results**

| Measurement number | Measured wavelength (nm) | Pass/<br>fail result (Note) |
|---|---|---|
| 1 | | |
| 2 | | |
| 3 | | |
| 4 | | |
| 5 | | |
| NOTE – See pass/fail criteria below. | | |

**Pass/fail criteria**:

Allowable OLT emission wavelengths fall within the range specified by Table 2c of [ITU-T G.984.2] (1480-1500 nm).

- Pass if wavelength is between 1480 nm and 1500 nm.
- Fail if wavelength is <1480 nm or >1500 nm.

**Test report**: Pass _____Fail _____ Not supported _____

**Observation**:

**Last modified**: January 2, 2009.

### 5.4.2 Nominal ONU emission wavelength

**Test case** # 5.90

**Purpose**:

To measure the ONU emission wavelength.

**Standard (criteria)**: Table 2f of [ITU-T G.984.2]. Optionally, Table 1 of [ITU-T G.984.5] may be used if the ONU under test is designed to comply with either the reduced wavelength band option or the narrow wavelength band option, both of which are defined in [ITU-T G.984.5].

**Preconditions and dependencies**:

The measurement requires that the OLT-ONU combination successfully activate, and that a data port be successfully provisioned at both the ONU (customer facing) and OLT ("V" interface). A traffic generator is also connected to the ONU in order to generate upstream traffic. Each equipment used for this measurement has to work in the ideal conditions (temperature, power) recommended by the provider (equipment specifications).

**Test set-up**:

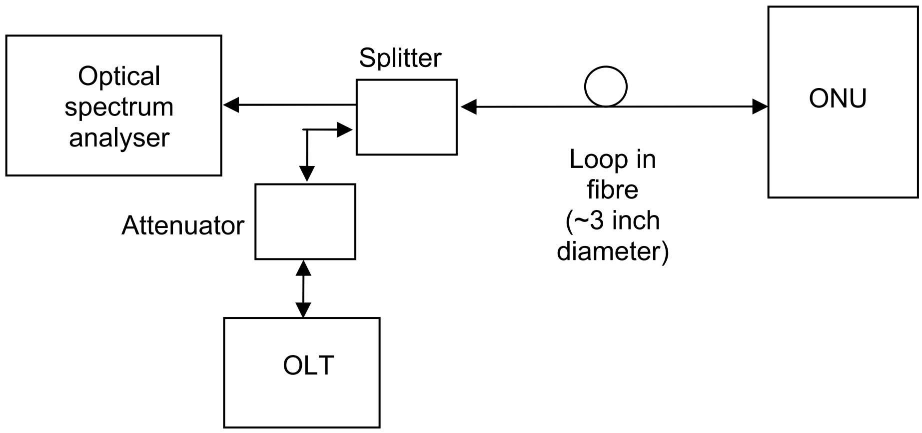



**Figure 10 – ONT emission wavelength test configuration**

**Test equipment**:

1) Optical spectrum analyser.
2) Optical splitter.
3) Optical attenuator (if necessary).
4) Traffic generator.

**Test procedure**:

1) Record the wavelength measured by the analyser, as illustrated in Figure 10.
2) Disconnect, clean and reconnect the fibre at the ONU's input/output connector, and repeat these steps until 5 values have been recorded.

**Table 7 – ONU emission wavelength results**

| Measurement number | Measured wavelength (nm) | Standard reference (G.984.2, G.984.5 reduced band option, or G.984.5 narrow-band option) | Pass/fail result (Note) |
|---|---|---|---|
| 1 | | | |
| 2 | | | |
| 3 | | | |
| 4 | | | |
| 5 | | | |
| NOTE – See pass/fail criteria below. | | | |

**Pass/fail criteria**:

Allowable ONU emission wavelengths fall within the range specified by Table 2f of [ITU-T G.984.2] (1260-1360 nm).

- Pass if wavelength is between 1260 nm and 1360 nm.
- Fail if wavelength is <1260 nm or >1360 nm.

If the ONU is being tested against the reduced wavelength band option (1290-1330 nm) specified in [ITU-T G.984.5], then the following criteria apply:

- Pass if wavelength is between 1290 nm and 1330 nm.
- Fail if wavelength is <1290 nm or >1330 nm.

If the ONU is being tested against the narrow wavelength band option (1300-1320 nm) specified in [ITU-T G.984.5], then the following criteria apply:

- Pass if wavelength is between 1300 nm and 1320 nm.
- Fail if wavelength is <1300 nm or >1320 nm.

**Test report**: Pass _____Fail _____ Not supported _____

**Observation**:

**Last modified**: January 2, 2009.

# 6 ONU turn-up and management

This test area considers fundamental PON functionality, both for turn-up and ONU management as described in [ITU-T G.984.3]. The test cases are generally characterized by the pair-wise nature of the testing (i.e., a single ONU interoperating with the OLT).

## 6.1 ONU start-up

Unlike B-PON, there is only one method for ONU discovery in G-PON. It requires an automatic detection mechanism of the serial number of the ONU.

Activation of an ONU may be initiated in two possible ways:

- The network operator enables the activation process to start when it is known that a new ONU has been connected. After successful ranging (or a time-out), ranging is automatically stopped.
- The OLT periodically and automatically initiates the activation process, testing to see if any new ONUs have been connected. The frequency of polling is programmable such that ranging can occur every millisecond to every second.

### 6.1.1 Cold PON – Cold ONU

This situation exists when no upstream traffic is running on the PON and the ONUs have not yet received PON-IDs from the OLT.

**Test case** # 6.10

Initialization, cold PON, cold ONU.

**Purpose**:

To verify that the OLT initializes the ONU.

**Standard**:

Clause 10 of [ITU-T G.984.3].

**Preconditions**:

Three ONUs not connected to the PON and powered down. OLT auto detects the ONU serial numbers of the ONUs under test. EMS or craft terminal on the OLT to recognize the presence of the ONU.

**Test equipment**:

None.

**Test set-up**:

Default test set-up as shown in Figure 1.

**Test procedure**:

Automatic activation:

1) Power up ONU1.
2) After the ONU1 completes its boot process connect ONU1 to the fibre.
3) ONU shall range in 30 s.
4) Disconnect ONU1 from the fibre and power down.
   Repeat for ONU2 and ONU3.

Manual activation:

1) Power up ONU1.
2) After the ONU1 completes its boot process connect ONU1 to the fibre.
3) Manually start the ranging process.
4) ONU shall range in 30 s.
5) Disconnect ONU1 from the fibre and power down.
   Repeat for ONU2 and ONU3.

**Pass/fail criteria**:

Fail if any ONU does not range or if the ranging times exceed the requirement.

**Test report**: Pass _____Fail _____ Not supported _____

**Observations**:

Elapsed time, power on to ranging complete (min, average, max).

**Last modified**: July 25, 2006.

### 6.1.2 Warm PON and cold ONU

This situation is characterized by the addition of new ONU(s) which have not been previously ranged, or by the addition of previously active ONU(s) having power restored and coming back to the PON while traffic is running on the PON.

**Test case** # 6.20

**Purpose**:

To verify that the OLT initializes the ONU.

**Standard**:

Clause 10 of [ITU-T G.984.3].

**Preconditions**:

Three ONUs not connected to the PON and powered down plus one additional ONU connected and ranged to PON. OLT auto detects the ONU serial numbers of the ONUs under test. The PON has at least one ONU connected and ranged with upstream traffic. EMS or craft terminal on the OLT to recognize the presence of the ONU.

**Test equipment**:

Traffic generator.

**Test set-up**:

Default test set-up as shown in Figure 1 with an additional ONU connected and active during test iterations. A traffic generator is also connected to the additional ONU in order to generate upstream traffic.

**Test procedure**:

Automatic activation:

1) Connect ONU1 to fibre and power up.
2) ONU shall range within 30 s.
3) Power down and disconnect ONU1 fibre.

   Repeat for ONU2 and ONU3.

Manual activation:

1) Connect ONU1 to fibre and power up.
2) Manually start ranging.
3) ONU shall range within 30 s.
4) Power down and disconnect ONU1 fibre.

   Repeat for ONU2 and ONU3.

**Pass/fail criteria**:

Fail if any ONU does not range or if the ranging times exceed the requirement or if the upstream traffic on the additional ONU is disrupted.

**Test report**: Pass _____Fail _____Not supported _____

**Observations**:

Elapsed time, power on to ranging complete (min, average, max).

**Last modified**: December 16, 2008.

### 6.1.3 ONU ranging – Various cable lengths

The following test cases verify start-up interoperability between OLTs and ONUs for ranging at various fibre lengths. The tests are iterations of test case 6.10 with different ODN characteristics.

Test cases are performed with 10 km and 20 km of fibre between the OLT and the splitter. Optional test cases are included that incorporate an extender box and use 40 km and 60 km between the OLT and the splitter.

**Test set-up**:

The basic test set-up for the ONU start-up tests is shown in Figure 11. It consists of a single ONU connected to the OLT, except as noted in certain test cases, with either 10 or 20 km of fibre between the OLT and the splitter. Note that the splitting ratio will vary according to the optical class. The figure below shows a 1 x 32 splitter for reference only.

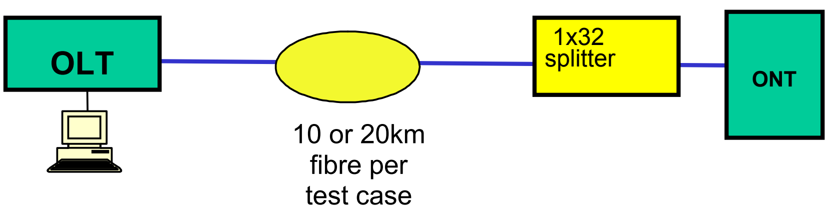



**Figure 11 – ONU ranging test configuration**

Figure 12 shows the test set-up for the optional test cases that use 40 or 60 km of fibre between the OLT and splitter.

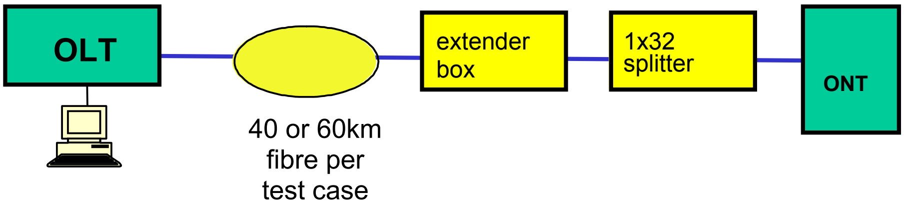



**Figure 12 – ONU ranging with extender box**

#### 6.1.3.1 Cold PON – Cold ONU – 10 km fibre

**Test case** # 6.30

**Purpose**:

To verify that the OLT initializes the ONU when the ONU is registered in OLT prior to startup and when the ONU is at a given fibre distance from OLT.

**Standard**:

Clause 10 of [ITU-T G.984.3].

**Preconditions**:

Three ONUs not connected to the PON and powered down. OLT contains the serial numbers of the ONUs under test. EMS or craft terminal on the OLT to recognize the presence of the ONU. There is a 10 km fibre cable between the OLT and the 1 x 32 splitter.

**Test equipment**:

None.

**Test set-up**:

A 10 km test set-up as shown in clause 6.1.3.

**Test procedure**:

Automatic activation:

1) Connect ONU1 to fibre and power up.
2) ONU shall range within 30 s.
3) Power down and disconnect ONU1 fibre.

   Repeat for ONU2 and ONU3.

Manual activation:

1) Connect ONU1 to fibre and power up.
2) Manually start ranging.
3) ONU shall range within 30 s.
4) Power down and disconnect ONU1 fibre.

   Repeat for ONU2 and ONU3.

**Pass/fail criteria**:

Fail if any ONU does not range or if the ranging times exceed the requirement.

**Test report**: Pass _____Fail _____ Not supported _____

**Observations**:

Elapsed time, power on to ranging complete (min, average, max).

**Last modified**: July 26, 2006.

#### 6.1.3.2 Cold PON – Cold ONU – 20 km

**Test case** # 6.40

**Purpose**:

To verify that the OLT initializes the ONU when the ONU is registered in OLT prior to start-up and the ONU is at a given fibre distance from the OLT.

**Standard**:

Clause 10 of [ITU-T G.984.3].

**Preconditions**:

Three ONUs not connected to the PON and powered down. OLT auto detects the ONU serial numbers of the ONUs under test. EMS or craft terminal on the OLT to recognize the presence of the ONU. There is a 20 km fibre cable between the OLT and the 1 x 16, 1 x 32, or 1 x 64 splitter.

**Test equipment**:

None.

**Test set-up**:

A 20 km test set-up as shown in clause 6.1.3.

**Test procedure**:

Automatic activation:

1) Connect ONU1 to fibre and power up.
2) ONU shall range within 30 s.
3) Power down and disconnect ONU1 fibre.

   Repeat for ONU2 and ONU3.

Manual activation:

1) Connect ONU1 to fibre and power up.
2) Manually start ranging.
3) ONU shall range within 30 s.
4) Power down and disconnect ONU1 fibre.

   Repeat for ONU2 and ONU3.

**Pass/fail criteria**:

Fail if any ONU does not range or if the ranging times exceed the requirement.

**Test report**: Pass _____Fail _____ Not supported _____

**Observations**:

Elapsed time, power on to ranging complete (min, average, max).

**Last modified**: July 26, 2006.

#### 6.1.3.3 Optional: Cold PON – Cold ONU – 40 km

**Test case** # 6.50

**Purpose**:

This test case is optional and requires use of a reach extender. To verify that the OLT initializes the ONU when the ONU is registered in OLT prior to start-up and the ONU is at a given fibre distance from the OLT.

**Standard**:

Clause 10 of [ITU-T G.984.3].

**Preconditions**:

Three ONUs not connected to the PON and powered down. OLT auto detects the ONU serial numbers of the ONUs under test. EMS or craft terminal on the OLT to recognize the presence of the ONU. There is a 40 km fibre cable between the OLT and the 1 x 8 splitter (to be in conformance with all the G-PON optical classes).

**Test equipment**:

None.

**Test set-up**:

A 40 km test set-up with extender box as shown in clause 6.1.3.

**Test procedure**:

Automatic activation:

1) Connect ONU1 to fibre and power up.
2) ONU shall range within 30 s.
3) Power down and disconnect ONU1 fibre.
   Repeat for ONU2 and ONU3.

Manual activation:

1) Connect ONU1 to fibre and power up.
2) Manually start ranging.
3) ONU shall range within 30 s.
4) Power down and disconnect ONU1 fibre.
   Repeat for ONU2 and ONU3.

**Pass/fail criteria**:

Fail if any ONU does not range or if the ranging times exceed the requirement.

**Test report**: Pass _____Fail _____ Not supported _____

**Observations**:

Elapsed time, power on to ranging complete (min, average, max).

**Last modified**: December 12, 2008.

#### 6.1.3.4 Optional: Cold PON – Cold ONU – 60 km

**Test case** # 6.60

**Purpose**:

This test case is optional and requires use of a reach extender. To verify that the OLT initializes the ONU when the ONU is registered in OLT prior to start-up and the ONU is at a given fibre distance from the OLT.

**Standard**:

Clause 10 of [ITU-T G.984.3].

**Preconditions**:

Three ONUs not connected to the PON and powered down. OLT auto detects the ONU serial numbers of the ONUs under test. EMS or craft terminal on the OLT to recognize the presence of the ONU. There is a 60 km fibre cable between the OLT and the 1 x 4 splitter (to be in conformance with all the G-PON optical classes).

**Test equipment**:

None.

**Test set-up**:

A 60 km test set-up with extender box as shown in clause 6.1.3.

**Test procedure**:

Automatic activation:

1) Connect ONU1 to fibre and power up.
2) ONU shall range within 30 s.
3) Power down and disconnect ONU1 fibre.
   Repeat for ONU2 and ONU3.

Manual activation:

1) Connect ONU1 to fibre and power up.
2) Manually start ranging.
3) ONU shall range within 30 s.
4) Power down and disconnect ONU1 fibre.
   Repeat for ONU2 and ONU3.

**Pass/fail criteria**:

Fail if any ONU does not range or if the ranging times exceed the requirement.

**Test report**: Pass _____Fail _____ Not supported _____

**Observations**:

Elapsed time, power on to ranging complete (min, average, max).

**Last modified**: December 12, 2008.

## 6.2 TC-layer OAM operation

### 6.2.1 LOS or LCD detection

**Test case** # 6.70

**Test set-up**:

Default test set-up as shown in Figure 1.

**Purpose**:

To verify that the OLT detects the loss of an ONU and declares LOS or LCD.

**Standard**: Clause 11.1.1 of [ITU-T G.984.3].

**Preconditions**: ONU ranged.

**Test equipment**: None.

**Procedure**:

1) Disconnect fibre from ONU. OLT is expected to declare LOS or LCD against ONU, possibly with a soak interval.
2) After a minimum of 30 s, restore the fibre to the ONU. The OLT should range the ONU and, possibly after a soak interval, clear the LOS/LCD condition.

**Pass/fail criteria**: Fail if OLT fails to declare or clear LOS or LCD.

**Test report**: Pass _____Fail _____ Not supported _____

**Observations**: Record soak times; record whether the OLT declares LOS or LCD (either is acceptable).

**Last modified**: July 26, 2006.

### 6.2.2 Reaction to deactivate ONU-ID message

**Test case** # 6.80

**Test set-up**:

Default test set-up as shown in Figure 1.

**Purpose**:

The OLT is required to deactivate the ONU when the ONU's upstream link fails in any of several ways. The test case requires an ODN that separates upstream and downstream wavelengths, with upstream problems simulated by detaching the upstream fibre of a ranged ONU.

Notifications, log entries and indicators at OLT and ONU are not standardized, but, if they are specified by the equipment vendors, they should be checked.

The OLT is expected to attempt to re-range the ONU under test. Immediately after ONU deactivation, an optical power meter should show no light transmitted upstream from the ONU. The delay before the OLT begins the ranging attempt is not specified, but once re-ranging begins, the ONU transmits PLOAM cells in response to ranging grants, and these will be visible in the upstream direction on the optical power meter. Accurate power measurements are unnecessary, but the OPM should be sufficiently sensitive to observe the presence of individual PLOAM cells.

**Standard**: Clauses 9.2.1 and 9.2.3.5 of [ITU-T G.984.3].

**Preconditions**: ONU ranged. ODN configured with wavelength splitters and ability to interrupt the upstream path at point A. Upstream path split into an optical power meter.

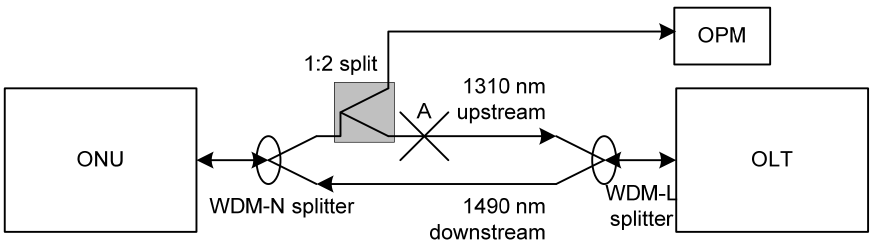



**Figure 13 – Test case # 6.80 configuration**

Because the test relies largely on non-standardized behaviour, the vendors should establish a protocol before executing this test. It is of interest to know the OLT's behaviour at loss of upstream signal (e.g., LOS or LOA, soak time), the ONU's behaviour upon deactivation (e.g., extinguishing of an online indicator), and the OLT's behaviour in attempting to re-range the ONU (e.g., automatic re-start after *N* seconds delay).

**Test equipment**: Optical power meter, able to observe pulsed emissions upstream at A.

**Procedure**:

1) With the ONU ranged, confirm that optical power is present from the ONU under test. Power should appear in bursts according to the OLT's grant mechanism; the OPM should be capable of detecting the presence of a burst.
2) Interrupt upstream transmission at point A.
3) Immediately confirm that optical power drops to zero. Prior to the OLT attempting to re-range the ONU, no upstream power should be observed.
4) When the OLT attempts to re-range the ONU, optical power should be observed on the OPM consistent with the OLT's ranging grant algorithm.
5) Repeat step 1 above and then configure the OLT to transmit the *Deactivate_ONU-ID* PLOAM message using the broadcast ONU-ID address. Then repeat steps 3 and 4 above.

   Note that step 5 above can only be executed if the reference OLT supports the generation of the *Deactivate_ONU-ID* PLOAM message addressed to all ONUs on the ODN and this can be manually initiated by the test operator.

   The EUT ONU should react to a *Deactivate_ONU-ID* PLOAM message containing the broadcast ONU-ID address in the same way it does to a *Deactivate_ONU-ID* PLOAM message directly addressed with its ONU-ID.

**Pass/fail criteria**: Fail if ONU continues to transmit.

**Test report**: Pass _____Fail _____ Not supported _____

**Observations**: Record the alarms generated, indicators illuminated or extinguished, and pertinent delays.

**Last modified**: July 26, 2006.

### 6.2.3 Emergency stop behaviour

**Test case #** 6.90

**Test set-up**:

Default test set-up as shown in Figure 1.

**Purpose**:

[ITU-T G.984.3] provides a disable_serial_number PLOAM message. Upon receipt of this message, the ONU stops responding to grants. Although the mechanism for triggering this message is proprietary to the OLT vendor, the ability of the ONU to respond to this message is included in this test plan.

If an extra split is available in the upstream direction of the ODN, it should be used to attach a power meter to verify that the ONU does in fact remain off the PON until it receives a SN enable message. In the absence of direct verification, the OLT's alarm, PM or log mechanisms must be relied upon to identify anomalous ONU behaviour.

Since emergency stop is expected to be triggered by a management command, it is not expected that the OLT will automatically reset and attempt to re-range the ONU until authorized to do so by the management client. After deactivation and before re-ranging begins, an optical power meter should show no upstream power from the ONU.

**Standard**: Clauses 9.2.1 and 9.2.3.6 of [ITU-T G.984.3]

**Preconditions**: Same as test case # 6.80.

**Test equipment**: Same as test case # 6.80.

**Procedure**:

1) With the ONU ranged, confirm that optical power is present from the ONU under test. Power should appear in bursts according to the OLT's grant mechanism; the OPM should be capable of detecting the presence of a burst.
2) Invoke the OLT's mechanism to sends e-stop with serial number disabled to the ONU.
3) Confirm that upstream optical power drops to zero. Until the OLT sends e-stop with serial number enabled to the ONU, no upstream power should be observed.
4) Force the OLT to forget the disabled state of the ONU, e.g., through OLT reinitialization. The reinitialized OLT is expected to attempt to re-range the ONU normally, and the ONU is expected not to respond.
5) [ITU-T G.984.3] (clause 11.1.2) specifies that the ONU retain the disabled state across a power cycle. To verify this, remove and restore power to the ONU, allow sufficient time for the ONU to boot up, and confirm that the ONU still does not range.
6) Invoke the OLT's mechanism to sends e-stop with serial number enabled to the ONU. Confirm that the ONU returns to normal service.
7) Repeat steps 1 through 4 above, followed by step 6 with the OLT configured to enable the serial numbers of all ONUs on the ODN that had previously been denied upstream access. <resulting in the OLT transmitting a *Disable_serial_number* PLOAM message with a 0x0F value in the *Disable/Enable* field>.

   Note that step 7 above can only be executed if the reference OLT can be triggered to generate a *Disable_serial_number* PLOAM message addressed to all currently disabled ONUs. For some OLT implementations this may require the addition of a second ONU on the ODN.

   The EUT ONU should react to a PLOAM message containing a 0x0F value in the *Disable/Enable* field in the same way it does to a *Disable_serial_number* PLOAM message directly addressed with its serial number.

**Pass/fail criteria**: Fail if the ONU continues to transmit. Fail if the OLT cannot restore the ONU to service.

**Test report**: Pass _____Fail _____ Not supported _____

**Observations**: Record the OLT's mechanism for generating emergency stop and subsequently reactivating the ONU.

**Last modified**: July 26, 2006.

### 6.2.4 ONU reaction to PEE message from OLT

**Test case** # 6.100

**Test set-up**:

Default test set-up as shown in Figure 1.

**Purpose**:

If an OLT and an ONU both claim to support PEE (physical equipment error) in a mutually testable relation, this test case confirms that they support it as documented. The OLT generates PEE and the ONU's response is observed.

This test case requires some mechanism to manually initiate a PEE message being sent downstream by the OLT. The ONU's response upon receipt of a PEE message is undefined, but may include illuminating an indicator, and may include service conditioning (e.g., DS1 AIS, release of POTS calls).

**Standard**: Clauses 9.1.2 and 9.2.3.15 of [ITU-T G.984.3].

**Preconditions**: ONU ranged, provisioned with any services whose behaviour is to be monitored.

**Test equipment**: Test sets to observe service conditioning, if any.

**Procedure**:

1) Invoke the OLT's mechanism to generate a PEE message to the ONU (all ONUs).
2) Verify that the ONU's response is in accordance with the vendor's specifications.
3) Release PEE from the OLT.
4) Verify that the ONU returns to normal service after a nominal three seconds.

**Pass/fail criteria**: Failure to perform as specified by the vendors.

**Test report**: Pass _____Fail _____ Not supported _____

**Observations**: Record the predicted and observed behaviour.

**Last modified**: July 26, 2006.

### 6.2.5 OLT reaction to PEE message from ONU

**Test case** # 6.110

**Test set-up**:

Default test set-up as shown in Figure 1.

**Purpose**:

If an OLT and an ONU both claim to support PEE in a mutually testable relation, this test case confirms that they support it as documented. The ONU generates PEE and the OLT's response is observed.

This test case requires some mechanism to manually initiate a PEE message being sent upstream by the ONU. The OLT's response upon receipt of a PEE message is undefined, but is likely to include declaring an alarm and possibly conditioning of services.

**Standard**: Clauses 9.2.2 and 9.2.4.6 of [ITU-T G.984.3].

**Preconditions**: ONU ranged, provisioned with any services whose behaviour is to be monitored.

**Test equipment**: Test sets to observe service conditioning, if any.

**Procedure**:

1) Invoke the ONU's mechanism to generate a PEE message to the OLT.
2) Verify that the OLT's response is in accordance with the vendor's specifications.
3) Release PEE from the ONU.
4) Verify that the OLT returns to normal service after a nominal three seconds.

**Pass/fail criteria**: Failure to perform as specified by the vendors.

**Test report**: Pass _____Fail _____ Not supported _____

**Observations**: Record the predicted and observed behaviour.

**Last modified**: July 26, 2006.

### 6.2.6 Dying gasp PLOAM

**Test case** # 6.120

**Test set-up**:

Default test set-up as shown in Figure 1.

**Purpose**:

Dying Gasp is a PLOAM-layer notification that indicates an ONU is about to shut down intentionally. It is not clear when this might actually occur. After sending one of these notifications, the ONU is expected to shut down. The OLT is expected to register the event and go into ranging mode on the ONU, awaiting its return.

If there is a manual way to reliably generate this message, the ONU vendor should specify it. The OLT vendor should specify the black-box observables to be expected upon receiving these messages, e.g., log entry, notification, state change.

**Standard**: Clauses 9.2.2 and 9.2.4.3 of [ITU-T G.984.3].

**Preconditions**: ONU ranged. A representative set of services provisioned, such that service conditioning can be verified, both at the ONU and at the OLT gateway into the network.

**Test equipment**: Test sets to verify service conditioning.

**Procedure**:

1) In accordance with procedures specified by the ONU vendor, create the conditions necessary to stimulate a dying gasp alarm, e.g., by removing power. Observe the OLT's behaviour.
2) Restore the ONU by releasing the conditions created in step 1, e.g., by restoring power. Verify that the OLT ranges the ONU and restores it to normal operation.

**Pass/fail criteria**: Fail if the ONU and OLT do not perform according to the vendors' documentation.

**Test report**: Pass _____Fail _____ Not supported _____

**Observations**: Record the ONU's mechanism for stimulating the *Dying_Gasp* PLOAM, and which messages are transmitted. Record the OLT's behaviour (e.g., alarm declared, service conditioning).

**Last modified**: July 26, 2006.

### 6.2.7 REI operation

**Test case** # 6.130

**Test set-up**:

Default test set-up as shown in Figure 1.

**Purpose**:

REI is a way for the ONU to report how many bit errors it observes on the downstream PON. The BIP-8 covers all GEM frames transmitted on the PON, including idle frames and GEM frames directed to other ONUs. REI intervals are not necessarily synchronized (or even identical) between ONUs, but over the long term, the error count should be consistent, as reported by each ONU. Differences in REI may indicate problems with an ONU or with a particular optical drop.

The OLT vendor specifies the management mechanism, if any, to set the BER interval. Both OLT and ONU agree on the range of the interval.

This test first confirms that the interval can be set to values within the commonly-supported range.

During normal operation, the expected value in the bit error counter is zero, and this is verified as the absence of REI messages.

There may be no black-box mechanism for the OLT to inject downstream bit errors, in which case there is no way to test for non-zero REI. If there is a way to inject a known error rate into the PON, the full functionality of REI should be confirmed. Error injection must occur after the PON's BIP calculation, or the BIP field must itself be corrupted.

When it receives an REI message from the ONU, the OLT declares an REI defect, which is not necessarily observable (defects are normally soaked before being declared as alarms). The OLT's behaviour should be characterized and confirmed to comply with the OLT vendor's documentation. OLT behaviour may include TCAs or alarms, based on history and/or soaking intervals. In a redundant PON, the OLT may also perform a protection switch.

**Standard**: Clauses 9.2.2 and 9.2.4.8 of [ITU-T G.984.3].

**Preconditions**: ONU ranged.

**Test equipment**: Means to inject bit errors in the downstream flow.

**Procedure**:

1) If it is provisionable, provision the BER interval to the minimum value supported by both OLT and ONU. With step 2, this confirms the BER range.
2) If it is provisionable, provision the BER interval to the maximum value supported by both OLT and ONU.
3) If it is provisionable, provision the BER interval to a nominal value. 100 ms is suggested.
4) Hitherto, no errors have been injected into the downstream traffic. Any non-zero steady-state REI messages should be noted in the observations section.
5) Inject a known error rate into the downstream flow. At $10^{-6}$, the expected error count of a 2488-Mb/s PON is 249 per 100 ms, scaling proportionately with BER interval, PON speed and BER.
6) Observe the OLT's behaviour, including soaking, leading to a possible alarm, and accumulation leading to a PM TCA.
7) Stop injecting errors, and observe the OLT's behaviour, including soaking prior to clearing a possible alarm.

**Pass/fail criteria**: Fail if the ONU does not report an accurate count of bit errors.

**Test report**: Pass _____Fail _____ Not supported _____

**Observations**: Record the range of BER interval if it is provisionable; record the fixed value of the interval if it is not provisionable. Record the OLT's behaviour including protection switching, logging, notifications, soak interval, etc.

**Last modified**: July 26, 2006.

## 6.3 Security functionality

### 6.3.1 Local craft terminal access support

**Test case** # 6.140

**Test set-up**:

Default test set-up as shown in Figure 1.

**Purpose**:

To verify that, if the ONU supports a local craft terminal, it can be accessed when administratively unlocked. Also verify that, when the LCT is administratively locked, it cannot be used.

The test case is written under the assumption that there is only one LCT port. [ITU-T G.984.4] allows for more than one. If there are in fact multiple LCT ports, repeat the test for each.

The test case is also written under the assumption that LCT access is via a serial port. If this is not the case, e.g., if craft access is via Ethernet, modify the test accordingly.

This is an interoperability topic because an uncontrollable LCT in the field represents a security risk.

**Standard**: Clause 9.13.3 of [ITU-T G.984.4].

**Preconditions**: ONU ranged.

**Test equipment**: Terminal server or PC with serial port; cable with suitable pinout.

**Procedure**:

1) Perform a MIB upload operation from the OLT. Verify that the LCT PPTP is not included.
2) Connect the PC serial port or terminal server to the ONU craft port.
3) If the administrative state of the local craft terminal ME is locked, unlock it from the OLT via OMCI.
4) Log on to the craft port of the ONU according to the practice defined by the ONU vendor.
5) Verify that commands supported by the ONU may be interactively entered. This is not an exhaustive test; password management is the focus of interoperability, and may be appropriate for the commands to be exercised in this test step.
6) From the OLT, lock the administrative state of the local craft terminal. Verify that the session is terminated by the ONU and that login to the ONU craft port is no longer possible.
7) While the LCT is administratively locked, remove the ONU from the PON. Characterize whether craft access is available to the detached ONU.
8) Power cycle the ONU while it is detached from the PON. Characterize whether craft access is available.

**Pass/fail criteria**: Fail if MIB upload includes the LCT PPTP. Fail if locking the PPTP LCT UNI ME does not disable craft access.

**Test report**: Pass _____Fail _____ Not supported _____

**Observations**: Note whether ONU complies with vendor documentation. Record the behaviour of the ONU with a locked LCT when it is disconnected from the PON and when it re-boots while disconnected.

**Last modified**: July 26, 2006.

### 6.3.2 Setting and retrieving ONU PLOAM password

**Test case** # 6.150

**Test set-up**:

Default test set-up as shown in Figure 1.

**Purpose**:

Though it is not part of the standards, an ONU is expected to have out-of-band means for setting its password, e.g., via craft terminal. The OLT may, but is not required to, check the password, typically when it ranges the ONU. If the OLT checks the password, it is expected that the OLT denies service and/or issues a security alert if the ONU's password does not match its expected value.

The OLT may auto discover the password when the ONU is first ranged, or it may require that the expected password be provisioned. The test case should be executed in accordance with the OLT vendor's documentation.

This test case starts with an ONU whose password is not previously known to the OLT. The OLT's initial treatment of the password is characterized.

Once the ONU is ranged and in service, the password is changed in the manner specified by the ONU vendor. The ONU is then re-ranged, and the OLT's behaviour is recorded. The password is then restored to its original value, the ONU is again re-ranged and the OLT's behaviour recorded.

The test can fail if the OLT requests the password and the ONU does not respond correctly. It is not a failure if the OLT does not request the password.

**Standard**: [ITU-T G.984.3] (clauses 9.2.1 and 9.2.2) provides for the mechanism of password request/respond. According to clause 9.2.2 processing of the password is system dependent. Pass/fail criteria for this test case are therefore based on the vendors' documentation.

**Preconditions**: ONU not ranged on the PON. ONU's password known to the test operator, but not to the OLT.

**Test equipment**: Craft access terminal and cable or alternate equipment needed to change password, connected to the ONU.

**Procedure**:

1) If the OLT requires the password to be provisioned, provision the ONU's password in the OLT.
2) Connect the ONU to the PON and permit it to range.
3) Verify that the OLT's view of the expected ONU password matches the newly ranged ONU. Verify that the OLT regards the ONU as legitimate, e.g., through the absence of security alerts or abnormal states.
4) Change the ONU's password according to the practice specified by the ONU vendor.
5) Remove the ONU from the PON (e.g., by disconnecting its fibre for a minimum of ten seconds) and restore it. Permit it to range again.
6) Characterize the OLT's behaviour in the presence of an incorrect password.
7) Restore the ONU's password to the original value.
8) Remove and restore the ONU from the PON; permit it to range again.
9) Characterize the OLT's behaviour once the password is again the expected value.

**Pass/fail criteria**: Fail if OLT requests password and ONU does not respond correctly. Fail if password mismatch does not behave according to the vendors' specification.

**Test report**: Pass _____Fail _____ Not supported _____

**Observations**: Record behaviour of OLT when ONU's password changes.

**Last modified**: August 12, 2008.

### 6.3.3 Encryption (AES) enabled on OMCC

**Test case** # 6.160

**Test set-up**:

Default test set-up as shown in Figure 1.

**Purpose**:

This test case is intended to verify basic functionality of AES implemented on the ONU. Establish OMCC on an encrypted Port-ID. Confirm that management traffic flow is completely unaffected by encryption and key updates.

**Standard**: Clauses 12.2 and 12.3 of [ITU-T G.984.3].

**Preconditions**: ONU ranged. OMCC established and AES disabled on the Port ID used for OMCI traffic.

**Test equipment**: None.

**Procedure**:

1) Issue OMCI messages from the OLT to the ONU. Verify that OMCI messages/responses are interpreted correctly by OLT and ONU.
2) Stop downstream OMCI traffic and turn on encryption (AES) on GEM port-ID used for OMCC.
3) Issue the same OMCI messages from the OLT to the ONU. Verify that OMCI messages/responses are interpreted correctly by OLT and ONU.
4) Stop downstream OMCI traffic and change the encryption key being used for the ONU.
5) Issue OMCI messages from the OLT to the ONU. Verify that the ONU is not able to decrypt received frames and discards it.
6) Stop downstream OMCI traffic and turn off encryption (AES) on GEM port-ID used for OMCC.
7) Issue the same OMCI messages from the OLT to the ONU. Verify that OMCI messages/responses are interpreted correctly by OLT and ONU.

**Pass/fail criteria**: Fail if at least one bullet of the procedure fails. Pass if all bullets of the procedure are successful.

**Test report**: Pass _____Fail _____ Not supported _____

**Observations**:

**Last modified**: October 30, 2008.

#### 6.3.4 Ranging of ONU with encryption enabled on OMCC

**Test case** # 6.170

**Test set-up**:

Default test set-up as shown in Figure 1.

**Purpose**:

To demonstrate that encryption does not affect the ability of the ONU to reinitialize and return to normal service.

**Standard**: Clause 12.2 of [ITU-T G.984.3].

**Preconditions**: ONU ranged. OMCC established. Encryption (AES) is enabled on GEM port-ID used for OMCC.

**Test equipment**: None.

**Procedure**:

1) Re-boot the ONU. Confirm that it recovers and restores (1) encryption of the GEM port-ID used for the OMCC and (2) functionality of the OMCC.
2) Re-boot the OLT. Confirm that it recovers and that the ONU restores (1) encryption of the GEM port-ID used for the OMCC and (2) functionality of the OMCC.

**Pass/fail criteria**: Fail if OMCC is not restored to full functionality.

**Test report**: Pass _____Fail _____ Not supported _____

**Observations**: Record whether encryption initialization takes perceptibly longer than un-encrypted initialization.

**Last modified**: August 18, 2008.

# 7 OMCI-related verification

*NOTE – Some of the OMCI-related test cases in this supplement rely on the OLT vendor to provide a means to exercise the managed entities via some user interface.*

## 7.1 ONU management via OMCI

### 7.1.1 ONU-specific managed entities

#### 7.1.1.1 Managed entity – ONT-G

**Test case** # 7.10

**Test set-up**:

Default test set-up as shown in Figure 1.

**Purpose**:

To confirm that the ONT-G ME exists and supports all mandatory attributes and actions. Optional attributes and default values are characterized.

**Standard**: Clause 9.1.1 of [ITU-T G.984.4].

**Preconditions**: ONU ranged.

**Test equipment**: None.

**Procedure**:

1) Get the ONT-G ME from the OLT's management client. Verify the existence and values of all attributes. Verify that R/W attributes can be set. Execute the reboot, test and synchronize time actions and observe the results. (Confirm only whether synchronize time is supported; full evaluation of its functionality is for another test case.)
2) Repeat step 1 on the ONU-G ME.

**Pass/fail criteria**: Fail if an ONU supports neither ME. Fail if any mandatory attribute is absent. Fail if ONU supports DBA but does not support the three related traffic management attributes in the ONT-G ME. Fail if attribute defaults, ranges and values do not conform to ONU vendor's documentation.

**Test report**: Pass _____Fail _____ Not supported _____

**Observations**: Record values of R/O attributes, range of R/W attributes. Record the results of reboot, test and synchronize time actions.

**Last modified**: October 30, 2008.

#### 7.1.1.2 Managed entity – ONT2-G

**Test case** # 7.20

**Test set-up**:

Default test set-up as shown in Figure 1.

**Purpose**:

To confirm that the ONT2-G ME exists and supports all mandatory attributes and actions. Optional attributes and default values are characterized.

**Standard**: Clause 9.1.2 of [ITU-T G.984.4].

**Preconditions**: ONU ranged.

**Test equipment**: None.

**Procedure**:

1) Get the ONT2-G ME from the OLT's management client. Verify the existence and values of all attributes. Verify that R/W attributes can be set. Execute the reboot, test and synchronize time actions and observe the results. (Confirm only whether synchronize time is supported; full evaluation of its functionality is for another test case.)
2) Repeat step 1 on the ONU2-G ME.

**Pass/fail criteria**: Fail if an ONU supports neither ME. Fail if any mandatory attribute is absent. Fail if ONU supports DBA but does not support the three related traffic management attributes in the ONT2-G ME. Fail if attribute defaults, ranges and values do not conform to ONU vendor's documentation.

**Test report**: Pass _____Fail _____ Not supported _____

**Observations**: Record values of R/O attributes, range of R/W attributes. Record the results of reboot, test and synchronize time actions.

**Last modified**: October 30, 2008.

#### 7.1.1.3 Managed entity – Software image

**Test case** # 7.30

**Test set-up**:

Default test set-up as shown in Figure 1.

**Purpose**:

This managed entity represents a program stored in the ONU. It is used to report to the management system the software currently installed in non-volatile memory. There must be two instances of this managed entity for the ONU.

Software upgrade is covered in several subsequent test cases. This test case simply confirms the existence of the ME.

**Standard**: Clause 9.1.4 of [ITU-T G.984.4].

**Preconditions**: ONU ranged.

**Test equipment**: None.

**Procedure**:

1) Attempt to get two software image MEs for the ONU as a whole and for each pluggable module. The ONU MEs are mandatory. If pluggable modules have software image MEs, each must have two.
2) Verify that all mandatory attributes exist. Since this is not a test of abnormal scenarios, exactly one image of each pair should be committed. The committed image, and not the other one, should also be active. At least the committed image should be valid.
3) If pluggable modules have software image MEs, characterize the ME behaviour when the slot is pre-provisioned, de-provisioned, equipped with a given LIM type, swapped with another LIM of the same type, etc.

**Pass/fail criteria**: Fail if the MEs do not exist or if their attribute combinations do not agree with the description above.

**Test report**: Pass _____Fail _____ Not supported _____

**Observations**: Record whether there exist two software image MEs for pluggable modules, and if so, how the MEs behave with regard to unplugged modules, multiple modules of the same type, and modules of different types plugged successively into a given slot, etc.

**Last modified**: August 12, 2008.

#### 7.1.1.4 ONU software download from OLT

**Test case** # 7.40

**Test set-up**:

Default test set-up as shown in Figure 1.

**Purpose**:

This test case confirms that a software image can be downloaded onto the ONU. If the ONU supports several downloadable components (e.g., pluggable line cards), image download is confirmed for each type of component, as well as for the ONU as a whole.

For purposes of clarity, the original image is designated O, while the new image is designated N.

**Standard**: Clause 9.1.4 of [ITU-T G.984.4].

**Preconditions**: ONU ranged.

**Test equipment**: None.

**Procedure**:

1) For the ONU as a whole, get the software image MEs. Use the inactive image as the target for the subsequent download steps.
2) Download a new image N from the OLT.
3) At the completion of download, get the software image ME corresponding to image N; it should indicate that image N is valid. Confirm that the software version matches that of the downloaded image.
4) Repeat the download process for each downloadable module that supports a software image ME.

**Pass/fail criteria**: Fail if the download does not succeed.

**Test report**: Pass _____Fail _____ Not supported _____

**Observations**:

**Last modified**: August 12, 2008.

#### 7.1.1.5 New software activation

**Test case** # 7.50

**Test set-up**:

Default test set-up as shown in Figure 1.

**Purpose**:

After downloading a new image (e.g., via test case 7.30), this test case confirms that the new uncommitted image (N) can be activated. Query of the software image MEs should indicate that the new image is active and its counterpart (O) is not. The ONU, or its component downloadable module, is re-booted to confirm that it comes up on the committed load (O). The new image (N) should be marked inactive, but not lost.

For purposes of clarity, the original image is designated O, while the new image is designated N.

**Standard**: Clause 9.1.4 of [ITU-T G.984.4].

**Preconditions**: ONU (or pluggable modules) with committed and active image O, and downloaded with a valid new software image N. This test case continues naturally from test case 7.40.

**Test equipment**: None.

**Procedure**:

1) Test case 7.40 leaves a newly-downloaded inactive image N on the ONU (or its pluggable modules). Activate the image N.
2) It may be necessary to wait briefly for the ONU to re-start. Get both images. Image N should be active; image O should be inactive.
3) Re-boot the ONU. Get both images. Image O should be committed and active; image N should be uncommitted and inactive.
4) Repeat for one of each type of downloadable pluggable module that supports a software image ME.

**Pass/fail criteria**: Fail if behaviour does not comply with description above.

**Test report**: Pass _____Fail _____ Not supported _____

**Observations**:

**Last modified**: August 12, 2008.

### 7.1.1.6 Committing of new software download

**Test case** # 7.60

**Test set-up**:

Default test set-up as shown in Figure 1.

**Purpose**:

After downloading a new image (e.g., via test case 7.40), this test case confirms that the new (inactive) image can be committed. Query of the software image MEs should indicate that the new image is committed and its shadow counterpart is not. The ONU is to be re-booted, and is expected to come up on the committed image.

It must also be possible to commit an active image. This part of the test continues from test case 7.50, after the new image has been activated, to confirm that it can be committed.

For purposes of clarity, the original image is designated O, while the new image is designated N.

**Standard**: Clause 9.1.4 of [ITU-T G.984.4].

**Preconditions**: ONU or pluggable module containing two valid software images, O and N. O is active and committed, N is neither. This test case naturally continues from test case 7.50.

**Test equipment**: None.

**Procedure**:

1) Get both the software image MEs for the ONU. Confirm that image O is both committed and active, and image N is neither.
2) Commit the previously uncommitted image N. Get both MEs and confirm that the committed attribute has changed on each. The active attribute should remain unchanged, O active and N inactive.
3) Re-boot the ONU. Get both MEs. Confirm that image N is active, while image O is inactive. This confirms the ONU's ability to commit an inactive image.
4) Activate the previous image, O. After the ONU re-boots, get both MEs. Confirm that image N remains committed, but image O is now active.

5) Commit image O. Get both MEs. Confirm that the image O is both committed and active, while image N is neither.
6) Re-boot the ONU. Confirm that image O is active and committed, while N is neither. This confirms the ONU's ability to commit an active image.
7) Repeat for one of each type of downloadable module.

**Pass/fail criteria**: Fail if any of the steps does not progress as indicated above.

**Test report**: Pass _____Fail _____ Not Supported _____

**Observations**:

**Last modified**: August 12, 2008.

#### 7.1.1.7 Download of invalid software and proper error reporting

**Test case** # 7.70

**Test set-up**:

Default test set-up as shown in Figure 1.

**Purpose**:

This test case verifies a number of error checking mechanisms.

- An attempt to download onto an active image should fail.
- An attempt to download onto a committed image should fail.
- Downloading an invalid image should result in the *Is Valid* attribute of the *Software Image* ME being set to false by the ONU. According to [ITU-T G.984.4], an invalid image is one that has an invalid CRC or one that cannot be executed. The method by which an ONU determines that an image cannot be executed is not standardized but it is assumed to be detectable by the ONT at the time of download. This differs from an image that the ONT attempts to execute but causes the ONT to restart due to a processing error. The ONU equipment vendor must provide an invalid image that is detectable at the time of download. The ONU's response is to be characterized for the test report.

**Standard**: Clause 9.1.4 of [ITU-T G.984.4].

**Preconditions**: ONU ranged. One image (O), committed, a second image (N), active, both images valid.

**Test equipment**: None.

**Procedure**:

1) Attempt to download a new image onto O. If download succeeds, the test case fails.
2) Attempt to download a new image onto N. If download succeeds, the test case fails.
3) Provision image O to be active. The ONU should now show O as both committed and active.
4) Create an invalid ONU image with an invalid CRC, e.g., with an offline binary editor. Download this image onto N.
5) Verify that the ONU provides an error response in the Download complete response indicating a bad CRC was detected.
6) Observe whether the ONU now shows image N as invalid, uncommitted and inactive, or whether the previous image N was retained. The image N should show as invalid for the test to pass.
7) Download an image that cannot be executed but contains a valid CRC onto N.
8) Observe whether the ONU now shows image N as invalid, uncommitted and inactive. The image N should show as invalid for the test to pass. Alternatively, it is permissible for the ONU to reject the download and retain the previous image N.
9) If the ONU supports pluggable modules with downloadable software, attempt to download an image onto a module of the wrong type. Fail the test case if download succeeds.

**Pass/fail criteria**: Fail if the ONU-OLT combination:

- permits the download of a new image on top of a committed image,
- permits the download a new image on top of an active image,
- allows an image with an invalid CRC to be committed, active or valid,
- allows an image that cannot be executed to be committed, active or valid.

**Test report**: Pass _____Fail _____ Not supported _____

**Observations**:

**Last modified**: January 7, 2009.

#### 7.1.1.8 Managed entity – UNI-G

**Test case** # 7.80

**Test set-up**:

Default test set-up as shown in Figure 1.

**Purpose**:

To verify that there is an instance of this managed entity for each UNI. The ME's attributes must be set according to the UNI's capabilities or to the default values defined by [ITU-T G.984.4]. As a characterization result, note optional attributes that are supported, and record the default values of attributes that are not specified by the standard (e.g., administrative state).

If the ONU supports different types of LIM, one of each should be tested, either in parallel in distinct slots or sequentially in a single slot. The SLC state machine is tested in separate test cases and is not extensively exercised here.

**Standard**: Clause 9.12.1 of [ITU-T G.984.4].

**Preconditions**: Ranged ONU. If the ONU supports pluggable LIMs, a LIM installed in each slot.

**Test equipment**: None.

**Procedure**:

1) Verify that a UNI-G ME exists for each port of each subscriber line card. Verify that all mandatory attributes exist. Verify that all attributes are set to, or provisionable to, values consistent with the ONU vendor's documentation and the LIM type.
2) If the ONU supports pluggable LIMs, extract a LIM and deprovision the slot (expected type = no LIM). Verify that the ONU deletes the corresponding UNI-G MEs.
3) Repeat for each type of pluggable LIM supported by the ONU.

**Pass/fail criteria**: Fail if ONU does not create and delete MEs in accordance with the SLC state machine. Fail if mandatory attributes are not present or if any attributes do not conform to vendor documentation.

**Test report**: Pass _____Fail _____ Not supported _____

**Observations**: Record the existence of optional attributes. Record the default value of every attribute.

**Last modified**: July 25, 2006.

#### 7.1.1.9 Managed entity – Cardholder

**Test case** # 7.90

**Test set-up**:

Default test set-up as shown in Figure 1.

**Purpose**:

The cardholder represents the fixed equipment slot configuration of the ONT. One or more of these entities is contained in the ONT. Each cardholder can contain 0 or 1 circuit packs; the circuit pack models equipment information that can change over the lifetime of the ONT, e.g., through replacement.

An instance of this managed entity exists for each physical slot in an ONT that has pluggable circuit packs. One or more instances of this managed entity may also exist in an integrated ONT, to represent virtual slots. Instances of this managed entity are created automatically by the ONT, and the status attributes are populated according to data within the ONT itself.

For interoperability, the OLT and ONU must be able to support the same ME identification plan. Specifying the plan for PPTP identification is part of the pre-test documentation.

This test case is written as if the OLT's management client had direct visibility of the MEs. The actual mechanism to observe the test results is to be specified by the OLT vendor.

**Standard**: Clause 9.1.5 of [ITU-T G.984.4].

**Preconditions**: ONU ranged. If ONU has pluggable LIMs, all subscriber line card slots empty.

**Test equipment**: None.

**Procedure**:

1) For an ONU with integrated interfaces on the UNI side, get the Cardholder ME from an OLT management client. Record its attributes. Repeat for as many virtual Cardholders as the ONU supports. This completes the test case for such ONUs.
2) For an ONU with pluggable LIMs, get the Cardholder ME for each slot and record its attributes. The actual plug-in unit type attribute should indicate no LIM.
3) For the first slot (empty), provision the expected plug-in type to a value supported by both ONU and OLT. The ONU should declare a plugInLimMissing alarm.
4) Install a plug-in of the provisioned type. The ONU should send an actualType AVC and clear the plugInLimMissing alarm. Get the Cardholder ME; it should now show the corresponding actual plug-in type.
5) Extract the plug-in. The ONU should declare an improperCardRemoval alarm.
6) If the ONU supports a choice of LIMs for the slot, install a LIM of a different type. The ONU should send an actualType AVC and declare a plugInTypeMismatch alarm, while clearing the improperCardRemoval alarm. The Cardholder Actual Plug-in Unit Type attribute should reflect the type of the invalid LIM.
7) Provision the expected type to no LIM. The ONU should clear the plugInTypeMismatch alarm. Extract the LIM; there should be no further notification.
8) If the ONU supports plug and play, provision the expected type to plug and play. The ONU may or may not send a plugInLimMissing alarm.
9) Install a LIM that is valid for the slot. The ONU should send an actualType AVC and clear the plugInLimMissing alarm. The Cardholder ME should show the correct actualType value for the LIM.
10) Extract the LIM. The ONU should declare an improperCardRemoval alarm.
11) Provision the slot to expect no LIM. The ONU should clear all alarms.
12) For each remaining slot, verify that the expected plug-in type can be provisioned to the values documented by the ONU vendor and supported by the OLT. Slots may or may not be universal. Unless slots differ radically one from another, it is not deemed necessary to repeat steps 3-11 for each slot or slot type.

**Pass/fail criteria**: For an ONU with pluggable LIMs, the test fails if the ONU does not support the Cardholder ME, if the expected plug-in type cannot be provisioned to values supported in common by both vendors, if the actual plug-in type attribute does not match the physical LIM, or if the notifications are incorrect.

An integrated ONU need not support this ME, and most of the ME's characteristics are not meaningful in this context. It suffices to characterize the performance of the ME.

**Test report**: Pass _____Fail _____ Not supported _____

**Observations**: Record values of R/O attributes, range of R/W attributes. Record the results of LIM installation and extraction under combinations of matching type, mismatch, plug and play, deprovisioning, etc.

**Last modified**: June 17, 2008.

#### 7.1.1.10 Managed entity – Circuit pack

**Test case** # 7.100

**Test set-up**:

Default test set-up as shown in Figure 1.

**Purpose**:

This managed entity models a circuit pack that is equipped in an ONT slot. For ONTs with integrated interfaces, this managed entity may be used to distinguish available types of interfaces. (The port mapping package is another way.)

For ONTs with integrated interfaces, the ONT automatically creates an instance of this managed entity for each instance of the virtual cardholder managed entity.

**Standard**: Clause 9.1.6 of [ITU-T G.984.4].

**Preconditions**: ONU ranged. If ONU has pluggable LIMs, all cardholder slots empty and all cardholder MEs provisioned to expect *no LIM*.

**Test equipment**: None.

**Procedure**:

1) For an ONU with integrated UNIs, attempt to get each possible circuit pack ME (one for each virtual cardholder). It is acceptable if neither cardholder nor circuit pack ME exists; in this case, the test case is complete; record the result. If the cardholder ME exists and the circuit pack ME does not exist, the test case is complete with a failure. Assuming the circuit pack ME exists; continue the test with steps 4, 5, 6.
2) For an ONU with pluggable LIMs, attempt to get each possible circuit pack ME. The ME should not exist until step 3.
3) For slot 1, provision the slot's parent cardholder ME to the type of the intended LIM. Verify that the circuit pack ME exists.
4) Install the LIM. Verify that all mandatory attributes are present. Verify that read-only attributes have values in accordance with the ONU vendor's documentation. Verify that writeable attributes, if any, can be set to the full range of values common to the features supported by the combination of OLT and ONU.

   NOTE – Since service is not provisioned, administrative lock functionality is not verified by this test case.
5) Invoke the LIM's reboot and test actions and record the result.
6) If the ONU vendor provides a way to create or simulate AVCs or alarms, invoke them and observe the results.
7) Provision the parent cardholder to expect no LIM. The circuit pack ME should no longer exist (get fails).
8) Extract the LIM. There should be no alarms.
9) Provision the parent cardholder for plug and play.
10) Insert the LIM again. The ONU should auto-create the circuit pack ME, with attributes consistent with the LIM.
11) Provision the parent cardholder for no LIM. Attempt to get the circuit pack; it should no longer exist.
12) Extract the LIM. Provision the cardholder to expect plug and play. With the slot empty, attempt to create the circuit pack. Record the result.
13) Repeat steps 3 to 6 for each type of LIM supported by the ONU (and OLT). Different slots or slot groups may be necessary to cover the full range of LIMs. It is not deemed necessary to exercise the cardholder state machine for each slot or each LIM type.

**Pass/fail criteria**: Fail if the circuit pack ME exists at any time when its parent cardholder is provisioned to *no LIM*. Fail if the circuit pack ME's attributes and capabilities do not match vendor's documentation.

**Test report**: Pass _____Fail _____Not supported _____

**Observations**: Record the behaviour of the ME under the various provisioning actions of the test plan. Record its attribute values, ranges and notifications.

**Last modified**: June 17, 2008.

#### 7.1.1.11 Managed entity – Physical path termination point Ethernet UNI

**Test case** # 7.110

**Test set-up**:

Default test set-up as shown in Figure 1.

**Purpose**:

To verify that, for each subscriber line card of Ethernet type, there exists an instance of this managed entity for each of its Ethernet ports.

Confirm that the ME's attributes are set according to the capabilities of the Ethernet service or to the default values defined by [ITU-T G.984.4]. As a characterization result, note any optional attributes that are supported, and record the default values of attributes that are not specified by the standard (e.g., administrative state).

If the ONU supports different types of Ethernet LIM, one of each should be tested, either in parallel in distinct slots or sequentially in a single slot. It may be convenient to execute the complete Ethernet service provisioning test series (7.170 through 7.210 and 7.310) while a slot is equipped with a given LIM.

The circuit pack state machine is tested in separate test cases and is not extensively exercised here.

**Standard**: Clause 9.5.1 of [ITU-T G.984.4].

**Preconditions**: Ranged ONU. If the ONU supports pluggable Ethernet LIMs, an Ethernet LIM is installed.

**Test equipment**: None.

**Procedure**:

1) Verify that an Ethernet PPTP ME exists for each Ethernet port. Verify that all mandatory attributes exist. Verify that all attributes are set to, or provisionable to, values consistent with the ONU vendor's documentation and the LIM type.
2) If the ONU supports pluggable LIMs, extract the Ethernet LIM and deprovision the slot (Cardholder expected type = no LIM). Verify that the ONU deletes the corresponding Ethernet PPTPs.
3) Repeat for each type of pluggable Ethernet LIM supported by the ONU.

**Pass/fail criteria**: Fail if ONU does not create and delete MEs in accordance with the circuit pack state machine. Fail if mandatory attributes are missing or if any attributes do not conform to vendor's documentation.

**Test report**: Pass _____Fail _____ Not supported _____

**Observations**: Record the existence of optional attributes. Record the default value of every attribute.

**Last modified**: August 21, 2008.

#### 7.1.1.12 Managed entity physical path termination point MoCA UNI

**Test case** # 7.120

**Test set-up**:

Default test set-up as shown in Figure 1.

**Purpose**:

To verify that, for each subscriber line card of MoCA type, there exists an instance of this managed entity for each of its data ports.

Confirm that the ME's attributes are set according to the capabilities of the data service or to the default values defined by [ITU-T G.984.4]. As a characterization result, note any optional attributes that are supported, and record the default values of attributes that are not specified by the standard (e.g., administrative state).

If the ONU supports different types of data LIM, one of each should be tested, either in parallel in distinct slots or sequentially in a single slot.

**Standard**: Clause 9.10.1 of [ITU-T G.984.4].

**Preconditions**: Ranged ONU. If the ONU supports pluggable data LIMs, a data LIM is installed.

**Test equipment**: None.

**Procedure**:

1) Verify that a data PPTP ME exists for each MoCA port. Verify that all mandatory attributes exist. Verify that all attributes are set to, or provisionable to, values consistent with the ONU vendor's documentation and the LIM type.
2) If the ONU supports pluggable LIMs, extract the MoCA LIM and deprovision the slot (Cardholder expected type = no LIM). Verify that the ONU deletes the corresponding data PPTPs.
3) Repeat for each type of pluggable MoCA LIM supported by the ONU.

**Pass/fail criteria**: Fail if ONU does not create and delete MEs in accordance with the circuit pack state machine. Fail if mandatory attributes are missing or if any attributes do not conform to vendor's documentation.

**Test report**: Pass _____Fail _____ Not supported _____

**Observations**: Record the existence of optional attributes. Record the default value of every attribute.

**Last modified**: August 21, 2008.

### 7.1.1.13 Managed entity – Physical path termination point video ANI

**Test case** # 7.130

**Test set-up**:

Default test set-up as shown in Figure 1.

**Purpose**:

To verify that an instance of this managed entity exists in an ONU that supports RF video overlay. The ME's attributes must be set according to the data within the ONU itself, as specified by the OLT or to the default values defined by [ITU-T G.984.4]. As a characterization result, record the default values of attributes not specified by the OLT or by [ITU-T G.984.4].

**Standard**: Clause 9.13.2 of [ITU-T G.984.4].

**Preconditions**: ONU ranged.

**Test equipment**: Video head-end feeding an RF stream; TV or signal analyser connected to ONU video port. Signal quality is not assessed by this test case, merely its presence.

**Procedure**:

1) Verify that there exists an instance of this ME.
2) Verify that the read-only attributes match the ONU vendor's documented capabilities.
3) With the video UNI administratively unlocked (see also test case 7.140), lock and unlock the ANI's administrative state. Verify that video to the ONU output port is turned off and on by this action.
4) If the vendors document a procedure for using the AGC settings, exercise the attributes to ensure that they can be set and queried. Assessment of signal quality is not part of this test case.

**Pass/fail criteria**: Fail if the ME's read-only attributes and provisionable capabilities do not match the ONU vendor's documentation.

**Test report**: Pass _____Fail _____ Not supported _____

**Observations**: Record whether there is more than one instance of the ME. Record the default value of administrative state.

**Last modified**: August 12, 2008.

### 7.1.1.14 Managed entity – Physical path termination point video UNI

**Test case** # 7.140

**Test set-up**:

Default test set-up as shown in Figure 1.

**Purpose**:

This managed entity represents the downstream video output. The test verifies that instances of this managed entity are automatically created by the ONU upon creation of a subscriber line card of video type, one instance for each video port. The ME's attributes must be set according to the data within the ONU itself, as specified by the OLT, or to default values defined by [ITU-T G.984.4]. As a characterization result, record the default values of attributes not specified by the OLT or by [ITU-T G.984.4].

**Standard**: Clause 9.13.1 of [ITU-T G.984.4].

**Preconditions**: ONU ranged. If ONU supports pluggable video LIMs, the ONU is to be so equipped.

**Test equipment**: Video head-end feeding an RF stream; TV or signal analyser connected to ONU video port. Signal quality is not assessed by this test case, merely its presence.

**Procedure**:

1) Verify that there exists an instance of this ME for each video output port.
2) With the video ANI administratively unlocked (see also test case 7.130), lock and unlock the UNI's administrative state. Verify that video to the ONU output port is turned off and on by this action.
3) Exercise any other provisionable attributes supported by both ONU and OLT, e.g., power over co-ax.
4) If the video ports reside on a pluggable LIM whose slots can support more than one LIM type, verify that the PPTP MEs are created and destroyed in accordance with the provisioning of the LIM type.

**Pass/fail criteria**: Fail if the ME's read-only attributes and provisionable capabilities do not match the ONU vendor's documentation.

**Test report**: Pass _____Fail _____ Not supported _____

**Observations**: Record the default value of administrative state.

**Last modified**: August 12, 2008.

**7.1.1.15 Managed entity – ANI-G**

**Test case** # 7.150

**Test set-up**:

Default test set-up as shown in Figure 1.

**Purpose**:

This managed entity is used to organize data associated with the access network interface (ANI) supported by the ONU. The ME is meaningful if the ONU supports DBA. An instance of this managed entity is automatically created by the ONU. All attributes of this ME are read-only to the OLT, although their values may change as a result of other events.

The test verifies that the ME is reported in a MIB upload if and only if the ONU supports DBA.

**Standard**: Clause 9.2.1 of [ITU-T G.984.4].

**Preconditions**: ONU ranged.

**Test equipment**: None.

**Procedure**:

1) Get the ANI-G ME. Characterize the existence and value of all attributes.
2) Perform a MIB upload. Verify that the ANI-G ME is included if and only if the ONU supports DBA.

**Pass/fail criteria**: Fail if DBA is supported but the ANI-G ME or any of the attributes SR indication, total data grant, and total DS grant attributes do not exist. Fail if the ME does not correspond to the manufacturer's documentation. Fail if the ANI-G ME is incorrectly included or excluded from a MIB upload.

**Test report**: Pass _____Fail _____ Not supported _____

**Observations**: Record the existence and value of all attributes.

**Last modified**: August 12, 2008.

#### 7.1.1.16 Managed entity – Priority queue-G

**Test case** # 7.160

**Test set-up**:

Default test set-up as shown in Figure 1.

**Purpose**:

This managed entity specifies the priority queue in the ONU used by a GEM $CTP_{G\text{-}PON}$. Priority queues used for upstream traffic are created by the ONU after initialization. Priority queues used for downstream traffic are created/deleted by the ONU after the creation/deletion of the subscriber line card.

The test verifies that priority queues exist according to the common commitments of ONU and OLT vendors to upstream traffic management, DBA and support for back pressure.

**Standard**: Clause 9.11.1 of [ITU-T G.984.4].

**Preconditions**: ONU ranged. If the ONU supports queues associated with pluggable line cards, the ONU is to be equipped with suitable LIMs.

**Test equipment**: None.

**Procedure**:

1) Verify that priority queues exist in accordance with the ONU vendor's documentation and the OLT vendor's feature set. Verify their default attributes.
2) If DBA is supported, create and link a T-CONT or traffic scheduler to the priority queue.
3) Edit the priority queue MEs to demonstrate that they can be provisioned within the range of features claimed to be supported by both ONU and OLT (e.g., back pressure).
4) If there are additional line card types with their own priority queues, repeat this test case for an instance of each.

**Pass/fail criteria**: Fail if priority queue MEs do not exist or do not comply with the feature set claimed in common by ONU and OLT.

**Test report**: Pass _____ Fail _____ Not supported _____

**Observations**:

**Last modified**: July 25, 2006.

### 7.1.2 Managed entities relating to data services

#### 7.1.2.1 Managed entity – MAC bridge service profile

**Test case** # 7.170

**Test set-up**:

Default test set-up as shown in Figure 1.

**Purpose**:

The MAC bridge service profile represents an instance of a MAC bridge itself; it is the centre of a constellation of other MEs, many of which are – or can be – automatically updated by the ONU's spanning tree and learning algorithms. This ME is bound to a particular slot; the model does not support bridging across the ONU backplane. Several bridges can exist on a LIM, with one or more Ethernet ports bound to each.

If the ONU, in conjunction with the OLT, supports several kinds of Ethernet service, execute the test case for each. This may require provisioning different LIMs between one pass and the next. If this is the case, it may be convenient to execute the complete Ethernet service provisioning test series (7.110, 7.170 through 7.210, and 7.310) while a slot is equipped with a given LIM.

**Standard**: Clause 9.3.1 of [ITU-T G.984.4].

**Preconditions**: ONU ranged. ONU equipped to support Ethernet services.

**Test equipment**: None.

**Procedure**:

1) Create an instance of this ME, using attribute values within the documented capabilities of ONU and OLT.
2) Edit the ME to other values consistent with the features supported by both ONU and OLT.
3) Create at least one additional instance of the ME to demonstrate that multiple instances can exist.
4) Verify that an instance of the MAC bridge configuration data ME exists (auto-created by the ONU) for each instance of the MAC bridge service profile.
5) Delete some or all instances. Verify that the corresponding MAC bridge configuration data ME is auto-deleted by the ONU. It may be desirable to retain one or more profiles for use in test cases that verify service provisioning.

**Pass/fail criteria**: Fail if instances cannot be created, edited and deleted. Fail if profile does not support attribute range common to OLT and ONU vendors' documentation. Fail if ONU does not automatically create and delete secondary MEs.

**Test report**: Pass _____Fail _____ Not supported _____

**Observations**:

**Last modified**: August 12, 2008.

#### 7.1.2.2 Managed entity – GAL Ethernet profile

**Test case** # 7.180

**Test set-up**:

Default test set-up as shown in Figure 1.

**Purpose**:

To verify that instances of this ME can be created and deleted by the OLT. To verify that attribute values can be set within the range of features common to OLT and ONU.

**Standard**: Clause 9.2.7 of [ITU-T G.984.4].

**Preconditions**: ONU ranged.

**Test equipment**: None.

**Procedure**:

1) Create an instance of this ME, using attribute values within the documented capabilities of ONU and OLT.
2) Create at least one additional instance of the ME to verify that multiple instances can exist. Demonstrate the range of values common to features supported by both OLT and ONU.
3) Delete some or all instances. It may be desirable to retain one or more profiles for use in test cases that verify service provisioning.

**Pass/fail criteria**: Fail if instances cannot be created or deleted. Fail if profile does not support attribute range common to OLT and ONU vendors' documentation.

**Test report**: Pass _____Fail _____ Not supported _____

**Observations**:

**Last modified**: August 21, 2006.

#### 7.1.2.3 Managed entity – GEM port network CTP

**Test case** # 7.190

**Test set-up**:

Default test set-up as shown in Figure 1.

**Purpose**:

The GEM port network CTP ties together other MEs, which therefore must exist first. This test case may be implicitly executed during other test cases, particularly 7.200.

Verify that instances of this ME can be created by the OLT.

**Standard**: Clause 9.2.3 of [ITU-T G.984.4].

**Preconditions**: ONU ranged.

**Test equipment**: None.

**Procedure**:

1) Ensure that all pertinent support MEs exists: UNI/ANI, priority queue or T-CONT, traffic descriptor. Create them if necessary.
2) Create a GEM port network CTP that refers to these MEs with the Direction attribute set to bidirectional. If the ONU and OLT under test support unidirectional GEM Ports, continue with step three; otherwise, end the test here and record the results.
3) Delete the GEM port network CTP ME.
4) Create a GEM port network CTP ME with the Direction attribute set to ANI to UNI. Ensure that all other attributes are set in accordance with the unidirectional setting per [ITU-T G.984.4].
5) Delete the GEM port network CTP ME.
6) Create a GEM port network CTP ME with the Direction attribute set to UNI to ANI. Ensure that all other attributes are set in accordance with the unidirectional setting per [ITU-T G.984.4].

**Pass/fail criteria**: Fail if ME cannot be created or if its attributes cannot be set to the range claimed in common by OLT and ONU vendors.

**Test report**: Pass _____Fail _____ Not supported _____

**Observations**:

**Last modified**: Aug. 25, 2008.

#### 7.1.2.4 Managed entity – GEM interworking termination point

**Test case** # 7.200

**Test set-up**:

Default test set-up as shown in Figure 1.

**Purpose**:

To verify that instances of this ME can be created and deleted by the OLT. To verify that attribute values can be set within the range of features common to the OLT and ONU.

**Standard**: Clause 9.2.4 of [ITU-T G.984.4].

**Preconditions**: ONU ranged. One of each type of line card, installed or available for installation in sequence, if there are more LIM types than slots.

**Test equipment**: None.

**Procedure**:

1) Perform steps 2 and 3 for each service type supported by the ONU. To confirm that services can exist in parallel, it is desirable to provision them cumulatively, rather than tearing down each service before provisioning the next.
2) For the service to be provisioned, create a GEM Port network CTP ME and suitable service and GEM profiles, if they do not already exist. For Ethernet service, create a PPTP Ethernet UNI ME. Along with step 3, these steps may not be discretely visible in the OLT's management client; use the OLT vendor's documentation to determine how to provision a service.
3) Create the GEM interworking termination point, pointing to the MEs of step 2. Verify that the ME is created as specified.

4) If the same resources (e.g., card slots) must be re-used to verify different service types, deprovision the services in reverse order, step 3, then step 2, to free up resources.

**Pass/fail criteria**:

**Test report**: Pass _____Fail _____ Not supported _____

**Observations**: Record whether optional attributes (operational state) are supported.

**Last modified**: August 21, 2006.

#### 7.1.2.5 Managed entity – MAC bridge port configuration data

**Test case** # 7.210

**Test set-up**:

Default test set-up as shown in Figure 1.

**Purpose**:

To verify that instances of this ME can be created and deleted by the ONT. To verify that attribute values can be set within the range of features common to the OLT and ONU.

If the ONU supports different types of Ethernet LIM, test one of each, either in parallel in distinct slots or sequentially in a single slot. It may be convenient to execute the complete Ethernet service provisioning test series (7.110, 7.170 through 7.210, and 7.310) while a slot is equipped with a given LIM.

**Standard**: Clause 9.3.4 of [ITU-T G.984.4].

**Preconditions**: ONU ranged.

**Test equipment**: None.

**Procedure**:

1) Create a MAC bridge port configuration data ME, selecting values common to the feature set supported by both OLT and ONU.
2) Verify that the ONU automatically creates the secondary MEs a) MAC bridge port designation data, b) MAC bridge port filter table data, c) MAC bridge port bridge table data.
3) Edit the ME to verify the range of values common to features supported by both OLT and ONU.
4) Create at least one additional instance of the ME to verify that multiple instances can exist.
5) Delete some or all instances. Verify that the ONU automatically deletes the secondary MEs. It may be desirable to retain one or more profiles for use in test cases that verify service provisioning.

**Pass/fail criteria**: Fail if secondary MEs are not auto-created and -deleted. Fail if ME does not support attribute range common to OLT and ONU vendors' documentation.

**Test report**: Pass _____Fail _____ Not supported _____

**Observations**:

**Last modified**: July 25, 2006.

### 7.1.3 Managed entities relating to SIP

#### 7.1.3.1 Managed entity – TCP/UDP config data ME

**Test case** # 7.220

**Test set-up**:

Default test set-up as shown in Figure 1.

**Purpose**:

To verify that instances of this ME can be created and deleted by the ONT. To verify that attribute values can be set within the range of features common to the OLT and ONU.

**Standard**: Clause 9.4.14 of [ITU-T G.984.4].

**Preconditions**: ONU ranged.

**Test equipment**: None.

**Procedure**:

1) Create a TCP/UDP config data ME, selecting values common to the feature set supported by both OLT and ONU.
2) Edit the ME to verify the range of values common to features supported by both OLT and ONU.
3) Create at least one additional instance of the ME to verify that multiple instances can exist.
4) Delete some or all instances. Verify that the ME has been removed by the ONU.

**Pass/fail criteria**: Fail if ME cannot be created or deleted. Fail if ME does not support attribute range common to OLT and ONU vendors' documentation.

**Test report**: Pass _____Fail _____ Not supported _____

**Observations**:

#### 7.1.3.2 Managed entity – Network Address ME

**Test case** # 7.230

**Test set-up**:

Default test set-up as shown in Figure 1.

**Purpose**:

To verify that instances of this ME can be created and deleted by the ONT. To verify that attribute values can be set within the range of features common to the OLT and ONU.

**Standard**: Clause 9.12.3 of [ITU-T G.984.4].

**Preconditions**: ONU ranged.

**Test equipment**: None.

**Procedure**:

1) Create a Network Address ME, selecting values common to the feature set supported by both OLT and ONU.
2) Create at least one additional instance of the ME to verify that multiple instances can exist.
3) Delete some or all instances. Verify that the ME has been removed by the ONU.

**Pass/fail criteria**: Fail if ME cannot be created or deleted. Fail if ME does not support attribute range common to OLT and ONU vendors' documentation.

**Test report**: Pass _____Fail _____ Not supported _____

**Observations**:

#### 7.1.3.3 Managed entity – Large string ME

**Test case** # 7.240

**Test set-up**:

Default test set-up as shown in Figure 1.

**Purpose**:

To verify that instances of this ME can be created and deleted by the ONT. To verify that attribute values can be set within the range of features common to the OLT and ONU.

**Standard**: Clause 9.12.5 of [ITU-T G.984.4].

**Preconditions**: ONU ranged.

**Test equipment**: None.

**Procedure**:

1) Create a large string ME containing a text string.
2) Get the text string from the ME and verify that it is the same as the one that was created.
3) Create at least one additional instance of the ME to verify that multiple instances can exist.
4) Create a Network Address ME that references the large string ME created in step 1 (see clause 7.1.3.2).
5) Delete the large string ME that was created in step 1. This should fail because the large string ME is still referenced by the Network Address ME.
6) Delete the Network Address ME created in step 4.
7) Delete some or all instances of the large string ME. Verify that the ME has been removed by the ONU.

**Pass/fail criteria**: Fail if ME cannot be created or deleted. Fail if ME does not support attribute range common to OLT and ONU vendors' documentation.

**Test report**: Pass _____Fail _____ Not supported _____

**Observations**:

#### 7.1.3.4 Managed entity – SIP Agent config data ME

**Test case #** 7.250

**Test set-up**:

Default test set-up as shown in Figure 1.

**Purpose**:

To verify that instances of this ME can be created and deleted by the ONT. To verify that attribute values can be set within the range of features common to the OLT and ONU.

**Standard**: Clause 9.9.3 of [ITU-T G.984.4].

**Preconditions**: ONU ranged.

**Test equipment**: None.

**Procedure**:

1) Create a SIP Agent config data ME, selecting values common to the feature set supported by both OLT and ONU.
2) Edit the ME to verify the range of values common to features supported by both OLT and ONU.
3) Create at least one additional instance of the ME to verify that multiple instances can exist.
4) Delete some or all instances. Verify that the ME has been removed by the ONU.

**Pass/fail criteria**: Fail if ME cannot be created or deleted. Fail if ME does not support attribute range common to OLT and ONU vendors' documentation.

**Test report**: Pass _____Fail _____ Not supported _____

**Observations**:

#### 7.1.3.5 Managed entity – SIP user data ME

**Test case #** 7.260

**Test set-up**:

Default test set-up as shown in Figure 1.

**Purpose**:

To verify that instances of this ME can be created and deleted by the ONT. To verify that attribute values can be set within the range of features common to the OLT and ONU.

**Standard**: Clause 9.9.2 of [ITU-T G.984.4].

**Preconditions**: ONU ranged.

**Test equipment**: None.

**Procedure**:

1) Create a SIP User Data ME, selecting values common to the feature set supported by both OLT and ONU.
2) Edit the ME to verify the range of values common to features supported by both OLT and ONU.
3) Create at least one additional instance of the ME to verify that multiple instances can exist.
4) Delete some or all instances. Verify that the ME has been removed by the ONU.

**Pass/fail criteria**: Fail if ME cannot be created or deleted. Fail if ME does not support attribute range common to OLT and ONU vendors' documentation.

**Test report**: Pass _____Fail _____ Not supported _____

**Observations**:

#### 7.1.3.6 Managed entity – RTP profile data ME

**Test case** # 7.270

**Test set-up**:

Default test set-up as shown in Figure 1.

**Purpose**:

To verify that instances of this ME can be created and deleted by the ONT. To verify that attribute values can be set within the range of features common to the OLT and ONU.

**Standard**: Clause 9.9.7 of [ITU-T G.984.4].

**Preconditions**: ONU ranged.

**Test equipment**: None.

**Procedure**:

1) Create a RTP profile data ME, selecting values common to the feature set supported by both OLT and ONU.
2) Edit the ME to verify the range of values common to features supported by both OLT and ONU.
3) Create at least one additional instance of the ME to verify that multiple instances can exist.
4) Delete some or all instances. Verify that the ME has been removed by the ONU.

**Pass/fail criteria**: Fail if ME cannot be created or deleted. Fail if ME does not support attribute range common to OLT and ONU vendors' documentation.

**Test report**: Pass _____Fail _____ Not supported _____

**Observations**:

#### 7.1.3.7 Managed entity – VoIP media profile ME

**Test case** # 7.280

**Test set-up**:

Default test set-up as shown in Figure 1.

**Purpose**:

To verify that instances of this ME can be created and deleted by the ONT. To verify that attribute values can be set within the range of features common to the OLT and ONU.

**Standard**: Clause 9.9.5 of [ITU-T G.984.4].

**Preconditions**: ONU ranged.

**Test equipment**: None.

**Procedure**:

1) Create a VoIP media profile ME, selecting values common to the feature set supported by both OLT and ONU.
2) Edit the ME to verify the range of values common to features supported by both OLT and ONU.
3) Create at least one additional instance of the ME to verify that multiple instances can exist.
4) Delete some or all instances. Verify that the ME has been removed by the ONU.

**Pass/fail criteria**: Fail if ME cannot be created or deleted. Fail if ME does not support attribute range common to OLT and ONU vendors' documentation.

**Test report**: Pass _____Fail _____ Not supported _____

**Observations**:

#### 7.1.3.8 Managed entity – VoIP voice CTP ME

**Test case** # 7.290

**Test set-up**:

Default test set-up as shown in Figure 1.

**Purpose**:

To verify that instances of this ME can be created and deleted by the ONT. To verify that attribute values can be set within the range of features common to the OLT and ONU.

**Standard**: Clause 9.9.4 of [ITU-T G.984.4].

**Preconditions**: ONU ranged.

**Test equipment**: None.

**Procedure**:

1) Create a VoIP voice CTP ME, selecting values common to the feature set supported by both OLT and ONU.
2) Edit the ME to verify the range of values common to features supported by both OLT and ONU.
3) Create at least one additional instance of the ME to verify that multiple instances can exist.
4) Delete some or all instances. Verify that the ME has been removed by the ONU.

**Pass/fail criteria**: Fail if ME cannot be created or deleted. Fail if ME does not support attribute range common to OLT and ONU vendors' documentation.

**Test report**: Pass _____Fail _____ Not supported _____

**Observations**:

### 7.1.4 Managed entities relating to [ITU-T H.248.1]

#### 7.1.4.1 Managed entity – TCP/UDP config data ME

**Test case** # 7.300

**Test set-up**:

Default test set-up as shown in Figure 1.

**Purpose**:

To verify that instances of this ME can be created and deleted by the ONT. To verify that attribute values can be set within the range of features common to the OLT and ONU.

**Standard**: Clause 9.4.14 of [ITU-T G.984.4].

**Preconditions**: ONU ranged.

**Test equipment**: None.

**Procedure**:

1) Create a TCP/UDP config data ME, selecting values common to the feature set supported by both OLT and ONU.
2) Edit the ME to verify the range of values common to features supported by both OLT and ONU.
3) Create at least one additional instance of the ME to verify that multiple instances can exist.
4) Delete some or all instances. Verify that the ME has been removed by the ONU.

**Pass/fail criteria**: Fail if ME cannot be created or deleted. Fail if ME does not support attribute range common to OLT and ONU vendors' documentation.

**Test report**: Pass _____Fail _____ Not supported _____

**Observations**:

#### 7.1.4.2 Managed entity – Network address ME

**Test case** # 7.310

**Test set-up**:

Default test set-up as shown in Figure 1.

**Purpose**:

To verify that instances of this ME can be created and deleted by the ONT. To verify that attribute values can be set within the range of features common to the OLT and ONU.

**Standard**: Clause 9.12.3 of [ITU-T G.984.4].

**Preconditions**: ONU ranged.

**Test equipment**: None.

**Procedure**:

1) Create a network address ME, selecting values common to the feature set supported by both OLT and ONU.
2) Create at least one additional instance of the ME to verify that multiple instances can exist.
3) Delete some or all instances. Verify that the ME has been removed by the ONU.

**Pass/fail criteria**: Fail if ME cannot be created or deleted. Fail if ME does not support attribute range common to OLT and ONU vendors' documentation.

**Test report**: Pass _____Fail _____ Not supported _____

**Observations**:

#### 7.1.4.3 Managed entity – Large string ME

**Test case** # 7.320

**Test set-up**:

Default test set-up as shown in Figure 1.

**Purpose**:

To verify that instances of this ME can be created and deleted by the ONT. To verify that attribute values can be set within the range of features common to the OLT and ONU.

**Standard**: Clause 9.12.5 of [ITU-T G.984.4].

**Preconditions**: ONU ranged.

**Test equipment**: None.

**Procedure**:

1) Create a large string ME containing a text string.
2) Get the text string from the ME and verify that it is the same as the one that was created.

3) Create at least one additional instance of the ME to verify that multiple instances can exist.
4) Create a network address ME that references the large string ME created in step 1 (see test case 7.310).
5) Delete the large string ME that was created in step 1. This should fail because the large string ME is still referenced by the network address ME.
6) Delete the network address ME created in step 4.
7) Delete some or all instances of the large string ME. Verify that the ME has been removed by the ONU.

**Pass/fail criteria**: Fail if ME cannot be created or deleted. Fail if ME does not support attribute range common to OLT and ONU vendors' documentation.

**Test report**: Pass _____Fail _____ Not supported _____

**Observations**:

#### 7.1.4.4 Managed entity – RTP profile data ME

**Test case** # 7.330

**Test set-up**:

Default test set-up as shown in Figure 1.

**Purpose**:

To verify that instances of this ME can be created and deleted by the ONT. To verify that attribute values can be set within the range of features common to the OLT and ONU.

**Standard**: Clause 9.9.7 of [ITU-T G.984.4].

**Preconditions**: ONU ranged.

**Test equipment**: None.

**Procedure**:

1) Create a RTP profile data ME, selecting values common to the feature set supported by both OLT and ONU.
2) Edit the ME to verify the range of values common to features supported by both OLT and ONU.
3) Create at least one additional instance of the ME to verify that multiple instances can exist.
4) Delete some or all instances. Verify that the ME has been removed by the ONU.

**Pass/fail criteria**: Fail if ME cannot be created or deleted. Fail if ME does not support attribute range common to OLT and ONU vendors' documentation.

**Test report**: Pass _____Fail _____ Not supported _____

**Observations**:

#### 7.1.4.5 Managed entity – VoIP media profile ME

**Test case** # 7.340

**Test set-up**:

Default test set-up as shown in Figure 1.

**Purpose**:

To verify that instances of this ME can be created and deleted by the ONT. To verify that attribute values can be set within the range of features common to the OLT and ONU.

**Standard**: Clause 9.9.5 of [ITU-T G.984.4].

**Preconditions**: ONU ranged.

**Test equipment**: None.

**Procedure**:

1) Create a VoIP media profile ME, selecting values common to the feature set supported by both OLT and ONU.
2) Edit the ME to verify the range of values common to features supported by both OLT and ONU.
3) Create at least one additional instance of the ME to verify that multiple instances can exist.
4) Delete some or all instances. Verify that the ME has been removed by the ONU.

**Pass/fail criteria**: Fail if ME cannot be created or deleted. Fail if ME does not support attribute range common to OLT and ONU vendors' documentation.

**Test report**: Pass _____Fail _____ Not supported _____

**Observations**:

#### 7.1.4.6 Managed entity – VoIP voice CTP ME

**Test case** # 7.350

**Test set-up**:

Default test set-up as shown in Figure 1.

**Purpose**:

To verify that instances of this ME can be created and deleted by the ONT. To verify that attribute values can be set within the range of features common to the OLT and ONU.

**Standard**: Clause 9.9.4 of [ITU-T G.984.4].

**Preconditions**: ONU ranged.

**Test equipment**: None.

**Procedure**:

1) Create a VoIP voice CTP ME, selecting values common to the feature set supported by both OLT and ONU.
2) Edit the ME to verify the range of values common to features supported by both OLT and ONU.
3) Create at least one additional instance of the ME to verify that multiple instances can exist.
4) Delete some or all instances. Verify that the ME has been removed by the ONU.

**Pass/fail criteria**: Fail if ME cannot be created or deleted. Fail if ME does not support attribute range common to OLT and ONU vendors' documentation.

**Test report**: Pass _____Fail _____ Not supported _____

**Observations**:

#### 7.1.4.7 Managed entity – MGC config data ME

**Test case** # 7.360

**Test set-up**:

Default test set-up as shown in Figure 1.

**Purpose**:

To verify that instances of this ME can be created and deleted by the ONT. To verify that attribute values can be set within the range of features common to the OLT and ONU.

**Standard**: Clause 9.9.16 of [ITU-T G.984.4].

**Preconditions**: ONU ranged.

**Test equipment**: None.

**Procedure**:

1) Create an MGC config data ME, selecting values common to the feature set supported by both OLT and ONU.
2) Edit the ME to verify the range of values common to features supported by both OLT and ONU.
3) Create at least one additional instance of the ME to verify that multiple instances can exist.
4) Delete some or all instances. Verify that the ME has been removed by the ONU.

**Pass/fail criteria**: Fail if ME cannot be created or deleted. Fail if ME does not support attribute range common to OLT and ONU vendors' documentation.

**Test report**: Pass _____Fail _____ Not supported _____

**Observations**:

### 7.1.5 Basic service provisioning – MAC bridge

**Test case** # 7.370

**Test set-up**:

Default test set-up as shown in Figure 1.

**Purpose**:

To demonstrate that a MAC bridge service can be provisioned. The intent is to verify OMCI messaging and ME support; although a data path is confirmed, full validation, especially testing of multiple-port bridges, and the interaction between multiple bridges on a LIM is for separate test cases, as is determination of throughput.

**Standard**: Clause I.2.1 of [ITU-T G.984.4].

**Preconditions**: ONU ranged. ONU equipped to provide Ethernet services.

**Test equipment**: Test equipment sufficient to validate the basic existence of service, connected at ONU and upstream of OLT.

**Procedure**:

1) If they do not already exist, create an instance of the MAC bridge service profile (test case 7.170) and the GAL Ethernet profile (test case 7.180) MEs.
2) Create one or more MAC bridge port configuration data MEs (test case 7.210), each referring to a physical Ethernet port. Bridging functionality is best verified with as many ports as possible.
3) Create a GEM port network CTP (test case 7.190).
4) If the vendors support traffic descriptors, provision a suitable one, e.g., UBR. Performance validation of all supported traffic classes is for separate test cases.
5) Create GEM port PM history data, bridge port PM history data, bridge PM history data, Ethernet PM history data and Ethernet PM history data 2 MEs. The behaviour of PM is for separate test cases; this step merely confirms that the MEs can be created.
6) Populate the MAC bridge port filter table data MEs if necessary to establish service, or enable learning mode. With the test equipment, verify that Ethernet traffic is served in both directions.
7) Edit the attributes of the MAC bridge service profile and the MAC bridge port configuration data, remaining within the range of features supported by both OLT and ONU. Evaluate the effect on service.
8) For each of the profiles, attempt to delete the ME, if the OLT provides a mechanism to do so. Record the result, including the effect on traffic, if any.
9) If a managed entity can be deleted while in use, re-boot the ONU and observe the effect on traffic when the ONU returns to service.
10) Lock the PPTP; confirm that service is no longer provided. Delete as many of the MEs as are not intended for use in other test cases.
11) Repeat steps 1-8 and 11 for each distinct service or LIM type (e.g., 10/100BaseT, GbE).

**Pass/fail criteria**: Fail if service cannot be established.

**Test report**: Pass _____Fail _____ Not supported _____

**Observations**: Record whether MEs can be edited or deleted while in use. If so, record the effect on service, both immediately and after the ONU reinitializes.

### 7.1.6 Reporting of attribute value changes

**Test case** # 7.380

**Test set-up**:

Default test set-up as shown in Figure 1.

**Purpose**:

To verify that the managed entities generate AVCs as shown in Table 8.

**Table 8 – MEs that emit AVCs**

| ME type | Op state | Other AVCs |
|---|---|---|
| 802.11 station management data 2 | | dot11DeauthenticateStation; dot11DisassociateStation; dot11AuthenticateFailStation. |
| ANI | | Total DS grant;<br>Total data grant;<br>T-CONT reporting type. |
| ONT-G | x | |
| ONU-G | x | |
| PPTP 802.11 UNI | x | |
| PPTP ADSL UNI part 1 | x | |
| PPTP Ethernet UNI | x | SensedType. |
| PPTP VDSL UNI | x | |
| PPTP video ANI | x | |
| PPTP video UNI | x | |
| Circuit Pack | x | |
| Cardholder | | Actual equipment ID. |
| TC adapter G-PON | x | |
| Traffic scheduler | | Autonomous change of any attribute. |
| Video return path service profile | x | |

**Standard**: [ITU-T G.984.4].

**Preconditions**: ONU ranged. Other preconditions specific to the ME type.

**Test equipment**: None.

**Procedure**:

1) For each supported ME and each AVC shown in Table 8, generate the change at the ONU and confirm that the AVC is reported to the OLT. In many cases, especially operational state, it may not be possible to cause the AVC in a black-box test environment. Verify that MIB sync is not updated by AVCs.
2) If the OLT supports the AVC, some externally observable result is expected from the AVC; typically this would be a log entry or a notification to an EMS. Record the observed behaviour.
3) If the ONU can generate proprietary AVCs or standard AVCs that are not supported by the OLT, generate such AVCs to determine how the OLT handles them. The behaviour of the OLT is not specified, but might include logging or silent discard.

**Pass/fail criteria**:

**Test report**: Pass _____Fail _____ Not supported _____

**Observations**: Indicate which AVCs were possible, and record the OLT's behaviour upon receiving them.

**Last modified**: August 12, 2008.

## 7.2 OMCI equipment management

### 7.2.1 Powering alarm

**Test case** # 7.390

**Test set-up**:

Default test set-up as shown in Figure 1.

**Purpose**:

To verify that the ONU reports loss of external power to the OLT. The OLT's response to this alarm is not standardized since an individual power outage typically falls below the level of a minor alarm. The OLT response may include a state change, an alarm report or a log entry. It is also undesirable to generate an alarm from every ONU in the city during a widespread power outage.

The OLT vendor should specify how to discover the existence of the alarm.

**Standard**: Clauses 9.1.1 and 9.1.2 of [ITU-T G.984.4].

**Preconditions**: ONU ranged. ONU powered by UPS.

**Test equipment**: None.

**Procedure**:

1) Provision battery backup on the ONU.
2) Disconnect the AC power source. The OLT should declare a powering alarm against the ONU, possibly after a soak interval.
3) Reconnect AC power. After a possible soak interval, the OLT should clear the powering alarm condition.
4) Provision battery backup to be off. Disconnect AC power. Although the standard does not specify this case, it is expected that the ONU declare no alarm. Record the result.
5) With AC power disconnected, provision battery backup to be on. It is expected that the ONU declare a powering alarm. Record the result.

**Pass/fail criteria**: Failure to declare or to clear the alarm.

**Test report**: Pass _____Fail _____ Not supported _____

**Observations**: Record the effect of battery backup provisioning.

**Last modified**: August 12, 2008.

### 7.2.2 Battery missing

**Test case** # 7.400

**Test set-up**:

Default test set-up as shown in Figure 1.

**Purpose**:

To verify that the ONU reports to the OLT that the battery is provisioned but is missing. It is not standardized whether the alarm is reported (or its severity) or whether it is simply logged. The OLT vendor should specify how to discover the existence of the alarm.

It is not deemed necessary to re-assess the behaviour of the ONU when battery backup is provisioned off; see test case 7.390.

**Standard**: Clauses 9.1.1 and 9.1.2 of [ITU-T G.984.4].

**Preconditions**: ONU ranged. ONU powered by UPS.

**Test equipment**: None.

**Procedure**:

1) Provision battery backup on the ONU.
2) Remove the battery from the UPS. The OLT should declare a battery missing condition against the ONU, possibly after a soak interval.
3) Re-install the battery. After a possible soak interval, the OLT should clear the battery missing condition.

**Pass/fail criteria**: Failure to declare or to clear the alarm.

**Test report**: Pass _____Fail _____ Not supported _____

**Observations**:

**Last modified**: August 12, 2008.

### 7.2.3 Battery failure

**Test case** # 7.410

**Test set-up**:

Default test set-up as shown in Figure 1.

**Purpose**:

To verify that the ONU reports to the OLT that the battery is provisioned and present but cannot recharge. The definition of battery failure is specific to the UPS vendor. The ONU vendor should specify how to create this condition, if it can be created at all.

It is not standardized whether the alarm is reported (or its severity) or whether it is simply logged. The OLT vendor should specify how to discover the existence of the alarm.

It is not deemed necessary to re-assess the behaviour of the ONU when battery backup is provisioned off; see test case 7.390.

**Standard**: Clauses 9.1.1 and 9.1.2 of [ITU-T G.984.4].

**Preconditions**: ONU ranged. ONU powered by UPS.

**Test equipment**: None.

**Procedure**:

1) Provision battery backup on the ONU.
2) In accordance with the procedure defined by the ONU vendor, provoke the battery failure condition. The OLT should declare a battery failure condition against the ONU, possibly after a soak interval.
3) Restore the battery to health. After a possible soak interval, the OLT should clear the battery failure condition.

**Pass/fail criteria**: Failure to declare or to clear the alarm.

**Test report**: Pass _____Fail _____ Not supported _____

**Observations**:

**Last modified**: August 12, 2008.

### 7.2.4 Battery low

**Test case** # 7.420

**Test set-up**:

Default test set-up as shown in Figure 1.

**Purpose**:

To verify that the ONU reports to the OLT that the battery is provisioned but its voltage is low. The definition of low battery is specific to the UPS or the ONU vendor. The ONU vendor should specify how to create this condition, if it can be created at all.

It is not standardized whether the alarm is reported (or its severity) or whether it is simply logged. The OLT vendor should specify how to discover the existence of the alarm.

It is not deemed necessary to re-assess the behaviour of the ONU when battery backup is provisioned off; see test case 7.390.

**Standard**: Clauses 9.1.1 and 9.1.2 of [ITU-T G.984.4].

**Preconditions**: ONU ranged. ONU powered by UPS.

**Test equipment**: None.

**Procedure**:

1) Provision battery backup on the ONU.
2) In accordance with the procedure defined by the ONU vendor, provoke the battery low condition. The OLT should declare a battery low condition against the ONU, possibly after a soak interval.
3) Restore the battery to health. After a possible soak interval, the OLT should clear the battery low condition.

**Pass/fail criteria**: Failure to declare or to clear the alarm.

**Test report**: Pass _____Fail _____ Not supported _____

**Observations**:

**Last modified**: August 12, 2008.

# 8 System performance tests

G-PON systems utilize point-to-multipoint communications links. The test cases of clauses 5, 6, and 7 are primarily focused on OLT interoperability with a single EUT (i.e., ONU) on the ODN. Test cases in this clause check for interoperability issues that arise when multiple (≥ 8) ONUs are connected to the PON. Potentially ONUs other than EUTs (e.g., ONUs that have a different model number or are from a different manufacturer) could also be placed on the PON. A mixture of EUT ONUs and non-EUT ONUs may be placed on the PON interface to simulate a deployment environment of interest to the test campaign participants.

When non-EUT ONUs are added to the PON interface, care should be taken to make sure that any identified unexpected behaviours or performance issues are not the result of problems with the non-EUT ONUs. This may require *a priori* knowledge that the non-EUT ONU has been qualified as being interoperable with the reference OLT, or it may require the test operator to perform troubleshooting to isolate the source of the anomaly.

Some of the functionality tested in clause 6 (ONU turn-up and management) is re-examined but with a loaded PON interface. The earlier test cases provide a necessary baseline for the tests in this test area.

For test cases that load a PON with ONUs, the intent is not to explicitly examine the OLT behaviour, but rather to verify that unexpected interoperability issues do not result. As the baseline/qualified equipment, it is assumed that the OLT has a well-known behaviour when supporting a loaded PON interface. In addition, OLT behaviour when fully loaded with PON interfaces is beyond the scope of interoperability testing.

## 8.1 Overview

The system and performance tests utilize a number of optical distribution network (ODN) test configurations. These ODN test configurations include:

1) **Near cluster** – All the ONUs, including the EUT ONU are located very near the OLT ("zero distance").
2) **Far cluster** – All the ONUs, including the EUT ONU are located far from the OLT. The length of feeder fibre is expected to be the maximum allowable reach for the ODN Class operation being tested (typically 20 km).
3) **Near EUT, far cluster** – All the ONUs, except the EUT ONU, are located far from the OLT. The EUT is located very near (e.g., 0.5 km) the OLT. This ODN test configuration provides both minimum and maximum signal levels, and minimum and maximum delays on the same PON interface.
4) **Far EUT, near cluster** – All the ONUs, except the EUT ONU, are located very near the OLT. The EUT is located 20 km from the OLT (or at the maximum allowable reach for the ODN class). This ODN test configuration also provides both minimum and maximum signal levels, and minimum and maximum delays on the same PON interface.

Appendix I fully defines these ODN test configurations.

## 8.2 Cold PON, multi-ONU

**Test case #** 8.10

**Purpose**: This test case verifies proper activation of all ONUs on a PON interface when eight or more[9] ONUs concurrently begin in the ranging standby state 1 (O2) and are ranged using the automatic discovery method. Activation on four ODN configurations is considered, each providing different received signal levels and delay characteristics.

**Standard**: Clause 10 of [ITU-T G.984.3].

**Preconditions**:

1) Some number "k" ONUs ($k \geq 8$), at least one of which is the EUT ONU (other ONUs may be different models than the ONU that is the subject of the test campaign) not powered.
2) An EMS or craft interface on the OLT to verify the successful completion of ONU activation.
3) Correction Factor ($T_{CF}$) – The time from when power is applied to the OLT to when the OLT begins the ONU discovery process must be known, unless the discovery process is manually triggered in the OLT.

**Test set-up**: The EUT ONU will be tested using the four ODN test configurations provided in Appendix I.

1) For ODN test configurations #1 (clause I.1) and #2 (clause I.2), select either a single stage or a multi-stage variation.
2) Follow local procedures for cleaning all fibre connectors before making any fibre connections.

**Test equipment**: An optical power meter or functional equivalent may be needed to adjust optical attenuator values. Launch power measurements are made in accordance with the procedures of clause 5.1.

**Test procedure**:

1) With power removed from the OLT and all the ONUs, connect all electronics to ODN test configuration #1.
2) Apply power to the ONUs, allowing them to reach the *Initial-state (O1)* (fully booted, but no received signal detected).
3) Apply power to the OLT and allow OLT to completely boot. If the ONU discovery process requires manual triggering, trigger and begin timing of that process. If the discovery process is initiated automatically, begin timing from the application of power to the OLT.
4) Record the time required for all ONUs to complete the activation (ranging) process, entering the *Operating-state* (O5). The time is recorded either relative to the application of power to the OLT (in which case the correction factor $T_{CF}$ is subsequently applied), or relative to the start of the manually initiated ONU discovery process.
5) Power down the ONUs, remove the ONU SN information from the OLT, power down the OLT, and repeat steps 1 through 4 for a total of five measurements.
6) Repeat steps 1 through 5 for the remaining ODN test configurations.

A test results table is provided below as a tabular illustration of the measurement steps described in the test procedure.

**Table 9 – Cold PON activation times**

| ODN # | Measurement # | $T_{measured}$ | $T_{CF}$ | $T_{ACT}$ ($T_{measured}$-$T_{CF}$) |
|---|---|---|---|---|
| 1 (A or B) | 1 | | | |
| | 2 | | " | |
| | 3 | | " | |
| | 4 | | " | |
| | 5 | | " | |

[9] Ideally the number of ONUs on the PON interface should be large enough to make the probability of a collision during the ranging process high. A single fully loaded PON interface (32 or 64 ONUs) would be ideal but may not always be practical.

**Table 9 – Cold PON activation times**

| ODN # | Measurement # | $T_{measured}$ | $T_{CF}$ | $T_{ACT}$ ($T_{measured}$-$T_{CF}$) |
|---|---|---|---|---|
| 2 (A or B) | 1 | | " | |
| | 2 | | " | |
| | 3 | | " | |
| | 4 | | " | |
| | 5 | | " | |
| 3 | 1 | | " | |
| | 2 | | " | |
| | 3 | | " | |
| | 4 | | " | |
| | 5 | | " | |
| 4 | 1 | | " | |
| | 2 | | " | |
| | 3 | | " | |
| | 4 | | " | |
| | 5 | | " | |

**Pass/fail criteria**:

All ONUs on the PON interface should be in the *Operating-state* (O5) within $(10 * k) + T_{CF}$ seconds of the application of power to the OLT (or of the manual triggering of ONU discovery process, where $T_{CF} = 0$), where "k" is the number of ONUs on the ODN.

**Test report**: Pass _____Fail _____ Not supported _____

**Observation**:

**Last modified**: April 15, 2009.

## 8.3 Warm PON, multi-ONU

The test cases in this clause examine the effects of adding a cold ONU to a warm PON for the four ODN test configurations specified in Appendix I.

### 8.3.1 Warm PON, Cluster ODN

**Test case #** 8.20

**Purpose**: This test case verifies proper operation of some number "M" (M ≥ 8) of warm ONUs after the addition of one EUT ONU to ODN test configuration #1 (clause I.1 – *Near cluster*) and ODN test configuration #2 (clause I.2 – *Far cluster*). The focus of this test case is to verify activation of the cold ONU on a warm PON, plus spot check for service disruptions on the warm ONU.

**Standard**: Clause 10 of [ITU-T G.984.3].

**Preconditions**:

1) One EUT ONU not powered and not connected to the ODN.
2) The variable attenuator of ODN test configuration #1 (clause I.1 – *Near cluster*) is adjusted to avoid overloading either the OLT or ONU receivers. See the results from clause 5.3 to determine the receiver overload thresholds.
3) Some number "k-1" ONUs (k ≥ 8) connected to ODN test configuration #1 (clause I.1 – *Near cluster*), at least one of which is the EUT ONU (other ONUs may be different models than the ONU that is the subject of the test campaign), and in the *Operating-state* (O5).
4) At least one 100 Mbps data connection is provisioned between a warm EUT ONU UNI and the OLT SNI.
5) An EMS or craft interface on the OLT to verify the successful completion of ONU activation.

6) Correction factor ($T_{CF}$) – The time from when power is applied to the EUT ONU to when the ONU enters the *Standby-state* (O2) must be known. If unknown, then the cold ONU should be added to warm PON when already on the *Standby-state* (O2) (a modification to step 1 of the procedure below), making $T_{CF}$ zero.

**Test set-up**:

1) The EUT ONU will be tested using the ODN test configuration #1 (clause I.1 – *Near cluster*) and then using ODN test configuration #2 (clause I.2 – *Far cluster*).
2) Follow local procedures for cleaning all fibre connectors before making any fibre connections.
3) Connect a traffic generator/error detector to the UNI port of a warm ONU and the SNI of the OLT.

**Test equipment**:

1) Optical power meter – An optical power meter or functional equivalent may be needed to adjust optical attenuator values. Launch power measurements are made in accordance with the procedures of clause 5.1.
2) Traffic generator/Error detector.

**Test procedure**:

1) With a 100 Mbps data flow being monitored by the traffic generator/error detector between the OLT SNI and the warm ONU UNI, connect the un-powered ONU to the ODN.
2) Apply power to the cold ONU (now connected to the ODN) while monitoring the data flow from the warm ONU for packet loss.
3) Observe the time for the cold EUT ONU to reach the *Operating-state* (O5) while continuing to monitor the data flow from the warm ONU for packet loss or a significant degradation in throughput.
4) Remove the ONU SN information from the OLT and repeat steps 1 through 3 for a total of five measurements.
5) Repeat steps 1 through 4 using the ODN test configuration #2 (clause I.2 – *Far cluster*).

A test results table is provided below as a tabular illustration of the measurement steps described in the test procedure.

**Table 10 – Warm PON – Cluster ODN test results**

| ODN # | Measurement# | $T_{measured}$ | $T_{CF}$ | $T_{ACT}$ ($T_{measured}$-$T_{CF}$) | Impacts on existing traffic? (Note) |
|---|---|---|---|---|---|
| 1 | 1 | | | | |
| | 2 | | " | | |
| | 3 | | " | | |
| | 4 | | " | | |
| 2 | 1 | | " | | |
| | 2 | | " | | |
| | 3 | | " | | |
| | 4 | | " | | |
| NOTE – "Traffic impacts" include significant degradations in the background 100 Mbps data throughput and changes in the activation state of any of the warm ONUs. | | | | | |

**Pass/fail criteria**:

1) The cold EUT ONU should be in the *Operating-state* (O5) within *3 seconds*. Due to uncertainties in the measurement process (e.g., when the discovery process begins, when the EUT ONU becomes active), a measured activation time of *30 seconds* may be deemed acceptable.
2) The warm EUT ONUs should remain in the *Operating-state* and existing services should not be disrupted by the addition of the cold ONU.

**Test report**: Pass _____Fail _____Not supported _____

**Observation**:

**Last modified**: August 21, 2006.

### 8.3.2 Warm PON, Min-Max ODN

**Test case #** 8.30

**Purpose**: This test case verifies proper operation of a warm EUT ONU after the addition of some number "M" (M ≥ 8) cold ONUs using ODN test configuration #3 (clause I.3 – *Near EUT, far cluster*) and ODN test configuration #4 (clause I.4 – *Far EUT, near cluster*). The focus of this test case is to verify activation of the cold ONUs on a warm PON, plus spot check for service disruptions on the warm ONU. This test case also explores the impacts on the warm PON when the maximum ONU round-trip delay suddenly increases when ONUs are added to the far end of the ODN.

The warm PON scenarios considered here are analogous to those in clause 8.3.1, with difference being the "M" ONUs in the following test cases are in the cold condition.

**Standard**: Clause 10 of [ITU-T G.984.3].

**Preconditions**:

1) Some number "M" ONUs (M ≥ 8), at least one of which is the EUT ONU (other ONUs may be different models than the ONU that is the subject of the test campaign) not powered and disconnected from the ODN.
2) One EUT ONU connected to the near-end of ODN test configuration #3 (clause I.3 – *Near EUT, far cluster*) and in the *Operating-state* (O5). The variable attenuator is adjusted to avoid overloading either the OLT or ONU receiver. See the results from clause 5.3 to determine the receiver overload thresholds.
3) At least one 100 Mbps data connection is provisioned between the near end EUT ONU UNI and the OLT SNI.
4) An EMS or craft interface on the OLT to verify the successful completion of ONU activation.
5) Correction Factor ($T_{CF}$) – The time from when power is applied to the "cluster" ONUs to when the ONUs enters the *Standby-state* (O2) must be known.

**Test set-up**:

1) The EUT ONU will be tested using the ODN test configuration #3 (clause I.3 – *Near EUT, far cluster*) and then using ODN test configuration #4 (clause I.4 – *Far EUT, near cluster*).
2) Follow local procedures for cleaning all fibre connectors before making any fibre connections.
3) Connect a traffic generator/error detector to the UNI port of EUT ONU at the near-end of the ODN of test configuration #3 (clause I.3 – *Near EUT, far cluster*) and the SNI of the OLT.

**Test equipment**:

1) Optical power meter – An optical power meter or functional equivalent may be needed to adjust optical attenuator values. Launch power measurements are made in accordance with the procedures of clause 5.1.
2) Traffic generator/error detector.

**Test procedure**:

1) With a 100 Mbps data flow being monitored by the traffic generator/error detector between the OLT SNI and the warm EUT ONU UNI, connect the "M" un-powered ONUs to the far end of the ODN.
2) Apply power to the "M" ONUs (now connected to the ODN) while monitoring the data flow from the near-end ONU for packet loss.
3) Observe the time for the "M" ONUs to reach the *Operating-state* (O5) while continuing to monitor the data flow from the warm ONU for packet loss or a significant degradation in throughput.
4) Power down the "M" ONUs, remove the ONU SN information from the OLT, and repeat steps 1 through 3 for a total of five measurements.
5) Repeat steps 1 through 4 using the ODN test configuration #4 (clause I.4 – *Far EUT, near cluster*), with the warm EUT ONU now at the far end of the ODN and the "M" cold ONUs are at the near-end of the ODN. Before connecting to the ODN (step 1), adjust the variable attenuator to avoid overloading either the OLT or any of the "M" ONU receivers.

A test results table is provided below as a tabular illustration of the measurement steps described in the test procedure.

**Table 11 – Warm PON – Min-Max ODN test results**

| ODN # | Measurement # | Sum of ONUs $T_{ACT}$ | Impacts on existing traffic? (Note) |
|---|---|---|---|
| 3 | 1 | | |
| | 2 | | |
| | 3 | | |
| | 4 | | |
| | 5 | | |
| 4 | 1 | | |
| | 2 | | |
| | 3 | | |
| | 4 | | |
| | 5 | | |
| NOTE – "Traffic impacts" include significant degradations in the background 100 Mbps data throughput and changes in the activation state of the EUT ONU. | | | |

**Pass/fail criteria**:

1) All "M" cold ONUs shall reach the *Operating-state* in no more than *M * 3 seconds* of the start of the OLT beginning its ONU discovery process. Due to uncertainties in the measurement process (e.g., when the discovery process begins, when all "M" ONUs become active), a measured activation time of ($M+2+T_{CF}$) ** 3 seconds* may be deemed acceptable.
2) The warm EUT ONU should remain in the *Operating-state* and existing services should not be disrupted by the addition of the "M" ONUs.

**Test report**: Pass _____Fail _____ Not supported _____

**Observation**:

**Last modified**: August 21, 2006.

## 8.4 Receiver performance

Test cases in this clause examine ONU and OLT receiver performance under the "Min-Max" Multi-ONU ODN configurations of Appendix I, (i.e., test configuration #3 (clause I.3 – *Near EUT, far cluster*) and test configuration #4 (clause I.4 – *Far EUT, near cluster*)). In addition, cold EUT activation on a warm PON is examined. The warm PON scenarios considered here are analogous to those in clause 8.2, with the difference being that the "M" ONUs in the following test cases are in the warm condition.

### 8.4.1 Receiver performance – Near EUT

**Test case #** 8.40

**Purpose**:

1) This test case examines BER performance of the EUT ONU and OLT when operating on ODN test configuration #3 (clause I.3 – *Near EUT, far cluster*), with a total of "M" ONUs on the far end of the PON interface (where $M \geq 8$). BER performance of "far end" ONUs will also be examined.
2) The activation of the EUT ONU under a *cold EUT, warm PON* scenario is also examined.

**Standard**: Clause 8.2.8 of [ITU-T G.984.2].

**Preconditions**:

1) Some number "M" ONUs ($M \geq 8$) connected to the far end of ODN test configuration #3 (clause I.3 – *Near EUT, far cluster*) and in the *Operating-state* (O5).
2) An EMS or craft interface on the OLT to retrieve OLT receiver BER performance data (per ONU) and to retrieve estimated ONU receiver BER performance data derived from ONU REI PLOAM message data.
3) At least one 100 Mbps data connection is provisioned between a (warm) far end-ONU UNI and the OLT SNI.

4) Correction factor ($T_{CF}$) – The time from when power is applied to the EUT ONU to when the ONU enters the *Standby-state* (O2) must be known. If unknown, the procedure provided below should be modified such that the cold ONU is added to warm PON when already on the *Standby-state (O2),* making $T_{CF}$ zero.

**Test set-up**:

1) The EUT ONU will be tested using the ODN test configuration #3 (clause I.3 – *Near EUT, far cluster*).
2) Follow local procedures for cleaning all fibre connectors before making any fibre connections.
3) Connect a traffic generator/error detector to the UNI port of one or more ONUs at the far end of the ODN of test configuration #3 (clause I.3 – *Near EUT, far cluster*) and the SNI of the OLT.

**Test equipment**:

1) Optical power meter – An optical power meter or functional equivalent may be needed to adjust optical attenuator values. Launch power measurements are made in accordance with the procedures of clause 5.1.
2) Traffic generator/error detector.

**Test procedure**:

1) With "M" activated ONUs connected to the far end of ODN test configuration #3 (clause I.3 – *Near EUT, far cluster*), record the estimated BER (up/down) of the "M" ONUs after the ONUs have been operational for at least 10 minutes (but before adding the cold EUT ONU to the ODN).
2) With at least one 100 Mbps data flow being monitored by the traffic generator/error detector between the OLT SNI and an ONU UNI, connect the un-powered EUT ONU to the near-end of the ODN.
3) Adjust the variable attenuator to avoid overload of either receiver, and ideally so that the EUT ONU received signal and the OLT received signal are just below the receiver overload thresholds determined in clause 5.3.
4) Apply power to the EUT ONU (now connected to the ODN) while monitoring the bidirectional data flow from the far end ONU for packet loss.
5) Observe the time for the ONU to reach the *Operating-state* (O5) while continuing to monitor the data flow from the far end ONU for packet loss or a significant degradation in throughput. Verify all "M" ONUs remain in the *Operating-state* (O5).
6) Power down the EUT ONU, remove the ONU SN information from the OLT, and repeat steps 2 through 5 for a total of five measurements.
7) After a 10-minute "soak period", retrieve the estimated BER data (up/down) from the OLT for the EUT ONU and remaining "M" ONUs on the PON.
8) Compare the estimated BER data for the "M" ONUs to the data recorded in step 1.

A test results table is provided below as a tabular illustration of the measurement steps described in the test procedure.

**Table 12 – Receiver performance – Near EUT test results**

| Measurement # | EUT $T_{ACT}$ | Impacts on existing traffic? (Note) |
|---|---|---|
| 1 | | |
| 2 | | |
| 3 | | |
| 4 | | |
| 5 | | |
| | | |
| | **Upstream** | **Downstream** |
| EUT BER | | |
| "M" ONU BER impacts? (Y/N) | | |
| NOTE – "Traffic impacts" include significant degradations in the background 100 Mbps data throughput and changes in the activation state of any of the "M" ONUs. | | |

**Pass/fail criteria**:

1) The cold EUT ONU should be in the *Operating-state* (O5) within *3 +* $T_{CF}$ *seconds*. Due to uncertainties in the measurement process (e.g., when the discovery process begins, when the EUT ONU becomes active), a measured activation time of *30 seconds* may be deemed acceptable.
2) EUT ONU BER shall be $\leq 10^{-10}$.

**Test report**: Pass _____Fail _____ Not supported _____

**Observation**:

**Last modified**: August 21, 2006.

### 8.4.2 Receiver performance – Far EUT

**Test case #** 8.50

**Purpose**:

1) This test case examines BER performance of the EUT ONU and OLT when operating on ODN test configuration #4 (clause I.4 – *Far EUT, near cluster*), with a total of "M" ONUs on the near-end of the PON interface (where M ≥ 8). BER performance of "near-end" ONUs will also be examined.
2) The activation of the EUT ONU under a *cold EUT, warm PON* scenario is also examined.

**Standard**: Clause 8.2.8 of [ITU-T G.984.2].

**Preconditions**:

1) Some number "M" ONUs (M ≥ 8) connected to the near-end of ODN test configuration #4 (clause I.4 – *Far EUT, near cluster*) and in the *Operating-state* (O5).
2) An EMS or craft interface on the OLT to retrieve OLT receiver BER performance data (per ONU) and to retrieve estimated ONU receiver BER performance data derived from ONU REI PLOAM message data.
3) At least one 100 Mbps data connection is provisioned between a near end-ONU UNI and the OLT SNI.
4) Correction factor ($T_{CF}$) – The time from when power is applied to the EUT ONU to when the ONU enters the *Standby-state* (O2) must be known. If unknown, the procedure provided below should be modified such that the cold ONU is added to warm PON when already on the *Standby-state (O2),* making $T_{CF}$ zero.

**Test set-up**:

1) The EUT ONU will be tested using the ODN test configuration #4 (clause I.4 – *Far EUT, near cluster*).
2) Follow local procedures for cleaning all fibre connectors before making any fibre connections.
3) Connect a traffic generator/error detector to the UNI port of one or more ONUs at the near-end of the ODN of test configuration #4 (clause I.4 – *Far EUT, near cluster*) and the SNI of the OLT.

**Test equipment**:

1) Optical power meter – An optical power meter or functional equivalent may be needed to adjust optical attenuator values. Launch power measurements are made in accordance with the procedures of clause 5.1.
2) Traffic generator/error detector.

**Test procedure**:

1) With "M" activated ONUs connected to the near-end of ODN test configuration #4 (clause I.4 – *Far EUT, near cluster*), record the estimated BER (up/down) of the "M" ONUs after the ONUs have been operational for at least 10 minutes (but before adding the cold EUT ONU to the ODN).
2) With at least one 100 Mbps data flow being monitored by the traffic generator/error detector between the OLT SNI and an ONU UNI, connect the un-powered EUT ONU to the far end of the ODN.
3) Apply power to the EUT ONU (now connected to the ODN) while monitoring the bidirectional data flow from the near-end ONU for packet loss.
4) Observe the time for the ONU to reach the *Operating-state* (O5) while continuing to monitor the data flow from the near-end ONU for packet loss or a significant degradation in throughput. Verify all "M" ONUs remain in the *Operating-state* (O5).
5) Repeat steps 2 through 5 for a total of five measurements.

6) After a 10-minute "soak period", retrieve the estimated BER data (up/down) from the OLT for the EUT ONU and remaining "M" ONUs on the PON.
7) Compare the estimated BER data for the "M" ONUs to the data recorded in step 1.

A test results table is provided below as a tabular illustration of the measurement steps described in the test procedure.

**Table 13 – Receiver performance – Far EUT test results**

| Measurement # | EUT $T_{ACT}$ | Impacts on existing traffic? (Note) |
|---|---|---|
| 1 | | |
| 2 | | |
| 3 | | |
| 4 | | |
| 5 | | |
| | | |
| | **Upstream** | **Downstream** |
| EUT BER | | |
| "M" ONU BER impacts? (Y/N) | | |
| NOTE – "Traffic impacts" include significant degradations in the background 100 Mbps data throughput and changes in the activation state of any of the "M" ONUs. | | |

**Pass/fail criteria**:

1) The EUT ONU should be in the *Operating-state* (O5) within 3 + $T_{CF}$ seconds. Due to uncertainties in the measurement process (e.g., when the discovery process begins, when the EUT ONU becomes active), a measured activation time of *30 seconds* may be deemed acceptable.
2) EUT ONU BER shall be $\leq 10^{-10}$

**Test report**: Pass _____Fail _____Not supported _____

**Observation**:

**Last modified**: August 21, 2006.

# 9 Fault recovery

Test cases in this area seek to discover interoperability issues that may result when multiple ONUs on the same PON interface are exposed to failure events or fault conditions expected to be encountered in field deployments.

Several test cases related to fault recovery include a Pass/fail criterion related to the length of time for service recovery after the fault is removed. This length of time will be determined in advance by the lab performing the interoperability testing.

## 9.1 PON (optical network) faults

This clause examines the ability of the OLT-ONU combination(s) to graciously recover from fault conditions on the optical interface. Fault conditions examined include loss of signal events caused by fibre disconnect and OLT PON interface pack pulls. In addition, the ability to recover from various optical signal degrade events is examined, where degrade events are both unidirectional and bidirectional in nature, affecting a single ONU, as well as all ONUs on the ODN.

The test cases in this clause are summarized below:

| | **Loss of signal** | | | **Unidirectional low signal** | |
|---|---|---|---|---|---|
| **Effecting** | **Fibre pull** | **OLT TX pack pull** | **Bidirectional low signal** | **Up λ** | **Down λ** |
| Single ONU | 9.1.1 | N/A | 9.1.4 | 9.1.6 | 9.1.8 |
| All ONUs | 9.1.2 | 9.1.3 | 9.1.5 | 9.1.7 | 9.1.9 |

Optical circulators are used to produce unidirectional low signal degradation conditions. "Gracious recovery" after removal of the fault condition is examined with a data services load on the system.

### 9.1.1 ONU Fibre Pull – Fibre fault to one ONU

This test verifies the ONU can range and recover data service after fibre pulls. All ONUs not affected by the injected fault shall continue to maintain normal functions.

**Test case** # 9.10

**Test set-up**:

Connect the EUT ONU to ODN configuration #3 (*Near EUT, far cluster*) and then repeat the testing using ODN configuration #4 (*Far EUT, near cluster*) of Appendix I.

**Purpose**:

To verify that a fibre break impacting one ONU does not affect the operation of the system, the OLT, or other ONUs.

**Standard**:

**Preconditions**:

1) Some number "k" active ONUs (k ≥ 8) connected to ODN test configuration #3 (clause I.3 – *Near EUT, far cluster*), at least one of which is the EUT ONU (other ONUs may be different models than the ONU that is the subject of the test campaign).
2) A traffic generator is configured for bidirectional packet transmission between the OLT and the "k" ONUs. Data connections (and associated traffic bandwidth) are uniformly distributed across all "k" ONUs.
3) An EMS or craft interface on the OLT to monitor ONU status on the PON interface.

**Test equipment**:

1) Traffic generator.

**Test procedure**:

1) Verify that the ONU is currently in a fully ranged state with data service functioning.
2) Cause a fibre fault (LOS or fibre break) to the EUT ONU.
3) Verify the remaining portions of the operating PON system (i.e., the other non-test ONUs) are fully functional without errors.
4) Remove fault.
5) Record the time for the EUT ONU to fully activate and return data service to normal (i.e., pre-fault condition) operation.

**Pass/fail criteria**:

1) After the fault condition is removed, the ONU shall re-range and data service shall be functioning within the time-limit specified by the test lab.
2) The initiation or removal of the EUT ONU fault condition shall not affect the services carried on other ONUs on the ODN.

**Test report**: Pass _____Fail _____ Not supported _____

**Observation**: Verify that the OLT EMS (or functional equivalent) indicates a loss of signal from the EUT ONU during the fibre pull condition.

**Last modified**: January 7, 2009.

### 9.1.2 ONU Fibre Pull – Fibre fault to "k" ONUs (PON network)

This test verifies that the ONUs can range and recover after PON fibre pulls affecting the "k" ONUs served by a single PON. Ensure that functionality for data services restore.

**Test case** # 9.20

**Test set-up**:

Connect the EUT ONU to ODN configuration #1 (*Near cluster*, alternative A or B) and then repeat the testing using ODN configuration #2 (*Far cluster*, alternative A or B) of Appendix I.

**Purpose**:

To determine that the system can restore after a fibre break to multiple ONUs.

**Standard**:

**Preconditions**:

See those specified in clause 9.1.1.

**Test equipment**:

See the equipment specified in clause 9.1.1.

**Test procedure**:

1) Verify that all ONUs are in a fully ranged state with data services functioning.
2) Cause a fibre fault (LOS or fibre break) affecting all ONUs.
3) Remove the fault condition.
4) Record the time for all ONUs to fully activate and return all data services to normal (i.e., pre-fault condition) operation.

**Pass/fail criteria**: All affected ONUs fully activate and return all data services to normal operation.

**Test report**: Pass _____Fail _____ Not supported _____

**Observation**:

1) After the fault condition is removed, record the time for all ONUs to fully activate and return all data services to normal (i.e., pre-fault condition) operation.
2) Verify that the OLT EMS (or functional equivalent) indicates a loss of signal from all subtending ONUs during the fibre pull condition.

**Last modified**: January 7, 2009.

### 9.1.3 OLT PON transmitter pack pull

This test case will verify that the ONU successfully ranges and recovers data service after an OLT transmitter pack is pulled from its chassis and is then restored to operation. The OLT supplier needs to provide information on which OLT packs can be pulled and what the effect on the ONUs (none or OOS) will be.

**Test case #** 9.30

**Test set-up**:

Connect the EUT ONU to ODN configuration #1 (*Near cluster*, alternative A or B) and then repeat the testing using ODN configuration #2 (*Far cluster*, alternative A or B) of Appendix I.

**Purpose**:

To determine that the system can restore after replacement of the OLT PON transceiver pack that serves multiple ONUs.

**Standard**:

**Preconditions**:

See those specified in clause 9.1.1.

**Test equipment**:

See the equipment specified in clause 9.1.1.

**Test procedure**:

1) Verify that all ONUs are in a fully ranged state with data services functioning.
2) Remove the PON transceiver pack that feeds the ODN.
3) Replace the transceiver pack.
4) Record the time for all ONUs to fully activate and return data services to normal (i.e., pre-fault condition) operation.

**Pass/fail criteria**: Following restoration all ONUs fully activate and properly return all services to normal operation.

**Test report**: Pass _____Fail _____ Not supported _____

**Observation**:

1) After the fault condition is removed record the time for all ONUs to fully activate and return data services to normal (i.e., pre-fault condition) operation.
2) Verify that the OLT EMS (or functional equivalent) indicates a loss of signal from all subtending ONUs during the fibre pull condition.

**Last modified**: January 7, 2009.

### 9.1.4 ONU PON transmitter pack pull

This test case will verify that the ONU successfully re-ranges when its non-integrated ODN circuit pack is pulled from the ONU chassis and restores data service.

**Test case #** 9.40

**Test set-up**:

Connect the EUT ONU to ODN configuration #1 (*Near cluster*, alternative A or B) and then repeat the testing using ODN configuration #2 (*Far cluster*, alternative A or B) of Appendix I.

**Purpose**:

To determine that the EUT ONU can restore after replacement of the ONU non-integrated PON (ODN) transceiver pack.

**Standard**:

**Preconditions**:

See those specified in clause 9.1.1.

**Test equipment**:

See the equipment specified in clause 9.1.1.

**Test procedure**:

1) Verify that all ONUs are in a fully ranged state with data services functioning.
2) Remove the PON transceiver pack of the EUT ONU.
3) Verify the remaining portions of the operating system are fully functional without errors.
4) Replace the transceiver pack of the EUT ONU.
5) Record the time for the EUT ONU to fully activate and return data service to normal (i.e., pre-fault condition) operation.

**Pass/fail criteria**: Removal or replacement of the EUT ONU ODN transceiver pack shall not affect the services carried on other ONUs on the ODN.

**Test report**: Pass _____Fail _____ Not supported _____

**Observation**:

1) After the ODN transceiver pack is replaced, record the time for the EUT ONU to fully activate and return data service to normal (i.e., pre-fault condition) operation.
2) Verify that the OLT EMS (or functional equivalent) indicates a loss of signal from the EUT ONU during the fault condition.

**Last modified**: January 7, 2009.

### 9.1.5 Optical signal fault – Degradation from the OLT to a single ONU

This test case increases the loss on a single ODN splitter leg (in both directions of transmission) until a loss of signal condition is created on the EUT ONU. The excessive attenuation condition is then removed. The test then verifies that services to the ONU are restored. All ONUs not affected by the optical degradation fault shall continue to maintain normal functions.

**Test case #** 9.50

**Test set-up**:

Connect the EUT ONU to ODN configuration #3 (*Near EUT*, *far cluster*) and then repeat the testing using ODN configuration #4 (*Far EUT*, *near cluster*) of Appendix I.

**Purpose**:

To determine that optical signal degradation to one ONU does not affect the operation of the system, the OLT, or other ONUs.

**Standard**:

**Preconditions**:

See those specified in clause 9.1.1.

**Test equipment**:

See the equipment specified in clause 9.1.1.

**Test procedure**:

1) Verify that the ONU is currently in a fully ranged state with data service functioning.
2) Insert an optical loss in the fibre to the EUT ONU.
3) Verify that the remaining portions of the operating system are fully functional without errors.
4) Remove the optical impairment.
5) Record the time for the EUT ONU to fully activate and return all services to normal (i.e., pre-fault condition) operation.

**Pass/fail criteria**: Optical signal degradation to the EUT ONU does not affect operation of the OLT or unaffected ONUs. After the fault condition is removed, the ONU shall re-range and data services shall be functioning within the time-limit specified by the test lab.

**Test report**: Pass _____Fail _____ Not supported _____

**Observation**: Verify that the OLT EMS (or functional equivalent) indicates a loss of signal from the EUT ONU during the fault condition.

**Last modified**: January 7, 2009.

### 9.1.6 Optical signal fault – Degradation from the OLT to multiple ONUs

This test case increases the loss on the OLT feeder fibre (in both directions of transmission) until a loss of signal condition is created on all ONUs on the ODN. The excessive attenuation condition is then removed. The test then verifies that services to the all ONUs are restored.

**Test case #** 9.60

**Test set-up**:

Connect the EUT ONU to ODN configuration #1 (*Near cluster*, alternative A or B) and then repeat the testing using ODN configuration #2 (*Far cluster*, alternative A or B) of Appendix I.

**Purpose**:

To determine that the system can automatically restore to normal operation after an optical degradation condition is applied to all ONUs, and subsequently removed.

**Standard**:

**Preconditions**:

See those specified in clause 9.1.1.

**Test equipment**:

See the equipment specified in clause 9.1.1.

**Test procedure**:

1) Verify that the all ONUs are in a fully ranged state with data services functioning.
2) Using an optical attenuator, increase attenuation on the OLT optical feeder until all ONUs are OOS.
3) Remove the optical degradation condition by decreasing the attenuation loss.
4) Record the time for all ONUs to fully activate and return all data services to normal (i.e., pre-fault condition) operation.

**Pass/fail criteria**: After fault condition is removed, all data services are restored for all ONUs.

**Test report**: Pass _____Fail _____ Not supported _____

**Observation**:

1) After the fault condition is removed, record the time for all ONUs to fully activate and return all data services to normal (i.e., pre-fault condition) operation.
2) Verify that the OLT EMS (or functional equivalent) indicates a loss of signal from all subtending ONUs during the fault condition.

**Last modified**: January 7, 2009.

NOTE – The optical signal faults induced in clause 9.1.7 through 9.1.10 use an optical circulator to separate the upstream and downstream optical signals to allow directional faults to be injected. The test cases are intended to simulate a single transmitter failure from one element (OLT or ONU) of the system.

### 9.1.7 Optical signal fault – Directional failure – Degradation from the OLT to a single ONU

Using an optical circulator this test case increases the loss on the OLT feeder fibre (in the downstream direction only) to the EUT ONU until a loss of signal condition is created in the ONU. The excessive attenuation condition is then removed. The test then verifies that services to the ONU are restored. All ONUs not affected by the injected fault are expected to maintain normal functions.

**Test case #** 9.70

**Test set-up**:

Connect the EUT ONU to ODN configuration #3 (*Near EUT*, *far cluster*) and then repeat the testing using ODN configuration #4 (*Far EUT*, *near cluster*) of Appendix I. Replace the variable attenuator of ODN configuration #3 and #4 with the splitter #1/variable attenuator/circulator/fixed attenuator combination of Figure 6.

**Purpose**:

To determine that a directional optical signal degradation to one ONU does not affect the operation of the system, the OLT, or other ONUs.

**Standard**:

**Preconditions**:

See those specified in clause 9.1.1.

**Test equipment**:

See the equipment specified in clause 9.1.1.

**Test procedure**:

1) Verify that the ONU is in a fully ranged state with data service functioning.
2) Inject optical loss in one direction of transmission in the fibre towards the EUT ONU.
3) Verify that the remaining system elements are functional without errors.

4) Remove the injected optical loss.
5) Record the time for the EUT ONU to fully activate and return data service to normal (i.e., pre-fault condition) operation.

**Pass/fail criteria**: All ONUs not affected by the injected fault maintain normal functions. After the fault condition is removed, the affected ONU shall re-range and all data services shall be functioning within the time-limit specified by the test lab.

**Test report**: Pass _____Fail _____ Not supported _____

**Observation**: Verify that the OLT EMS (or functional equivalent) indicates a loss of signal from the EUT ONU during the fault condition.

**Last modified**: January 7, 2009.

### 9.1.8 Optical signal fault – Directional failure – Degradation from the OLT to multiple ONUs

Using an optical circulator this test case increases the loss on the OLT feeder fibre (in the downstream direction only) until a loss of signal condition is created on all ONUs on the ODN. The excessive attenuation condition is then removed. The test then verifies that data services to all ONUs are restored.

**Test case #** 9.80

**Test set-up**:

Connect the EUT ONU to ODN configuration #1 (*Near cluster*, alternative A or B) and then repeat the testing using ODN configuration #2 (*Far cluster*, alternative A or B) of Appendix I.

**Purpose**:

To determine that the system can automatically restore to normal operation after an optical degradation condition is applied in the downstream direction to all ONUs and then subsequently removed.

**Standard**:

**Preconditions**:

See those specified in clause 9.1.1.

**Test equipment**:

See the equipment specified in clause 9.1.1.

**Test procedure**:

1) Verify that the all ONUs are in a fully ranged state with data services functioning.
2) Using an optical attenuator, increase attenuation in the downstream direction (1490 nm) on the OLT optical feeder until all ONUs are OOS.
3) Remove the optical degradation condition by decreasing the attenuation loss.
4) Record the time for all ONUs to fully activate and return all data services to normal (i.e., pre-fault condition) operation.

**Pass/fail criteria**: After the fault condition is removed, all services are restored for all ONUs.

**Test report**: Pass _____Fail _____ Not supported _____

**Observation**:

1) After the fault condition is removed, record the time for all ONUs to fully activate and return all data services to normal (i.e., pre-fault condition) operation.
2) Verify that the OLT EMS (or functional equivalent) indicates a loss of signal from all subtending ONUs during the fault condition..

**Last modified**: January 7, 2009.

#### 9.1.9 Optical signal fault – Directional failure – Degradation from a single ONU to the OLT

Using an optical attenuator, this test case decreases the upstream (1310 nm) signal from the ONU EUT until a loss of signal condition is created on the OLT. The excessive attenuation condition is then removed. The test then verifies that data service to the EUT ONU is restored. All ONUs not affected by the injected fault are expected to maintain normal functions.

**Test case #** 9.90

**Test set-up**:

Connect the EUT ONU to ODN configuration #3 (*Near EUT*, *far cluster*) and then repeat the testing using ODN configuration #4 (*Far EUT*, *near cluster*) of Appendix I. Replace the variable attenuator of ODN configuration #3 and #4 with the splitter #1/variable attenuator/circulator/fixed attenuator combination of Figure 6.

**Purpose**:

To determine that a directional optical signal degradation from one ONU does not affect the operation of the system, the OLT, or other ONUs.

**Standard**:

**Preconditions**:

See those specified in clause 9.1.1.

**Test equipment**:

See the equipment specified in clause 9.1.1.

**Test procedure**:

1) Verify that the ONU is in a fully ranged state with data service functioning.
2) Increase the attenuation in the upstream (1310 nm) direction from the EUT ONU towards the OLT.
3) Verify the remaining system elements are functional without errors.
4) Remove the optical degradation condition in the upstream direction.
5) Record the time for the EUT ONU to fully activate and return data service to normal (i.e., pre-fault condition) operation.

**Pass/fail criteria**: After the fault condition is removed, the ONU shall re-range and data service shall be functioning within the time-limit specified by the test lab. All ONUs not affected by the injected fault maintain normal functions.

**Test report**: Pass _____Fail _____ Not supported _____

**Observation**: Verify that the OLT EMS (or functional equivalent) indicates a loss of signal from the EUT ONU during the fault condition

**Last modified**: January 7, 2009.

#### 9.1.10 Optical signal fault – Directional failure – Degradation from multiple ONUs to the OLT

Using an optical circulator, this test case increases the attenuation of upstream (1310 nm) signals from all ONUs until a loss of signal condition is created in the OLT. The excessive attenuation condition is then removed. The test then verifies that data services to all ONUs are restored.

**Test case #** 9.100

**Test set-up**:

Connect the EUT ONU to ODN configuration #1 (*Near cluster*, alternative A or B) and then repeat the testing using ODN configuration #2 (*Far cluster*, alternative A or B) of Appendix I.

**Purpose**:

To determine that the system can automatically restore to normal operation after an optical degradation condition is applied in the upstream direction from all ONUs, and then subsequently removed.

**Standard**:

**Preconditions**:

See those specified in clause 9.1.1.

**Test equipment**:

See the equipment specified in clause 9.1.1.

**Test procedure**:

1) Verify that the all ONUs are in a fully ranged state with data services functioning.
2) Using an optical attenuator, increase attenuation in the upstream direction (1310 nm) from all ONUs until all ONUs are in an out of service (OOS) state.
3) Remove the optical degradation condition by decreasing the attenuation loss.
4) Record the time for all ONUs to fully activate and return all data services to normal (i.e., pre-fault condition) operation.

**Pass/fail criteria**: After the fault condition is removed, data services are restored for all ONUs.

**Test report**: Pass _____Fail _____ Not supported _____

**Observation**:

1) After the fault condition is removed, record the time for all ONUs to fully activate and return all data services to normal (i.e., pre-fault condition) operation.
2) Verify that the OLT EMS (or functional equivalent) indicates a loss of signal from all subtending ONUs during the fault condition.

**Last modified**: January 7, 2009.

## 9.2 Equipment faults

Test cases in this clause examine the ability of the system to restore services to a single or multiple ONUs after a manual reboot or loss of power event.

### 9.2.1 ONU rebooting – Manual – No loss of power

This is a test to verify that the ONU can range and recover after ONU reboot. Data service on the ONU will be verified to be functioning properly. All ONUs not affected by the injected fault shall continue to maintain normal functions.

**Test case #** 9.200

**Test set-up**:

Connect the EUT ONU to ODN configuration #3 (*Near EUT*, *far cluster*) and then repeat the testing using ODN configuration #4 (*Far EUT*, *near cluster*) of Appendix I.

**Purpose**:

To determine that the OLT and ONU can recover without error from the reboot of an ONU.

**Standard**:

**Preconditions**:

See those specified in clause 9.1.1.

**Test equipment**:

See the equipment specified in clause 9.1.1.

**Test procedure**:

1) Verify that the ONU is in a fully ranged state with data service functioning.
2) Manually perform a soft reboot of the ONU without removing ONU power.
3) After the ONU fully initializes, record the time for the EUT ONU to fully activate and return data service to normal (i.e., pre-fault condition) operation.

**Pass/fail criteria**: After the reboot the ONU shall re-range and data service shall be functioning within the time-limit specified by the test lab.

**Test report**: Pass _____Fail _____ Not supported _____

**Observation**: Verify that the OLT EMS (or functional equivalent) indicates a loss of signal from the EUT ONU during the reboot process.

**Last modified**: January 7, 2009.

### 9.2.2 Loss and restoral of power to single ONU – Reboot

This is a test to verify that the ONU can range and recover after loss of power to a single ONU. Data service on the ONU will be verified to be functioning properly. All ONUs not affected by the injected fault shall continue to maintain normal functions.

**Test case #** 9.210

**Test set-up**:

Connect the EUT ONU to ODN configuration #3 (*Near EUT*, *far cluster*) and then repeat the testing using ODN configuration #4 (*Far EUT*, *near cluster*) of Appendix I.

**Purpose**:

To Determine that the OLT and ONU can recover without error from the loss and subsequent restoral of power to an ONU.

**Standard**:

**Preconditions**:

See those specified in clause 9.1.1.

**Test equipment**:

See the equipment specified in clause 9.1.1.

**Test procedure**:

1) Verify that the ONU is in a fully ranged state with data service functioning.
2) Remove power from the EUT ONU.
3) Restore power to the EUT ONU.
4) After the ONU fully initializes, record the time for the EUT ONU to fully activate and return data service to normal (i.e., pre-fault condition) operation.

**Pass/fail criteria**: After the reboot, the ONU shall re-range and data service shall be functioning within the time-limit specified by the test lab.

**Test report**: Pass _____Fail _____ Not supported _____

**Observation**: Verify that the OLT EMS (or functional equivalent) indicates a loss of signal from the EUT ONU during the reboot process.

**Last modified**: January 7, 2009.

### 9.2.3 Loss and restoral of power to multiple ONUs – Reboot

This is a test to verify that the ONU can range and recover after loss of power to multiple ONUs. Data services on the ONUs will be verified to be functioning properly.

**Test case #** 9.220

**Test set-up**:

Connect the EUT ONU to ODN configuration #1 (*Near cluster*, alternative A or B) and then repeat the testing using ODN configuration #2 (*Far cluster*, alternative A or B) of Appendix I.

**Purpose**:

To determine that the OLT and multiple ONUs can recover without error from the loss and subsequent restoral of power to multiple ONUs.

**Standard**:

**Preconditions**:

See those specified in clause 9.1.1.

**Test equipment**:

See the equipment specified in clause 9.1.1.

**Test procedure**:

1) Verify that all ONUs are in fully ranged state with data services functioning.
2) Remove power from all ONUs.
3) Restore power to all ONUs.
4) After the ONUs fully initialize, record the time for all ONUs to fully activate and return all data services to normal (i.e., pre-fault condition) operation.

**Pass/fail criteria**: All ONU data services are restored to normal operation.

**Test report**: Pass _____Fail _____ Not supported _____

**Observation**:

1) After the fault condition is removed, record the time for all ONUs to fully activate and return all data services to normal (i.e., pre-fault condition) operation.
2) Verify that the OLT EMS (or functional equivalent) indicates a loss of signal from all subtending ONUs during the fault condition.

**Last modified**: January 7, 2009.

#### 9.2.4 Loss and restoral of power to OLT

This is a test to verify that the ONU can range and recover after loss of power to an OLT. All data services between the OLT and the ONUs will be verified to be functioning properly.

**Test case #** 9.230

**Test set-up**:

Connect the EUT ONU to ODN configuration #1 (*Near cluster*, alternative A or B) and then repeat the testing using ODN configuration #2 (*Far cluster*, alternative A or B) of Appendix I.

**Purpose**:

To determine that the system can restore after a loss of power to an OLT that serves multiple ONUs.

**Standard**:

**Preconditions**:

See those specified in clause 9.1.1.

**Test equipment**:

See the equipment specified in clause 9.1.1.

**Test procedure**:

1) Verify that all ONUs are in fully ranged state with data services functioning.
2) Remove the power to the OLT.
3) Restore the power to the OLT.
4) After the OLT initializes and restores normal operation, record the time for all ONUs to fully activate and return all data services to normal (i.e., pre-fault condition) operation.

**Pass/fail criteria**: All ONU data services are restored to normal operation.

**Test report**: Pass _____Fail _____ Not supported _____

**Observation**: After the OLT fault condition is removed, record the time for all ONUs to fully activate and return all data services to normal (i.e., pre-fault condition) operation.

**Last modified**: January 7, 2009.

# 10 Optional functionality

## 10.1 Dynamic bandwidth allocation

This clause considers the functionality of DBA (dynamic bandwidth allocation). There are two DBA methods specified in [ITU-T G.984.3]: SR-DBA and TM-DBA. For the TM-DBA method, since it is fully handled by OLT, it is out of scope of this supplement. For the SR-DBA method, it is valid only when the ONU supports reporting the buffer occupancy status. Even if an ONU does not support the SR-DBA method, it still has to respond to the DBRu request using the correct DBRu format, with an invalid value and a correct CRC.

This clause focuses on the SR message format used by the ONU to respond, independently of whether it is a non-SR ONU or a SR ONU.

The following test cases require some mechanism to manually initiate a DBRu request with an assigned DBRu mode by OLT. A mechanism at the OLT side, to detect whether the DBRu is responded correctly, is also required.

### 10.1.1 SR ONU reaction to DBRu request from OLT

**Test case** # 10.10

**Test set-up**:

Default test set-up as shown in Figure 1.

**Purpose**:

If an ONU claims to support Status Report of DBA and an OLT claims to support the SR-DBA method in a manually testable mechanism, this test case confirms that they support it as documented. The OLT generates the assigned format DBRu request and the ONU's response is observed.

**Standard**: Clauses 7.4 and 8.4 of [ITU-T G.984.3].

**Preconditions**: ONU ranged, at least one T-CONT provisioned on ONU.

NOTE 1 – Whether or not an ONU can support the creation of T-CONTs without full service provisioning may depend on the vendor.

**Test equipment**: None.

**Procedure**:

1) Invoke the OLT's mechanism to generate the mode '0' DBRu request to the ONU (all ONUs).
2) Verify that the ONU's response is valid.
3) Invoke the OLT's mechanism to generate the mode '1' DBRu request to the ONU (all ONUs).
4) Verify that the ONU's response is valid.
5) Invoke the OLT's mechanism to generate the mode '2' DBRu request to the ONU (all ONUs) if available.
6) Verify that the ONU's response is invalid, with correct CRC.

NOTE 2 – Since DBRu mode '2' is deprecated, steps 5 and 6 are included (if step 5 is supported by the OLT) to verify that the ONU follows the principles set forth in clause 8.4.5 of [ITU-T G.984.3].

**Pass/fail criteria**:

Fail if no DBRu response is sent by ONU.

Fail if CRC error for the DBRu response.

Fail if DBRu is invalid for the mode '0' and mode '1' DBRu request.

Fail if DBRu is valid for the mode '2' DBRu request.

Pass if no fail criteria above is matched.

**Test report**: Pass _____Fail _____ Not supported _____

**Observations**: Record the predicted and observed behaviour.

**Last modified**: October 30, 2008.

### 10.1.2 Non-SR ONU reaction to DBRu request from OLT

**Test case** # 10.20

**Test set-up**:

Default test set-up as shown in Figure 1.

**Purpose**:

Based on [ITU-T G.984.3], the ONU which does not support the Status Report of the DBA shall still respond to the DBRu request with the correct CRC, but invalid value.

If an ONU claims not to support Status Report of DBA and an OLT claims to support the SR-DBA method in a manually testable mechanism, this test case confirms that they support it as documented. The OLT generates the assigned format DBRu request and the ONU's response is observed.

**Standard**: Clauses 7.4 and 8.4 of [ITU-T G.984.3].

**Preconditions**: ONU ranged, at least one T-CONT provisioned on ONU.

NOTE 1 – Whether or not an ONU can support the creation of T-CONTs without full service provisioning may depend on the vendor.

**Test equipment**: None.

**Procedure**:

1) Invoke the OLT's mechanism to generate the mode '0' DBRu request to the ONU (all ONUs).
2) Verify that the ONU's response is invalid, with correct CRC.
3) Invoke the OLT's mechanism to generate the mode '1' DBRu request to the ONU (all ONUs).
4) Verify that the ONU's response is invalid, with correct CRC.
5) Invoke the OLT's mechanism to generate the mode '2' DBRu request to the ONU (all ONUs) if available.
6) Verify that the ONU's response is invalid, with correct CRC.

NOTE 2 – Since DBRu mode '2' is deprecated, steps 5 and 6 are included (if step 5 is supported by the OLT) to verify that the ONU follows the principles set forth in clause 8.4.5 of [ITU-T G.984.3].

**Pass/fail criteria**:

Fail if no DBRu response is sent by ONU.

Fail if CRC error for the DBRu response.

Fail if DBRu is valid for any mode DBRu request.

Pass if no fail criteria above is matched.

**Test report**: Pass _____Fail _____ Not supported _____

**Observations**: Record the predicted and observed behaviour.

**Last modified**: October 30, 2008.

## 10.2 Forward error correction

### 10.2.1 FEC enabled on OMCC

**Test case** # 10.30

**Test set-up**:

Default test set-up as shown in Figure 1.

**Purpose**:

This test case is intended to verify the basic functionality of FEC implemented on the ONU. Establish OMCC. Confirm that management traffic flow is completely unaffected by enabling FEC.

**Standard**: Clause 13 of [ITU-T G.984.3].

**Preconditions**: ONU ranged. OMCC established.

**Test equipment**: None.

**Procedure**:

1) Issue OMCI messages from the OLT to the ONU. Verify that OMCI messages/responses are interpreted correctly by OLT and ONU.
2) Turn on FEC downstream for the ONU.
3) Issue OMCI messages from the OLT to the ONU. Verify that OMCI messages/responses are interpreted correctly by OLT and ONU.
4) Turn off FEC downstream.
5) Issue OMCI messages from the OLT to the ONU. Verify that OMCI messages/responses are interpreted correctly by OLT and ONU.
6) Turn on FEC upstream for the ONU.
7) Issue OMCI messages from the OLT to the ONU. Verify that OMCI messages/responses are interpreted correctly by OLT and ONU.

**Pass/fail criteria**: Fail if enabling FEC breaks the communication channel between the OLT and ONU.

**Test report**: Pass _____Fail _____ Not supported _____

**Observations**: Bit error rate and characteristics (e.g., error bursts correlating with updates to the encryption key).

**Last modified**: October 30, 2008.

## 10.3 Duplex PON operation

Test cases related to duplex PON operation will not be covered in this supplement and are for further study.

# Appendix I

## ODN test configurations

This appendix specifies a number of optical distribution networks (ODNs) used to verify operational functionality of the equipment under test (EUT) ONU on a multi-ONU PON interface (e.g., start-up operation under various PON conditions (i.e., cold and warm), EUT BER performance, etc.). These ODN test configurations are referenced by test cases in the test case clauses of this supplement.

Four test case configurations are proposed below:

1) **Near cluster** – All the ONUs, including the EUT ONU are located very near the OLT ("zero distance").
2) **Far cluster** – All the ONUs, including the EUT ONU are located far from the OLT. The length of feeder fibre is expected to be the maximum allowable reach for the ODN class operation being tested.
3) **Near EUT, far cluster** – All the ONUs, except the EUT ONU, are located far from the OLT. The EUT is located very near (e.g., 0.5 km) the OLT.
4) **Far EUT, Near cluster** – All the ONUs, except the EUT ONU, are located very near the OLT. The EUT is located far (e.g., 10 or 20 km) from the OLT.

For simplicity, the distribution fibre is effectively assumed to be zero length, with only short (≤ 30 m) "Termination (drop) fibres" subtending from the last splitter stage. More typical distribution fibre lengths are in the 500-1000 m range. Variations in ONU signal levels and delays introduced by variability in the distribution fibre working lengths are not directly considered in the proposed test ODN configurations. Extremes in signal level/delay variations are, however, considered in test ODN configurations #3 and #4 below.

The number of ONUs on the PON interface should be maximized within the practical constraints of the test environment. A minimum of eight ONUs on the ODN is recommended.

### I.1 Configuration #1 – Near cluster

This ODN configuration considers the situation where a group of customers is located very near the OLT. The variable attenuator shown in Figure I.1 is used to avoid overloading the OLT and ONU receivers. Both single stage and multi-stage variations are provided.

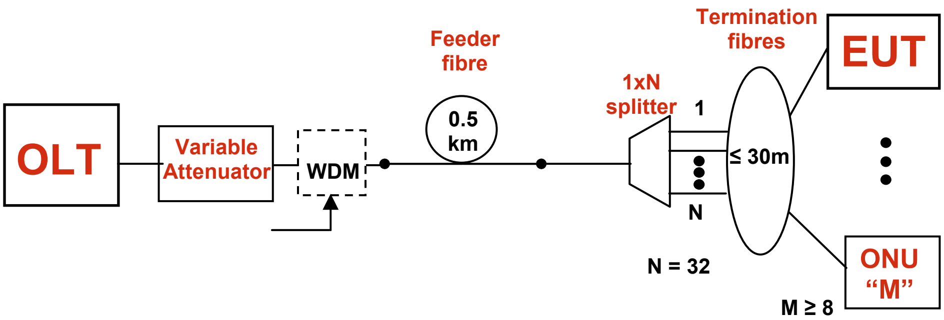



**Figure I.1 – ODN Configuration #1A – Near cluster, single stage ODN**

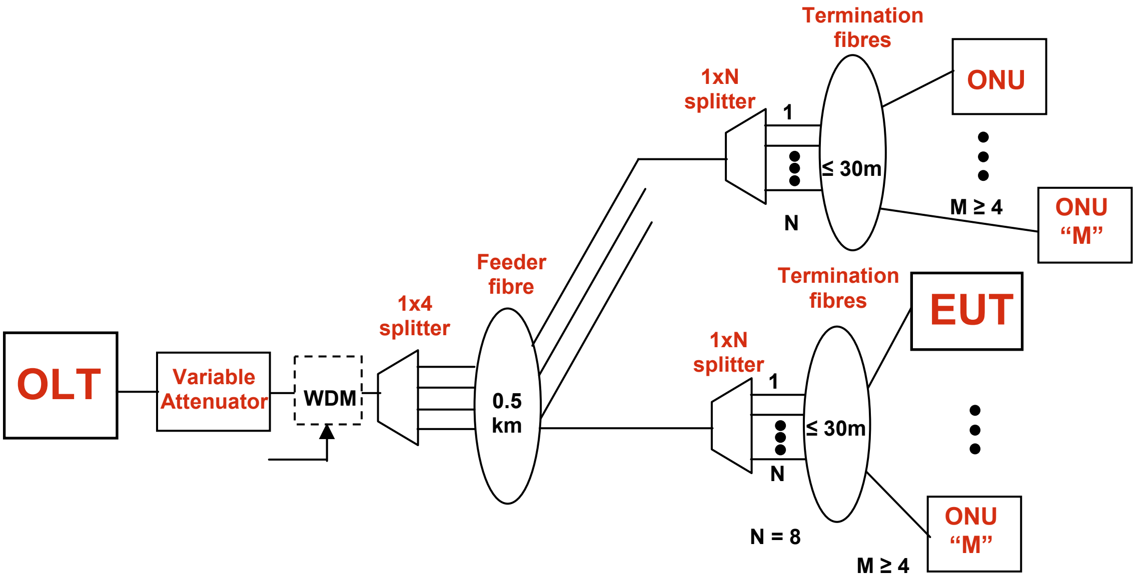



**Figure I.2 – ODN Configuration #1B – Near cluster, multi-stage ODN**

## I.2 Configuration #2 – Far cluster

This ODN configuration considers the situation where all ONUs, including the EUT ONU, are located far from the OLT. Both single stage and multi-stage variations are provided below. The length of feeder fibre ("X") is expected to be the maximum allowable reach for the ODN Class operation being tested. The 3.6 km reach is representative of a North American carrier serving area (CSA) deployment.

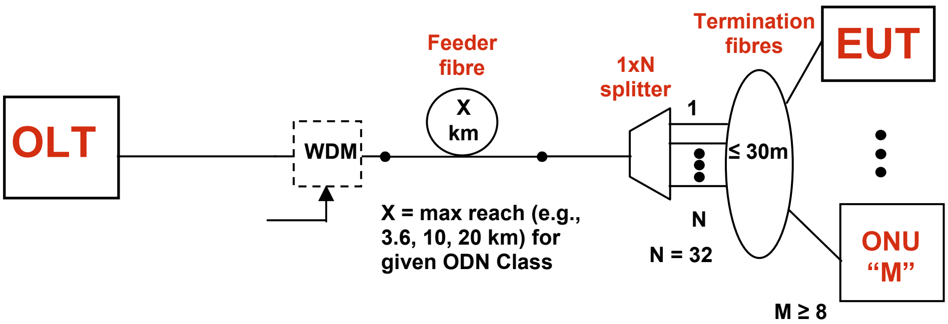



**Figure I.3 – ODN Configuration #2A – Far cluster, single stage ODN**

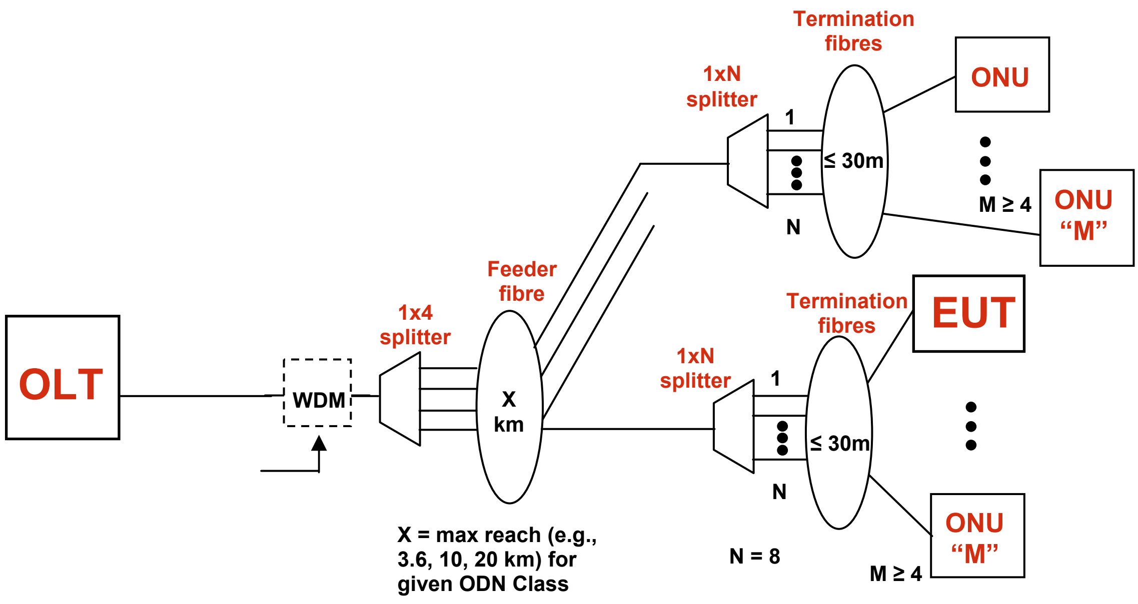



**Figure I.4 – ODN Configuration #2B – Far cluster, multi-stage ODN**

### I.3 Configuration #3 – Near EUT, far cluster

This is the first of two "Min-Max" ODN test configurations that provide both minimum signal delay/level and maximum signal delay/level on the same PON interface. Specifically, this ODN configuration considers the situation where the EUT ONU is located very near (e.g., 0.5 km) the OLT, while the remainder of the ONUs are at the maximum reach of the PON for the ODN class under consideration. The far end cluster of "M" ONUs should consist of at least one EUT ONU (other ONUs may be different models than the ONU that is the subject of the test campaign).

This ODN configuration results in a maximum delay and signal level difference between the near-end EUT ONU and the other ONUs on the PON interface.

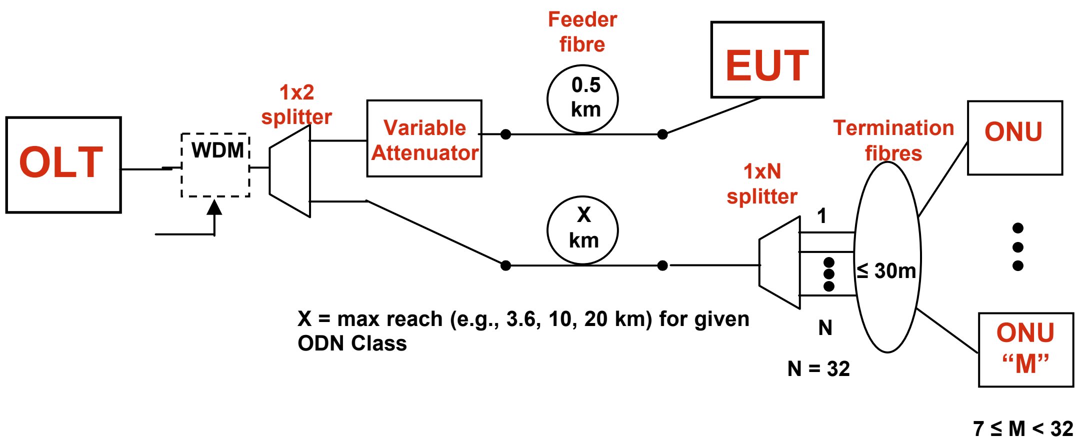



**Figure I.5 – ODN Configuration #3 – Near EUT, far cluster**

### I.4 Configuration #4 – Far EUT, near cluster

This is the second of two "Min-Max" ODN test configurations that provide both minimum signal delay/signal level and maximum signal delay/signal level on the same PON interface. Specifically, this ODN configuration considers the situation where the EUT ONU is located at the maximum reach of the PON for the ODN class under consideration and the remainder of the ONUs are very near (e.g., 0.5 km) the OLT. The near-end cluster of "M" ONUs should consist of at least one EUT ONU (other ONUs may be different models than the ONU that is the subject of the test campaign).

This ODN configuration also results in a maximum delay and signal level difference between the far-end EUT ONU and the other ONUs on the PON interface.

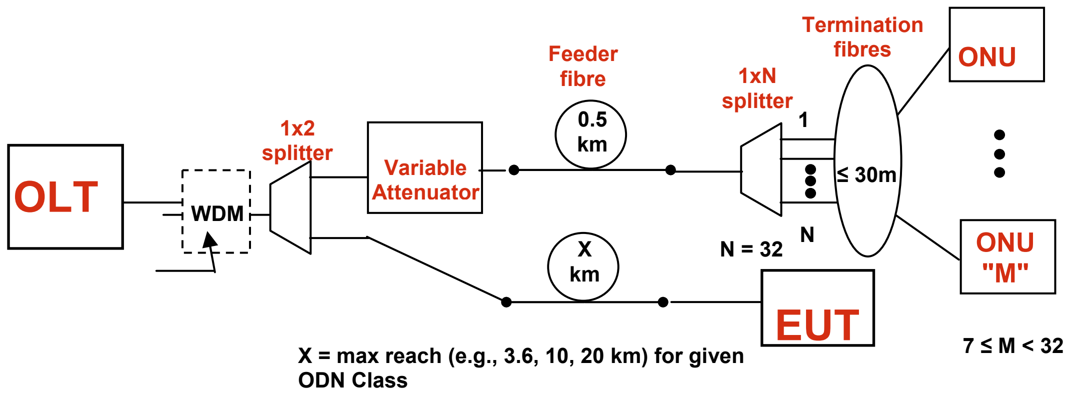



**Figure I.6 – Configuration #4 – Far EUT, near cluster**

# Appendix II

## References


[ITU-T G.984.1] Recommendation ITU-T G.984.1 (2003), *Gigabit-capable Passive Optical Networks (G-PON): General characteristics.*

[ITU-T G.984.2] Recommendation ITU-T G.984.2 (2003), *Gigabit-capable Passive Optical Networks (G-PON): Physical Media Dependent (PMD) layer specification,* plus Amendment 1 (2006) and Amendment 2 (2008).

[ITU-T G.984.3] Recommendation ITU-T G.984.3 (2008), *Gigabit-capable Passive Optical Networks (G-PON): Transmission convergence layer specification.*

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# Appendix III

## Acronyms

| | |
|---|---|
| AES | Advanced Encryption Standard |
| AIS | Alarm Indication Signal |
| ANI | Access Node Interface |
| AVC | Attribute Value Change |
| BER | Bit Error Rate |
| CRC | Cyclic Redundancy Check |
| CTP | Connection Termination Point |
| dB | Decibel |
| DBA | Dynamic Bandwidth Allocation |
| DBRu | Dynamic Bandwidth Report upstream |
| DSL | Digital Subscriber Line |
| EMS | Element Management System |
| EUT | Equipment Under Test |
| FEC | Forward Error Correction |
| FSAN | Full Service Access Network |
| GEM | G-PON Encapsulation Method |
| G-PON | Gigabit-capable Passive Optical Network |
| ICS | Implementation Conformance Statement |
| IP | Internet Protocol |
| LAN | Local Area Network |
| LCD | Loss of Channel Delineation |
| LCT | Local Craft Terminal |
| LIM | Line Interface Module |
| LOS | Loss of Signal |
| MAC | Media Access Control |
| ME | Managed Entity |
| MIB | Management Information Base |
| MoCA | Multimedia over Coax Alliance |
| OAM | Operations, Administration and Maintenance |
| ODN | Optical Distribution Network |
| OLT | Optical Line Terminal |
| OMCC | ONU Management and Control Channel |
| OMCI | ONU Management and Control Interface |
| ONT | Optical Network Terminal |
| ONU | Optical Network Unit |
| OOS | Out Of Service |

| | |
|---|---|
| ORL | Optical Return Loss |
| PEE | Physical Equipment Error |
| PLOAM | Physical Layer Operations, Administration and Maintenance |
| PM | Performance Monitoring |
| PMD | Physical Media Dependent |
| PON | Passive Optical Network |
| POTS | Plain Old Telephone Service |
| PPTP | Physical Path Termination Point |
| REI | Remote Error Indication |
| RF | Radio Frequency |
| RTP | Real-time Transport Protocol |
| SDH | Synchronous Digital Hierarchy |
| SIP | Session Initiation Protocol |
| SLC | Subscriber Line Card |
| SN | Serial Number |
| SNI | Service Node Interface |
| SONET | Synchronous Optical Network |
| SR-DBA | Status Reporting-DBA |
| TC | Transmission Convergence |
| TCA | Threshold Crossing Alert |
| TCP | Transmission Control Protocol |
| TIMS | Transmission Impairment Measurement Set |
| TM-DBA | Traffic Monitoring-DBA |
| UDP | User Datagram Protocol |
| UNI | User Network Interface |
| UPS | Uninterruptible Power Supply |
| VoIP | Voice over Internet Protocol |

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