FSAN GPON

OLT – ONU Interoperability Test Plan

Working Text
Version 1.0
September 2006

We invite all feedback, input will be used to adjust the scope and test cases.

Revision History

Revision	Date	Description
1.0	September 29, 2006	Convert BPON/GPON Working Text to GPON only

Change Log

Revision	Summary of Changes

Table of Contents

1 Introduction

This document defines a test plan whose purpose is to verify interoperability between a GPON OLT and ONU. In this document, 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 document, 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.

2 Scope

This section describes the scope of GPON 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. But 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 document is based on G.984 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 a 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 document, then these conditions will be explicitly stated in the test case

3 Interoperability Guidelines

3.1 Overview

In preparation for interoperability test cycles, this section 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 recommendations as the guidelines for all tests. This section identifies the functionality to be implemented based on these specifications. Both vendors should complete PICS documents for both G.984.2, G.984.3 and 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 recommendation G.984.3 Amendment 1.

3.2.2 Support of Equipment Management Entities

The ONU/OLT should support OMCI and the managed entities defined in G.984.4 & G.983.2. 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.

3.3 Circuit Emulation Services (CES)

The ability to transport unstructured DS1 service is evaluated if supported. The specific method used for CES depends on vendor implementation. Structured DS1 service is not supported in GEM mode.

3.4 Voice over IP (VoIP)

VoIP is evaluated for the ability to provide voice service and the applicable CLASS services.

3.5 High Speed Data Services

A variety of high speed data services are evaluated to determine the PON system capacity and compliance.

3.6 Video Services

IP Video Services are evaluated. IPTV uses IP Multicast and Video on Demand (VOD) uses IP unicast.

3.7 Multiple Services Testing

Mulltiple services will be tested concurrently to ensure that no service interferes with any other service provided for by the PON system.

4 Test Configuration and Equipment

4.1 Network Configuration

Figure 1 shows the test configuration for the interoperability testing of the OLT and ONU. Analog POTS phones and TIMS test equipment connected to the ONU are used to conduct the telephony test.

For voice gateways that require a separate CO switch, it can be either a simulator or a class 5 or a softswitch, which performs circuit-switched telephony functions.

Data services testing should have data test sets available for each side of the network.

DS1 service testing should have the appropriate applicable test gear

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

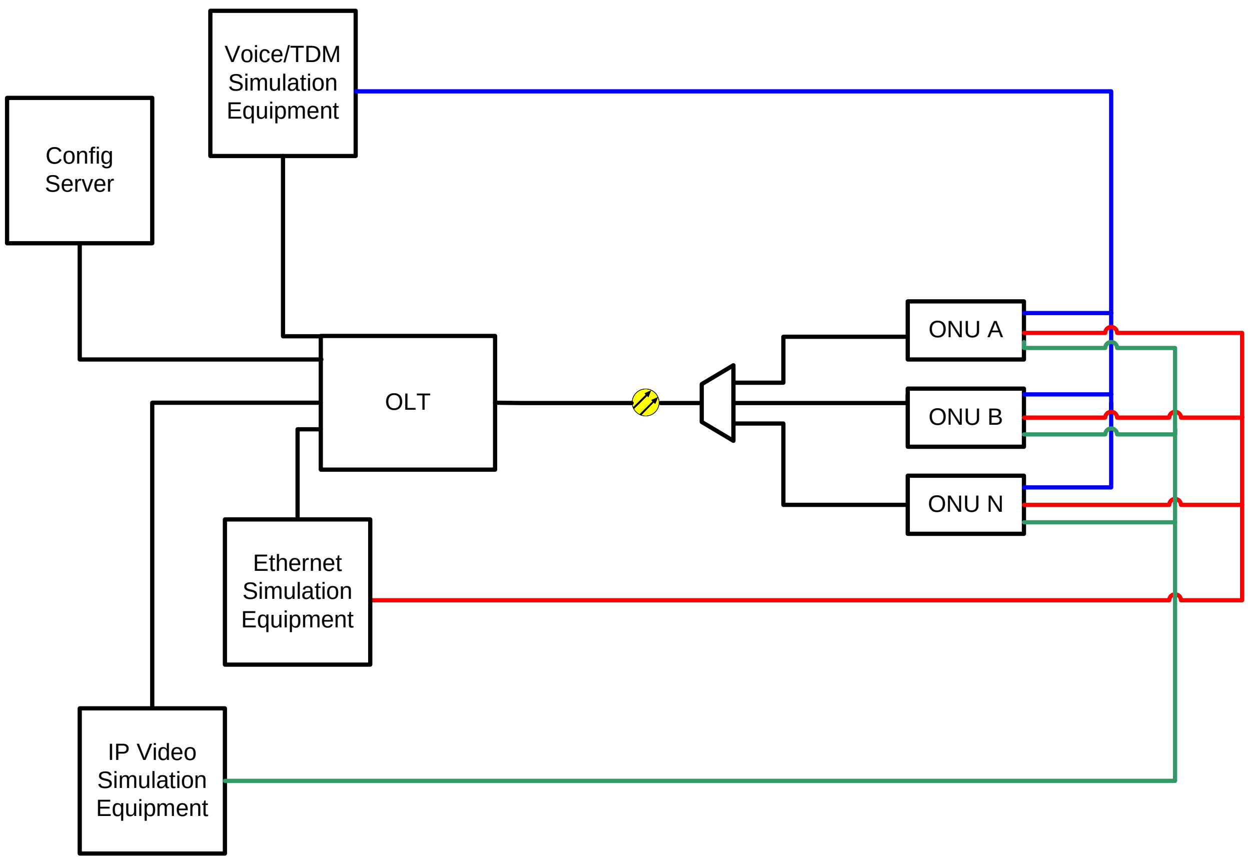


Figure 1.

4.2 Equipment Requirements

The following test equipment is required:

Telephones – At least two phones should be available .

Bulk Call Generator – The recommended number of lines should equal the number of POTS lines are available on the subscriber line interface.

TIMS – End to end voice quality measurements are to be made on each POTS line.

Fax – At least two FAXes or qualified FAX simulators must be available for testing from subscriber to gateway. For purposes of standardization of results the FAX rate should be compliant to V.32bis, 14.4Kbps Group 3 as well as to V.34 28.8Kbps.

Data Test Equipment – A single test unit with two interfaces should be available.

Modem – PC with modem connected either external or internal.

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. .

Voice Gateway – One Voice Gateway is required.

Voice Switch Simulator – One Voice Switch Simulator is required.

Video - EDFA, optical combiner, with ability to present the required optical signal level to the ONU.

4.3 Network Equipment Matrix

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

Equipment Type	Quantity	Manufacturer	Model	Software Version	Hardware Rev.	Hardware Serial Number
Telephones	2					
Bulk Call Generator	1					
TIMS	1					
Data Traffic Generator	1					
Voice Gateway	1					
OLT	1					
ONU	3					
Voice Switch or simulator						
Video EDFA						
Modem						
FAX						
Phones						
Data Switch						

4.4 Vendor Features Comparison Matrix

GPON ONU and OLT vendors are expected to complete an Implementation Conformance Statement (ICS) incorporated as a part of the test report checklist showing supported features. This checklist will help identify the portions of this test plan that should be executed for a given OLT-ONU combination. The checklist 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 GPON are FFS.

5 Optical Compatibility Verification

The tests in this area verify fundamental PMD/TC layer conformance to 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 section provides test cases for measuring the OLT and ONU transmitter launch power as specified in G.984.2 Amd. 1.

5.1.1 ONU Mean Launch Power – TX Off

Test Case # 5.00

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 unranged])

Standard (Criteria): Section 8.2.6.3 of G.984.2 and Appendix III.3 of G.984.2 Ammendment 1.

Preconditions and Dependencies:
The test described in this section is directly applicable to the ONU. However, it can only be performed if the appropriate equipment [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 leveling is supported), an optical filter to isolate the oscilloscope from the OLT transmitter] is available.

Test Setup:

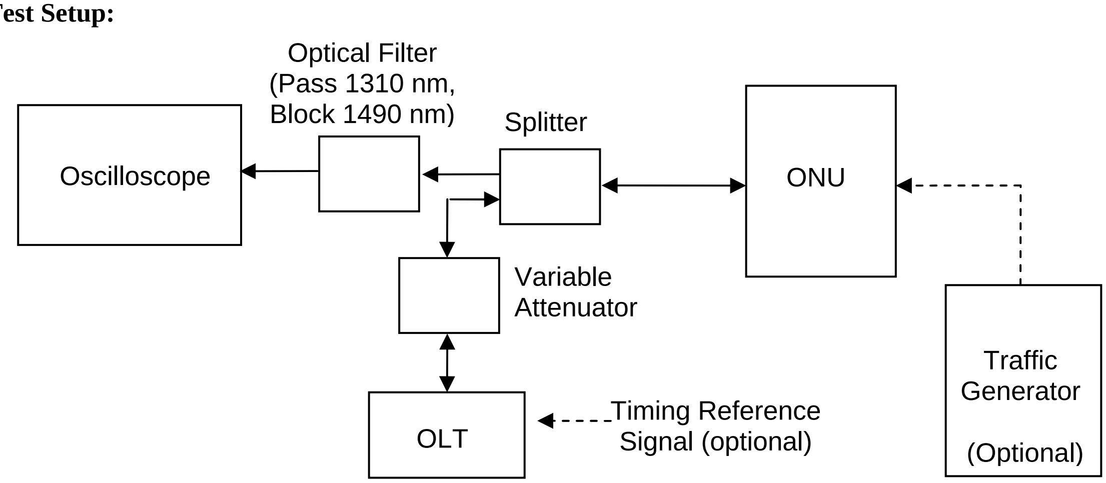


Figure 2. ONU Mean Launched Power Test Configuration – *ONU Ranged, TX off*

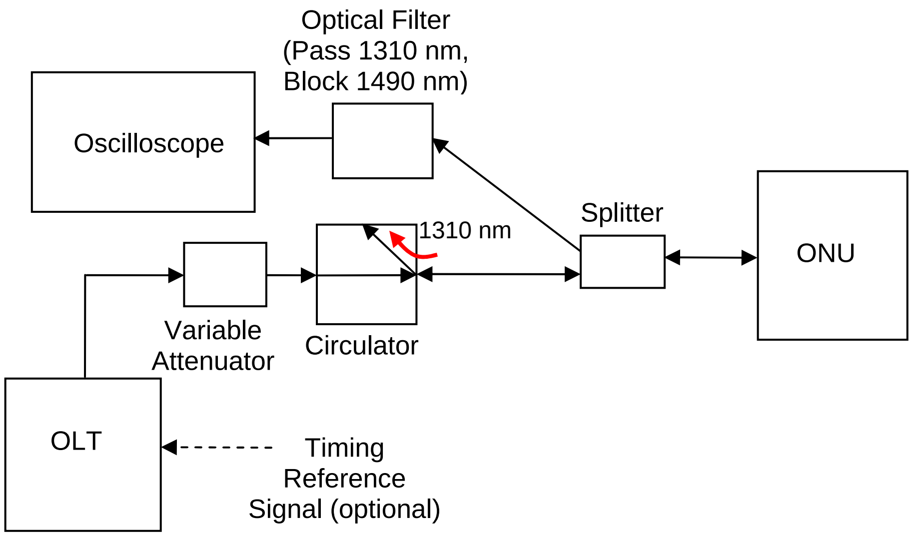


Figure 3. Disabled ONU Mean Launched Power Test Configuration – *ONU Un-ranged*

1. Follow local procedures for cleaning all fiber connectors before making any fiber 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 fiber connected to the oscilloscope (i.e., the difference between the input optical power to the splitter and the output power from that output fiber)
   - 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 fiber) the fiber jumper that provides the input signal to the oscilloscope, capping the end of that fiber so that no ambient light can enter the fiber 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
6. Optical Power Meter

Test Procedure:
1. Adjust the variable attenuator such that the power of the signal reaching the ONU receiver is slightly

[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.

greater than the minimum level that results in essentially error-free operation of that receiver. For an ONU that supports the power leveling mechanism defined in ITU-T Rec. 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 the ONU.
8. If supported by the GPON 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.

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[1]
Ranged ONU Tx-Off					
Unranged ONU Tx-Disabled					

Table Note 1: 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 G.984.2 and G.984.2 Amd 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 GPON ONUs are shown below:

Upstream Rate	Class A	Class B	Class C
1244 Mb/s (w/o power leveling)	-34 or possibly -38 dBm (if APD-based OLT RX)	-38 dBm	-39 dBm
1244 Mb/s (w/ power leveling	-33 dBm or possibly –38 dBm (if APD-based OLT RX)	-38 dBm	-39 dBm

5.1.2 ONU Mean Launch Power – TX Enabled

Test Case # 5.01

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 Section 5.1.3 may be used instead.)

Standard (Criteria): Section 8.2.6.3 of G.984.2 and Section III.3 of G.984.2 Amd 1

Preconditions and Dependencies:
The ONU and OLT need 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 fiber 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 Setup:

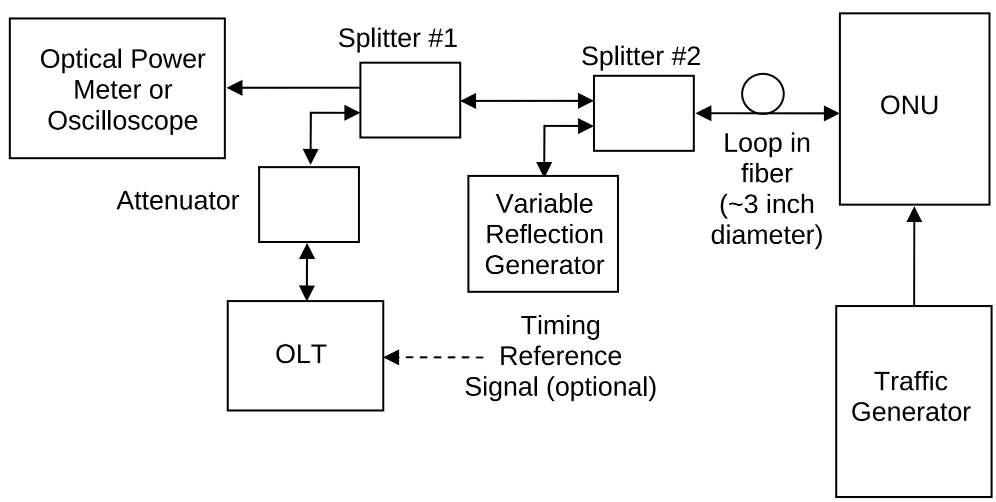


Figure 4. ONU Mean Launched Power Test Configuration[2]

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

[2] The loop in the fiber connecting the ONU to the test ODN is included in the test setup so that any optical power that gets launched into the cladding of the fiber (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 fiber used in the test and make the transmitter look hotter than it effectively is.

4. For a GPON ONU transmitting at 1244 or 2488 Mb/s, G.984.2 defines a power leveling 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 analyzer 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).

  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 to be determined to calculate the actual output power levels from the measured values. These include:

- The insertion loss of the splitters for the output fibers 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 fiber 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.

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

2. Disconnect, clean and reconnect the fiber 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. 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. 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 1 as a tubular illustration of the measurement steps described in the Test Procedure.

Table 2. ONU Mean Launched Power Test Results

Trial	Mode <GPON-only>	Measured Output Power (dBm)	Correction Factors (dB)	Corrected Output Power (dBm)	Max. & Average Output Power (dBm)	Pass/ Fail Result[1]
1 2 3 4 5	N/A or 0					
1 2 …	1					
1 2 …	2					

Table Note 1: 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 Section 8.2.6 of G.984.2 and Section III.3 of G.984.2 Amd 1.The ONU mean launched power specifications for 1244 Mb/s are as shown below:

Rate	**Mode**	**Class A**	**Class B**	**Class B+**	**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

Test report: Pass _____ Fail _____ Not Supported _____

Observation:

Last Modified: July 25, 2006

[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 fiber. 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 nonconformance to that specification (even if the average of the five measurements is within the specified range).

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 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 # 5.02

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 Section 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): Section 8.2.6 of G.984.2 and Section III.3 of G.984.2 Amd 1

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 Setup:

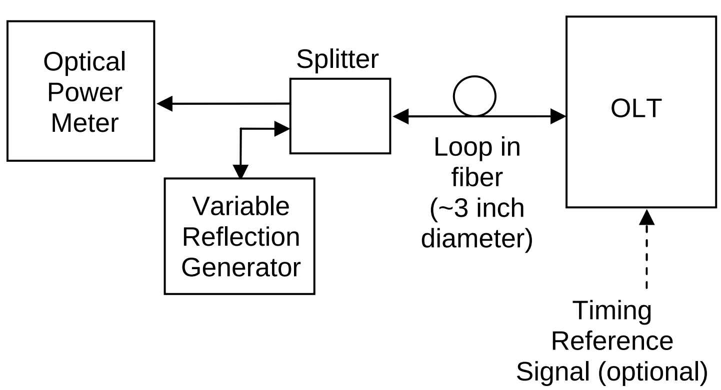


Figure 5. OLT Mean Launched Power Test Configuration

1. Follow local procedures for cleaning all fiber connectors before making any fiber 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 fiber connected to the power meter (i.e., the difference between the input optical power to the splitter and the output power from that output fiber) for use in correcting the power measurements obtained during the tests.

[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 Section 8.2.6.7 of G.984.2.

4. Although the data pattern for this test is specified in G.984 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

Test Procedure:
1. Record the power measured by the power meter, as illustrated in Table 3.
2. Disconnect, clean and reconnect the fiber 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[1]
OLT #1	1 2 3 4 5				

Note 1: 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 G.984.2.

Test report: Pass _____ Fail _____ Not Supported _____

Observation:

Last Modified: July 25, 2006

5.2 Receiver Sensitivity

This section 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 # 5.03

Purpose: This test case assesses whether the ONU is able to operate at a bit error ratio (BER) at or below 10^{-10} when

[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 fiber. Significant variations in the measured power level could indicate a low-quality or damaged connector.

the received signal is at the minimum acceptable average power specified in G.984. 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. 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 "Fiber 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): Section 8.2.6 of G.984.2 and Section III.3 of G.984.2 Amd 1

Preconditions and Dependencies: This 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 sensitivity rather than using external test equipment to estimate the BER. Accessing this data typically requires OLT management system or craft interface access.

Test Setup:

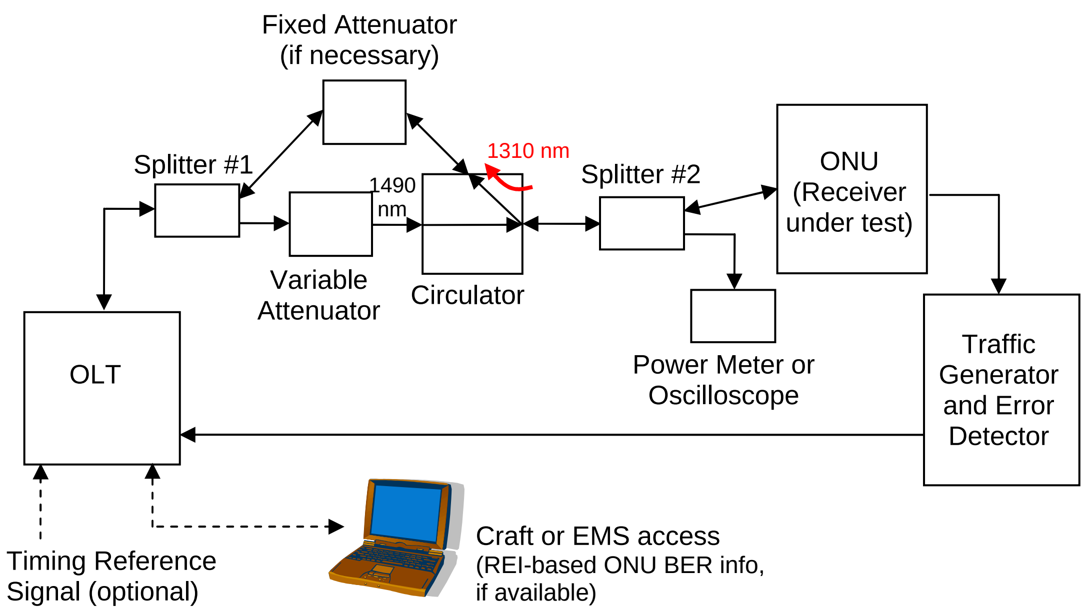


Figure 6. Receiver Sensitivity Test Configuration

1. Follow local procedures for cleaning all fiber connectors before making any fiber 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 (traveling 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. If available, a circulator optimized for operation at 1490 nm should be used. 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.

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 but 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).

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

PL = Packets Lost
PT = Packets Transmitted
N = # of bits within a packet, 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 setup 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 leveling function) that could have a significant impact on the short-term BER]. In the test setup 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 fibers, 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. Determine the correction factors that must 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. Ensure that downstream FEC is disabled.
4. 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.
5. 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.
6. 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].
7. 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.
8. 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.
9. 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 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].)
10. Fit a line through the data points and determine the power level at which that line crosses the BER level of 10^{-10}.
11. 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).
12. 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 11. 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 3 as a tubular 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[1]	Calc. Sens. (dBm) & Pass/Fail Results[2]

[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.

Table Notes:

1. The number of bits per packet (for use in the denominator of the BER calculation) is _______. (See the discussion in the “Setup” section above regarding the determination of the appropriate value.)
2. See Pass-Fail criteria section below.

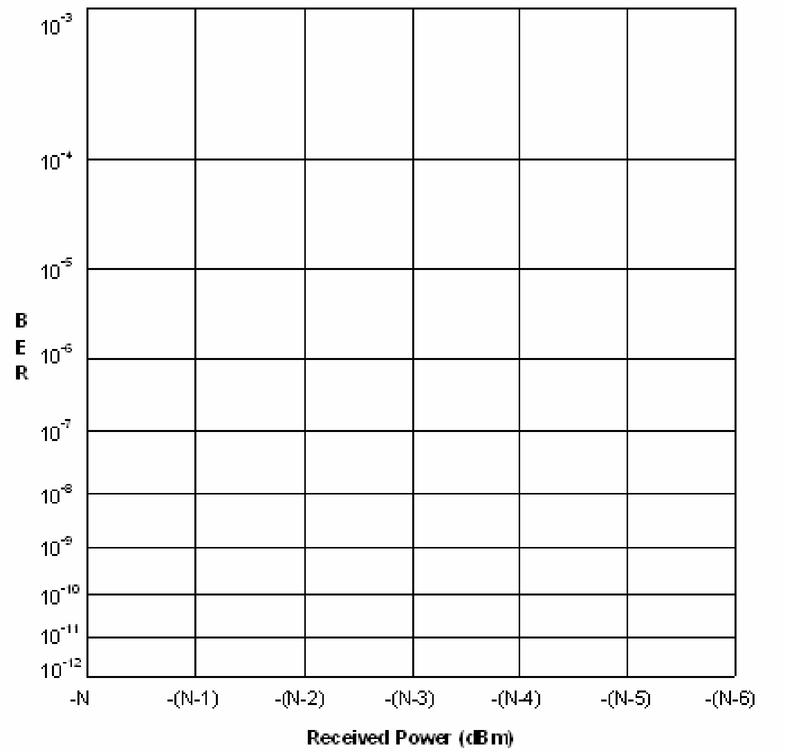


Figure 7. BER Versus Received Power Plotting Paper

Pass Fail Criteria:
The receiver sensitivity specifications are that the BER must be 1×10^{-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 4-c of G.984.2 and Table III.1 of G.984.2 Amd 1.

Downstream Rate	Class A	Class B	Class B+	Class C
2488 Mb/s	-21 dBm	-21 dBm	-27 dBm	-28 dBm

Test report: Pass _____ Fail _____ Not Supported _____

Observation:

Last Modified: July 25, 2006

5.2.2 OLT Receiver Sensitivity

Test Case # 5.04

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.

Standards: Section 8.2.6 of G.984.2 and Section III.3 of G.984.2 Amd 1.

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 Setup: See Figure 6 with the OLT now in the position of the receiver under test and a circulator optimized for operation at 1310 nm.

Test procedure: See ONU test case procedure of section 5.2.1, with OLT substituted for ONU. Note that the power correction factor equivalent to $\Delta P_{On/Off}$ (see Section 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 indicates 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 Section 8.2.8 of G.984.2.

The G.984.2 (GPON) section 8.2.8 OLT receiver sensitivity criteria are:
.

Upstream Rate	Class A	Class B	Class C
1244 Mb/s	-24 dBm	-28 dBm	-29 dBm

Test report: Pass _____ Fail _____ Not Supported _____

Observation:

Last Modified: Aug. 31, 2005

5.3 Receiver Overload

This section 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-caseG.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, Telcordia does not feel that FEC encoding/decoding will 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

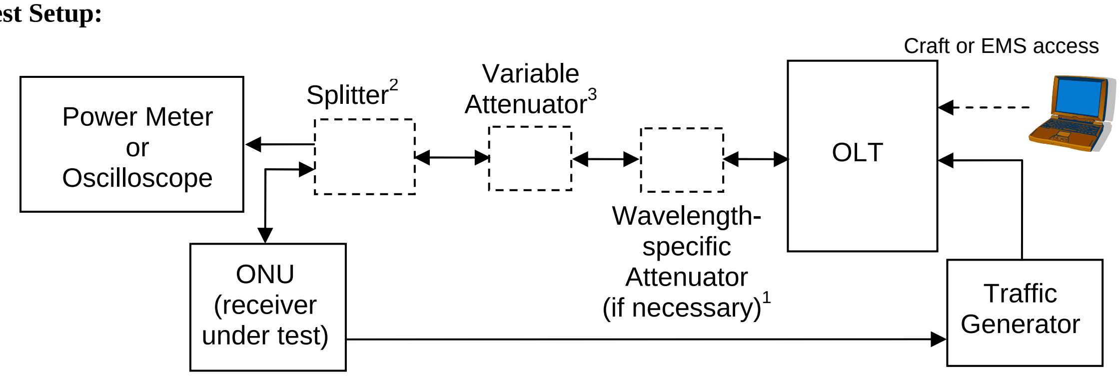
Test Case # 5.05

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: Section 8.2.6 of G.984.2 and Section III.3 of G.984.2 Amd 1

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 Setup:



Notes:

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.

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 setup, 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).

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 fiber connectors before making any fiber 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 section 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 6. (Note that the y-axis scale used for this graph paper 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[1]	Calc. Sens. (dBm) & Pass/Fail Results[2]

Table Notes:
1. The number of bits per packet (for use in the denominator of the BER calculation) is _______. (See the discussion in the “Setup” section of Section 5.2.1, *ONU Receiver Sensitivity* above regarding the determination of the appropriate value.)
2. See Pass-Fail criteria section 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.

GPON receiver overload criteria are specified in Section 8.2.8 of G.984.2.

Downstream Rate	Class A	Class B	Class B+	Class C

[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.

2488 Mb/s	-1 dBm	-1 dBm	-8 dBm	-8 dBm

Test report: Pass _____ Fail _____ Not Supported _____

Observation:

Last Modified: July 25, 2006

5.3.2 OLT Receiver Overload

Test Case # 5.06

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): Section 8.2.6 of G.984.2 and Section III.3 of G.984.2 Amd 1.

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 Setup: 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 section 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 section 8.2.8 of G.984.2.

The receiver overload specifications based on Section 8.2.6 of G.984.2 and Section III.3 of G.984.2 Amd 1 are shown below.

Upstream Rate	Class A	Class B	Class B+	Class C
1244 Mb/s	-3 dBm	-7 dBm	-8 dBm	-8 dBm

Test report: Pass _____ Fail _____ Not Supported _____

Observation:

Last Modified: July 25, 2006

6 ONU turn-up and management

This test area considers fundamental PON functionality, both for turn-up and ONU management. The test cases are generally characterized by the pairwise nature of the testing (ie a single ONU interoperating with the OLT).

6.1 ONU start-up

Unlike BPON there is only one method for ONU discover in GPON. 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:
Section 2.28 of G.984.3 Amd 1

Preconditions:
3 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 Setup:
Default test setup 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 fiber
3. ONU shall range in 30 seconds
4. Disconnect ONU1 from the fiber 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 fiber
3. Manually start the ranging process
4. ONU shall range in 30 seconds
5. disconnect ONU1 from the fiber 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:
Section 2.28 of G.984.3 Amd 1

Preconditions:
3 ONUs not connected to the PON and powered down 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:
None

Test Setup:
Default test setup as shown in Figure 1 with an additional ONU connected and active during test iterations.

Test Procedure
Automatic activation

1. Connect ONU1 to Fiber and power up
2. ONU shall range within 30s.
3. Power down and disconnect ONU1 fiber
4. PON in cold state – ONU1 in cold state
   Repeat for ONU2 and ONU3

Manual activation

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

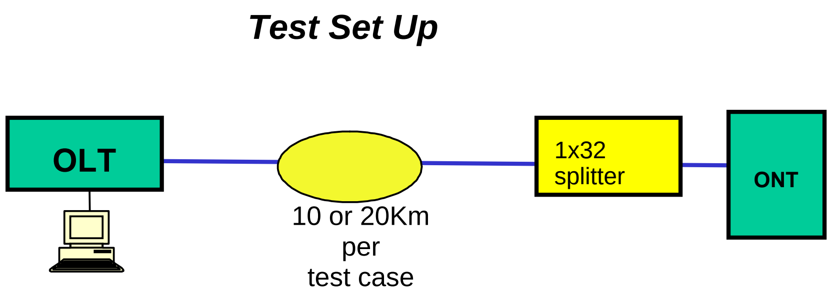
Observations:
Elapsed time, power on to ranging complete (min, average, max):

Last Modified: July 26, 2006

6.1.3 ONU Ranging Various Cable Lengths

The following test cases verify start-up interoperability between OLTs and ONUs for ranging at various fiber lengths. The tests are iterations of test cases 6.10 and 6.20 with different ODN characteristics.
Test cases are performed with 10km and 20km of fiber between the OLT and the splitter

Test Setup:
The basic test setup for the ONU start-up tests is shown in the figure below. It consists of a single ONU connected to the OLT, except as noted in certain test cases, with either 10 or 20 km. of fiber between the OLT and the splitter.



6.1.3.1 Cold PON Cold ONU – 10km Fiber

Test Case #6.30

Purpose:
To verify that the OLT initializes the ONU when the ONU is registered in OLT prior to startup.

Standard:
Section 2.28 of G.984.3 Amd 1

Preconditions:
3 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 10km. Of fiber cable between the OLT and the 1 x 32 splitter.

Test Equipment:
None

Test Setup:
10km. test setup as shown in 6.1.3

Test Procedure
Automatic activation
1. Connect ONU1 to fiber and power up
2. ONU shall range within 30s.
3. Power down and disconnect ONU1 fiber
   Repeat for ONU2 and ONU3

Manual activation
1. Connect ONU1 to fiber and power up
2. Manually start ranging
3. ONU shall range within 30s.
4. Power down and disconnect ONU1 fiber
   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 - 20km

Test Case #6.40

Purpose:
To verify that the OLT initializes the ONU when the ONU is registered in OLT prior to startup.

Standard:
Section 2.28 of G.984.3 Amd 1

Preconditions:
3 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 20km. Of fiber cable between the OLT and the 1 x 16, 1 x 32, or 1 x 64 splitter.

Test Equipment:
None

Test Setup:
20km. test setup as shown in 6.1.3

Test Procedure
Automatic activation
1. Connect ONU1 to fiber and power up
2. ONU shall range within 30s.
3. Power down and disconnect ONU1 fiber
   Repeat for ONU2 and ONU3

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

6.2 TC-layer OAM operation

6.2.1 LOS or LCD detection

Test Case # 6.50

Test Setup:
Default test setup as shown in Figure 1

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

Standard: Section 2.28 of G.984.3 Amd 1

Preconditions: ONU ranged

Test Equipment: None

Procedure:
1. Disconnect fiber from ONU. OLT is expected to declare LOS or LCD against ONU, possibly with a soak interval.
2. After a minimum of 30 seconds, restore the fiber 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 pon_id message

Test Case # 6.60

Test Setup:
Default test setup as shown in Figure 1

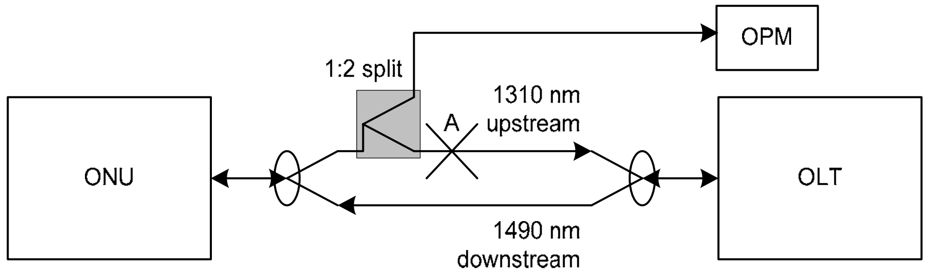
Purpose:
The OLT is required to deactivate the ONU when the ONU's upstream link fails in any of several ways. The test case requires an ODN that separates upstream and downstream wavelengths, with upstream problems simulated by detaching the upstream fiber of a ranged ONU.

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: Section 2.28 of G.984.3 Amd 1

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.



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

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 behavior

Test Case # 6.70

Test Setup:
Default test setup as shown in Figure 1

Purpose:
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 (see test case 6.60). In the absence of direct verification, the OLT's alarm, PM or log mechanisms must be relied upon to identify anomalous ONU behavior.

Since emergency stop is expected to be triggered by 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: Section 9.2.3.6 of G.984.3

Preconditions: Same as 6.60

Test Equipment: Same as 6.60

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.
5. Force the OLT to forget the disabled state of the ONU, eg through OLT reinitialization. The reinitialized OLT is expected to attempt to re-range the ONU normally, and the ONU is expected not to respond.
4. G.983.1 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
5. Invoke the OLT's mechanism to sends e-stop with serial number enabled to the ONU. Confirm that the ONU returns to normal service.

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 # 6.80

Test Setup:
Default test setup 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 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 (eg DS1 AIS, release of POTS calls).

Standard: Section 9.2.3.15 of G.984.3

Preconditions: ONU ranged, provisioned with any services whose behavior 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 behavior

Last Modified: July 26, 2006

6.2.5 OLT reaction to PEE message from ONU

Test Case # 6.90

Test Setup:
Default test setup 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 OLT. 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: Section 9.2.4.6 of G.984.3

Preconditions: ONU ranged, provisioned with any services whose behavior 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 behavior.

Last Modified: July 26, 2006

6.2.6 Dying Gasp PLOAM

Test Case # 6.100

Test Setup:
Default test setup 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, eg log entry, notification, state change.

Standard: Section 9.2.4.3 of 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, eg by removing power. Observe the OLT's behavior.
2. Restore the ONU by releasing the conditions created in step 1, eg 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 alarm, and which (either or both) messages are transmitted. Record the OLT's behavior (eg alarm declared, service conditioning).

Last Modified: July 26, 2006

6.2.7 REI operation

Test Case # 6.110

Test Setup:
Default test setup 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 behavior should be characterized and confirmed to comply with the OLT vendor's documentation. OLT behavior 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: Section 9.2.4.8 of 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 622-Mb/s PON is 62 per 100 ms, scaling proportionately with BER interval, PON speed and BER.
6. Observe the OLT's behavior, including soaking, leading to a possible alarm, and accumulation leading to a PM TCA.
7. Stop injecting errors, and observe the OLT's behavior, 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 behavior 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 # 6.120

Test Setup:
Default test setup 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. G.983 and G.984 allow 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, eg 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, and because the LCT is likely to be the only way to set or change an ONU's password.

Standard: G.983.2, 7.3.54

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 behavior 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 # 6.130

Test Setup:
Default test setup 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 behavior is recorded. The password is then restored to its original value, the ONU is again re-ranged and the OLT's behavior 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: G.984.3 provides for the mechanism of password request/respond but it relies on the BPON recommendation for the explanation. G.983.1 table 17 and 8.3.5.7. Table 17, line 18, says the OLT will (not *shall*) not activate the ONU upon password mismatch (*activate* is undefined). Table 17, line 30, says the consequence of a mismatch is system-dependent. According to 8.3.5.7, the OLT simply informs its management client upon password mismatch. 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, 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, eg 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 (eg by disconnecting its fiber for a minimum of ten seconds) and restore it. Permit it to range again.
6. Characterize the OLT's behavior 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 behavior 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 behavior of OLT when ONU's password changes.

Last Modified: July 26, 2006

6.3.3 Data services with encryption enabled

Test Case # 6.140

Test Setup:
Default test setup as shown in Figure 1

Purpose:
Provision Ethernet services on an encrypted Port-ID. Use data test sets to confirm that data traffic flow is completely unaffected by encryption and key updates.

Standard: Section 12.2 of G.984.3

Preconditions: ONU ranged. OLT and ONU provisioned for Ethernet service.

Test Equipment: Ethernet test set connected to ONU port and to a corresponding data port at, or upstream from, the OLT.

Procedure:

1. The vendors should agree with the test lab on the expected bit error rate and downstream Ethernet throughput, and derive a valid statistical sample size to demonstrate the desired performance at the desired confidence level. For example, the expected error count if 10^{10} bits are transferred at a BER of 10^{-10} is 1. At 10^{7} bits/second, 10^{3} seconds are required to transfer 10^{10} bits over a single port. An additional order of magnitude may be appropriate to establish a given level of statistical confidence.
2. Generate valid Ethernet traffic downstream, counting bit errors at the ONU, for a period sufficient to determine BER with the desired confidence.
3. Provision Port-ID to be encrypted. This is the Port-ID to be used for testing.
4. Generate valid Ethernet traffic downstream, counting bit errors at the ONU, for a period sufficient to determine BER with the desired confidence.

Pass-fail criteria: Fail if the error rate with encryption differs from the error rate without encryption.

Test report: Pass _____ Fail _____ Not Supported _____

Observations: Bit error rate and characteristics (eg error bursts correlating with updates to the encryption key)

Last Modified: July 26, 2006

6.3.4 MoCA services with encryption enabled

Test Case # 6.150

Test Setup:
Default test setup as shown in Figure 1

Purpose:
Provision MoCA services on an encrypted Port ID. Use data test sets to confirm that data traffic flow is completely unaffected by encryption and key updates.

Standard: G.984.4 Amd 2

Preconditions: ONU ranged. OLT and ONU provisioned for MoCA service. RGW ranged and linked up with ONU

Test Equipment: Data test set connected to RGW data port and to a corresponding data port at, or upstream from, the OLT.

Procedure:

1. The vendors should agree with the test lab on the expected bit error rate and downstream data throughput, and derive a valid statistical sample size to demonstrate the desired performance at the desired confidence level. For example, the expected error count if 10^{10} bits are transferred at a BER of 10^{-10} is 1. At 10^{7} bits/second, 10^{3} seconds are required to transfer 10^{10} bits over a single port. An additional order of magnitude may be appropriate to establish a given level of statistical confidence.
2. Generate valid data traffic downstream, counting bit errors at the RGW, for a period sufficient to determine BER with the desired confidence.
3. Provision data Port ID to be encrypted. This is the Port ID to be used for testing.
4. Generate valid data traffic downstream, counting bit errors at the RGW, for a period sufficient to determine BER with the desired confidence.

Pass-fail criteria: Fail if the error rate with encryption differs from the error rate without encryption.

Test report: Pass _____ Fail _____ Not Supported _____

Observations: Bit error rate and characteristics (eg error bursts correlating with updates to the encryption key)

Last Modified: July 10, 2006

6.3.5 Multi-service Encryption

Test Case # 6.160

Test Setup:
Default test setup as shown in Figure 1

Purpose:
To verify that encryption operates properly on all ONU services simultaneously.

Standard: Section 12.2 of G.984.3

Preconditions: ONU ranged.

Test Equipment: Traffic generators to generate traffic and monitor for bit, frame and packet errors on all services that are supported by encryption, eg voice & data.

Procedure:

1. Provision at least one encrypted instance of each service supported by the OLT-ONU pair. Higher loads increase the sample size and the statistical validity of the observations.
2. Setup traffic on each encrypted service; monitor the traffic to ensure that it is completely unaffected by changes in the encryption key.
3. Provision additional services on additional Port-IDs and enable encryption on each. If there is a limit on the number of encrypted Port-IDs, record it. Monitor the traffic on all services to ensure that it is completely unaffected by key updates. Continue the test until performance is established with the desired level of confidence.

Pass-fail criteria: Fail if the error rate with encryrption differs from the error rate without encryption.

Test report: Pass _____ Fail _____ Not Supported _____

Observations:

Last Modified: July 26, 2006

6.3.6 Ranging of ONU with encryption enabled

Test Case # 6.170

Test Setup:
Default test setup 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: Section 12.2 of G.984.3

Preconditions: ONU ranged. Encryption services setup and monitored for errors.

Test Equipment: Traffic generators and monitors for all traffic types supported jointly by the OLT and ONU.

Procedure:
1. Re-boot the ONU. Confirm that it recovers, and restores encryption error-free transmission on all provisioned services.
2. Re-boot the OLT. Confirm that it recovers the ONU and restores encryption error-free transmission on all provisioned services.

Pass-fail criteria: Fail if any service is not properly restored.

Test report: Pass _____ Fail _____ Not Supported _____

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

Last Modified: July 26, 2006

6.4 ONU management via OMCI

6.4.1 Managed entity – ONU-G, ONT -G

Test Case # 6.180

Test Setup:
Default test setup as shown in Figure 1

Purpose:
To confirm that the ONT or ONU ME exists and supports all mandatory attributes and actions. Optional attributes and default values are characterized.

Standard: Section 9.1 of 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/ONU 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: July 25, 2006

6.4.2 Managed entity – ONU2-G, ONT2-G

Test Case # 6.190

Test Setup:
Default test setup as shown in Figure 1

Purpose:
To confirm that the ONT2-G or ONU2-G ME exists and supports all mandatory attributes and actions. Optional attributes and default values are characterized.

Standard: Section 9.1 of G.984.4

Preconditions: ONU ranged

Test Equipment: None

Procedure:

3. 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.)
4. 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/ONU2 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: July 25, 2006

6.4.3 Managed entity – Software image

Test Case # 6.200

Test Setup:
Default test setup 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. G.983.2 specifies two more images for each downloadable subscriber line card, but they are not expected to be found in actual equipment, for reasons related to inter-module compatibility.

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

Standard: G.983.2 7.1.7 (This and many other sections of G.983.2 apply to GPON)

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 behavior 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: July 25, 2006

6.4.4 ONU software download from OLT

Test Case # 6.210

Test Setup:
Default test setup 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 (eg 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: G.983.2 7.1.7

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: July 25, 2006

6.4.5 New software activation

Test Case # 6.220

Test Setup:
Default test setup as shown in Figure 1

Purpose:
After downloading a new image (eg via test case 6.200), 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: G.983.2 7.1.7

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 6.210.

Test Equipment: None

Procedure:
1. Test case 6.210 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 behavior does not comply with description above.

Test report: Pass _____ Fail _____ Not Supported _____

Observations:

Last Modified: July 25, 2006

6.4.6 Committing of new software download

Test Case # 6.230

Test Setup:
Default test setup as shown in Figure 1

Purpose:
After downloading a new image (eg via test case 6.210), 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 6.220, 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: G.983.2 7.1.7

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 6.220.

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: July 25, 2006

6.4.7 Download of invalid software and proper error reporting

Test Case # 6.240

Test Setup:
Default test setup 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 a file that is not a proper image should fail. It may not be possible to force the OLT to generate an incorrect CRC, which is the only mechanism defined in G.983.2 to validate the image. The ONU's response is to be characterized for the test report.

All of these attempts should fail. Depending on the OLT's safeguards, some of these steps may be prevented at the OLT or its management client, while other steps may be permitted by the OLT and should be prevented at the ONU.

Standard: G.983.2 7.1.7

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 or CRC signature, eg with an offline binary editor. Attempt to download this image onto N. If download succeeds, the test case fails.
5. Observe whether the ONU now shows image N as invalid, uncommitted and inactive, or whether the previous image N was retained.

6. 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 download a new image on top of a committed or active image, or successful download of an invalid image.

Test report: Pass _____ Fail _____ Not Supported _____

Observations:

Last Modified: July 25, 2006

6.4.8 Managed entity – UNI-G

Test Case # 6.245

Test Setup:
Default test setup as shown in Figure 1

Purpose:
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 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 (eg 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: G.984.4 9.3.1

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

Test Equipment: None

Procedure:
7. 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.
8. 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.
9. 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

6.4.9 Managed entity – Cardholder

Test Case # 6.250

Test Setup:
Default test setup as shown in Figure 1

Purpose:

The SLCH managed entity represents a line card slot of the ONU. The ONU autonomously creates an instance of the SLCH ME for each physical subscriber line card slot. The expected LIM type can be provisioned from the OLT, and the SLCH monitors the presence of a physical LIM, reporting installation, extraction, type mismatch, etc.

For ONUs with integrated UNIs, this ME represents a virtual subscriber line card holder. Although it is optional, G.983.2 recommends that the ME exist. There are two choices:

- G.983.2 allows for the possibility that a single virtual SLCH exist with virtual slot-ID 0; the attributes of the SLCH are not meaningful in this case. However, this choice supports PPTP ME numbering for all services with a 0 slot-id.
- The alternative is that the integrated ONU create a series of SLCH MEs, one for each class of service offered by the ONU. The SLCH attributes are of interest only as a matter of record, but each service type has a distinct virtual slot, and PPTP MEs are numbered according to their virtual slots.

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.

Additional attributes (expected port count, expected equipment ID) have been proposed for this ME. When agreed, they will require an update to this test case.

Standard: G.983.2 7.1.3

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 SLCH ME from an OLT management client. Record its attributes. Repeat for as many virtual SLCs as the ONU supports. This completes the test case for such ONUs.
2. For an ONU with pluggable LIMs, get the SLCH 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 SLCH 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 SLCH actualType 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 SLCH 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 SLCH 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: July 25, 2006

6.4.10 Managed entity – Circuit Pack

Test Case # 6.260

Test Setup:
Default test setup as shown in Figure 1

Purpose:
This managed entity represents a subscriber line card provisioned in an ONU slot. For ONUs that support provisionable line cards, verify that an instance of this managed entity is created by the ONU when the OLT provisions the subscriber line card (that is, when the OLT sets the expected plug-in unit type of the subscriber line card holder to a specific LIM type). If the ONU supports plug and play line cards, characterize whether an instance of this managed entity is created by the ONU when the OLT sets the expected plug-in unit type of the corresponding subscriber line card holder to *plug and play*. The ONU must delete the SLC ME if the SLCH is provisioned to *no LIM*. The ONU may delete the SLC ME when the SLCH is provisioned to *plug and play*. This latter behavior is not expected, but should be characterized and noted if it occurs.

For an ONU with integrated UNIs, G.983.2 recommends, but does not require that the ONU create instances of this managed entity. If such an ONU supports this ME, it is to be characterized, largely without pass-fail criteria.

Standard: G.983.2 7.1.4

Preconditions: ONU ranged. If ONU has pluggable LIMs, all subscriber line card slots empty, all subscriber line cardholders provisioned to expect *no LIM*.

Test Equipment: None

Procedure:

1. For an ONU with integrated UNIs, attempt to get each possible SLC ME (one for each virtual slot). It is acceptable if neither SLCH nor SLC ME exists; in this case, the test case is complete; record the result. If the SLCH exists and the SLC ME does not exist, the test case is complete with a failure. Assuming the SLC ME exists; continue the test with steps 4, 5, 6.
2. For an ONU with pluggable LIMs, attempt to get each possible SLC ME. The ME should not exist until step 3.
3. For slot 1, provision the slot's parent SLCH ME to the type of the intended LIM. Verify that the SLC 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 SLCH to expect no LIM. The SLC ME should no longer exist (get fails).
8. Extract the LIM. There should be no alarms.
9. Provision the parent SLCH for plug and play.
10. Insert the LIM again. The ONU should auto-create the SLC ME, with attributes consistent with the LIM.
11. Provision the parent SLCH for no LIM. Attempt to get the SLC; it should no longer exist.
12. Extract the LIM. Provision the SLCH to expect plug and play. With the slot empty, attempt to create the SLC. Record the result.

13. Repeat steps 3-6 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 SLCH state machine for each slot or each LIM type.

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

Test report: Pass _____ Fail _____ Not Supported _____

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

Last Modified: July 25, 2006

6.4.11 Managed entity – Physical path termination point Ethernet UNI

Test Case # 6.270

Test Setup:
Default test setup as shown in Figure 1

Purpose:
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 G.983.2. 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 (eg 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 (6.340 through 6.390) while a slot is equipped with a given LIM.

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

Standard: G.983.2 7.3.2

Preconditions: Ranged ONU. If the ONU supports pluggable Ethernet LIMs, an Ethernet LIM 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 (SLCH 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 SLC state machine. Fail if mandatory attributes are missing 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

6.4.12 Managed Entity Physical Path termination point MoCA UNI

Test Case # 6.280

Test Setup:
Default test setup as shown in Figure 1

Purpose:
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 G.983.2. 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 (eg 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: G.983.2 R2 Am2

Preconditions: Ranged ONU. If the ONU supports pluggable data LIMs, an data LIM installed.

Test Equipment: None

Procedure:

4. Verify that an 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.
5. If the ONU supports pluggable LIMs, extract the MoCA LIM and deprovision the slot (SLCH expected type = no LIM). Verify that the ONU deletes the corresponding data PPTPs.
6. 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 SLC state machine. Fail if mandatory attributes are missing 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

6.4.13 Managed entity – Physical path termination point video ANI

Test Case # 6.300

Test Setup:
Default test setup 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 G.983.2. As a characterization result, record the default values of attributes not specified by the OLT or by G.983.2.

Standard: G.983.2 7.3.53

Preconditions: ONU ranged.

Test Equipment: Video head-end feeding an RF stream; TV or signal analyzer 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. The text of G.983.2/2005 states that more than one instance may exist, but does not provide for ME identification of additional instances (they might be associated with redundant PON interfaces, for example). If there is more than one instance, record it as an observation.
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 6.310), 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: July 25, 2006

6.4.14 Managed entity – Physical path termination point video UNI

Test Case # 6.310

Test Setup:
Default test setup as shown in Figure 1

Purpose:
This managed entity represents the downstream video output. Verify 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 G.983.2. As a characterization result, record the default values of attributes not specified by the OLT or by G.983.2.

Standard: G.983.2 7.3.52

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 analyzer 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 6.300), 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, eg 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: July 25, 2006

6.4.15 Managed entity – ANI-G

Test Case # 6.320

Test Setup:
Default test setup 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 (stated as a requirement by G.983.2 7.2.2, but as an option in table 1). All attributes of this ME are read-only to the OLT, although their values may change as the result of other events.

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

Standard: G.984.4 9.2.1

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: July 25, 2006

6.4.16 Managed entity – Priority Queue-G

Test Case # 6.330

Test Setup:
Default test setup 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.

Verify 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: G.984.4 9.5.1

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 (eg 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

6.4.17 Managed entity – MAC bridge service profile

Test Case # 6.340

Test Setup:
Default test setup as shown in Figure 1

Purpose:
The MAC bridge service profile represents an instance of a MAC bridge itself; it is the center 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 (6.270 and 6.340 through 6.390) while a slot is equipped with a given LIM.

Standard: G.983.2 7.3.29

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: July 25, 2006

6.4.18 Managed entity – GAL Ethernet profile

Test Case # 6.350

Test Setup:
Default test setup as shown in Figure 1

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

Standard: G.984.4 9.3.5

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: Aug. 21,2006

6.4.19 Managed entity – GEM Port network CTP

Test Case # 6.360

Test Setup:
Default test setup 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 6.370.

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

Standard: G.983.2 7.4.1

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. If the OLT and ONU support unidirectional GEM ports, edit the direction attribute to verify that all supported options can be set.

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. 21, 2006

6.4.20 Managed entity – GEM Interworking termination point

Test Case # 6.370

Test Setup:
Default test setup as shown in Figure 1

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

Standard: G.984.4 9.3.3

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 2-3 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 (eg 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: Aug. 21, 2006

6.4.21 Managed entity – MAC bridge port configuration data

Test Case # 6.380

Test Setup:
Default test setup as shown in Figure 1

Purpose:
Verify that instances of this ME can be created and deleted by the ONT. 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 (6.270 and 6.340 through 6.390) while a slot is equipped with a given LIM.

Standard: G.984.4 Amd 2 9.3.9

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

6.4.22 Basic service provisioning – MAC bridge

Test Case # 6.390

Test Setup:
Default test setup 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: G.984.4 I.2.1

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 6.340) and the GAL Ethernet profile (test case#6.350) MEs.
2. Create one or more MAC bridge port configuration data MEs (test case 6.350), 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 cases #6.360).
4. If the vendors support traffic descriptors, provision a suitable one, eg 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 behavior 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 (eg 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.

6.4.23 Reporting of attribute value changes

Test Case # 6.400

Test Setup:
Default test setup as shown in Figure 1

Purpose:
Managed entities generate AVCs as shown in table 1.

Table 1. MEs that emit AVCs

ME type	Op state	Other AVCs
802.11 station management data 2		dot11DeauthenticateStation dot11DisassociateStation dot11AuthenticateFailStation
ANI		Total DS grant Total data grant 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	
Subscriber line card	x	
Subscriber line cardholder		ActualType
TC adapter$_{G\text{-}PON}$	x	
Traffic scheduler		Autonomous change of any attribute
Video return path service profile	x	

Standard: G.983.2 , 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 1, 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 behavior.
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 behavior 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 behavior upon receiving them.

Last Modified: July 25, 2006

6.5 OMCI equipment management

6.5.1 Powering alarm

Test Case # 6.410

Test Setup:
Default test setup as shown in Figure 1

Purpose:
Verify that the ONU reports loss of external power to the OLT. The OLT's response to this alarm is not standardized, but may include a state change, an alarm report or a log entry. An individual power outage probably falls below the level of a minor alarm, and is likely to be the customer's responsibility in any event. 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: G.983.2 7.1.1

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: July 25, 2006

6.5.2 Battery missing

Test Case # 6.420

Test Setup:

Default test setup as shown in Figure 1

Purpose:
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 behavior of the ONU when battery backup is provisioned off; see test case 6.410.

Standard: G.983.2 7.1.1

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: July 25, 2006

6.5.3 Battery failure

Test Case # 6.430

Test Setup:
Default test setup as shown in Figure 1

Purpose:
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 behavior of the ONU when battery backup is provisioned off; see test case 6.410.

Standard: G.983.2 7.1.1

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: July 25, 2006

6.5.4 Battery low

Test Case # 6.440

Test Setup:
Default test setup as shown in Figure 1

Purpose:
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 behavior of the ONU when battery backup is provisioned off; see test case 6.410.

Standard: G.983.2 7.1.1

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 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: July 25, 2006

7 Service-related functionality

Once again, the test cases in this test area are generally characterized by the pair-wise nature of the testing (a single ONU interoperating with the OLT).
Last Modified: July 25, 2006

7.1 Voice service

7.1.1 Common

The initial condition assumes µ-law. However, the common section test cases should be repeated for each supported encoding type: µ-law, a-law, ADPCM, G.729 a & b, and G.723 a & b. For each test executed, record the coding method in the test results

7.1.1.1 Call Origination DTMF

Test Case # 7.100

Test Setup
Default test setup as shown in Figure 1 with connections to a switch or switch simulator and a bulk call generator.

Purpose:
Verify that an ONU can pass DTMF digits reliably. Reliably in this instance is a confidence factor of 95% for 4 nines. 4 nines is 1 error out 10,000 attempts, to build to a 95% confidence factor brings this to 100,000 attempts with 10 total errors. Using a 10 digit number this gives a repetition of 10,000 call attempts

This test is not needed to be repeated per codec. G.711 is defined as the codec standard for digit collection.

Standard:

Preconditions:
ONU ranged, POTS provisioning complete, switch or switch simulator set for a 10 digit numbering plan. ONU is devided into equal set of originate and terminate lines. All available lines to the ONU should be set up in order to reduce the overall time required for this test. If additional ONUs are present, they may be a part of this test as well. The total call attempts would be averaged across the total number of end to end connections possible.

Test Equipment:
Switch or switch simulator
Load generator with DTMF capability

Test Procedure
1. Take the originate line(s) of the ONU(s) off-hook
2. Verify the dial tone is received
3. Place a call from the originate end(s) to the terminate end(s)
4. Verify audible ring at the call origination end(s)
5. Verify the called parties receive an alerting signal
6. Called party answers the call
7. Verify cessation of audible ring on the originating end and alerting on the called end
8. Verify voice path is present
9. Hang up both ends
10. Repeat tests steps for a total of 10,000 call attempts

Pass-fail criteria:
There are to be no more than 10 misdialed digits.

Test report: Pass _____ Fail _____ Not Supported _____

Observation:

Last Modified: July 25, 2006

7.1.1.2 Call Origination Pulse Dialing

Test Case # 7.130

Test Setup
Default test setup as shown in Figure 1 with connections to a switch or switch simulator and a bulk call generator.

Purpose:
Verify that an ONU can pass DTMF digits reliably. Reliably in this instance is a confidence factor of 95% for 4 nines. 4 nines is 1 error out 10,000 attempts, to build to a 95% confidence factor brings this to 100,000 attempts with 10 total errors. Using a 10 digit number this gives a repetition of 10,000 call attempts

This test is not needed to be repeated per codec. G.711 is defined as the codec standard for digit collection.

Standard:

Preconditions:
ONU ranged, POTS provisioning complete, switch or switch simulator set for a 10 digit numbering plan. ONU is devided into equal set of originate and terminate lines. All available lines to the ONU should be set up in order to reduce the overall time required for this test. If additional ONUs are present, they may be a part of this test as well. The total call attempts would be averaged across the total number of end to end connections possible.

Test Equipment:
Switch or switch simulator
DP phone or load generator with DP capability

Test Procedure
1. Set phone or load generator for 8 pps and 64% break
2. Take the originate line(s) of the ONU(s) off-hook
3. Verify the dial tone is received
4. Place a call from the originate end(s) to the terminate end(s)
5. Verify audible ring at the call origination end(s)
6. Verify the called parties receive an alerting signal
7. Called party answers the call
8. Verify cessation of audible ring on the originating end and alerting on the called end
9. Verify voice path is present
10. Hang up both ends
11. Repeat tests steps for a total of 10,000 call attempts
12. Set phone or load generator for 12 pps and 58% break
13. Repeat the test steps

Pass-fail criteria:
There are to be no more than 10 misdialed digits.

Test report: Pass _____ Fail _____ Not Supported _____

Observation:

Last Modified: July 25, 2006

7.1.1.3 Permanent Signaling Condition

Test Case # 7.140

Test Setup
Default test setup as shown in Figure 1 with a phone connected to one of the POTS lines and the OLT interfaced to a switch or switch simulator.

Purpose:
Verify that permanent signaling condition is supported correctly, including channel deactivation.

Standard:

Preconditions:
Initial state is OLT and ONU are powered, ONU is ranged, and POTS is provisioned

Test Equipment:
Switch or switch simulator

Test Procedure
1. The ONU phone goes off-hook
2. Verify that dial tone is received
3. Wait until dial tone is removed
4. Verify that ROH (howler) tone is played
5. Wait until ROH tone removed
6. Verify that the channel is deactivated (LCFO)
7. Place the phone on-hook
8. Take the phone back off-hook
9. Verify that dial tone is received
10. Hang-up the phone

Pass-fail criteria:
Port should deactivate and then resume normal operation when line goes back on-hook.

Test report: Pass _____ Fail _____ Not Supported _____

Observation:

Last Modified: July 25, 2006

7.1.1.4 Distinctive Ringing

Test Case # 7.150

Test Setup
Default test setup as shown in Figure 1

Purpose:
Verify that the ONU can play specific ringing pattern to indicate for instance that the incoming call is a long distance phone call.

Standard:

Preconditions:
Initial state is OLT and ONU are powered and ranged, line-2 switch setting is configured for distinctive ringing

Test Equipment:
Switch or switch simulator.
Method to measure ring intervals

Test Procedure

1. Take line-1 off-hook
2. Verify the dial tone is received
3. Place a call from line 1 to line 2
4. Verify audible ring line 1
5. Verify line 2 receives the defined alerting signal
6. Take line-2 off-hook
7. Verify cessation of audible ring on line 1 and alerting on line 2
8. Verify the voice path.
9. Line-1 phone goes on-hook
10. Verify the call is released on line-2

Pass-fail criteria:
Observe that the ONU properly replicated the ringing pattern.

Test report: Pass _____ Fail _____ Not Supported _____

Observation:

Last Modified: July 25, 2006

7.1.1.5 Hookflash Verification

Test Case # 7.160

Test Setup
Default test setup as shown in Figure 1

Purpose:
Verify that the system can handle hookflash by establishing a call then adding another line to the existing call.

Standard:

Preconditions:
Initial state is OLT and ONU are powered and ranged, with POTS provisioned, switch configured to provide conference call Setup.

Test Equipment:
Switch or switch simulator

Test Procedure
1. From phone line-1, call phone line-2
2. Verify the talk path between phone line-1 and phone line-2
3. Cause a hookflash to be sent from the line-1
4. Verify that dial tone is heard on the line-1 phone
5. From phone line-1, call phone line-3
6. Verify that the line-3 phone can answer the call and connects to line-1 phone
7. Cause a hookflash to be sent from the line-1
8. Verify that the line-1 phone can talk to line-2 phone previously put on hold
9. Line-1 phone and line-2 phone go on-hook
10. Verify the call is released from all phones

Pass-fail criteria:
The switch acknowledged the reception of the hook-flash with the appropriate actions.

Test report: Pass _____ Fail _____ Not Supported _____

Observation:

Last Modified: July 25, 2006

7.1.1.6 Caller I.D.

Test Case # 7.170

Test Setup
Default test setup as shown in Figure 1

Purpose:
The purpose of this test case is to verify that the Caller ID and Caller Name can be transported over the VCC.

Standard:

Preconditions:
Initial state is OLT and ONU are powered and ranged, line-2 phone is equipped with Caller ID, switch is configured to provide Caller ID. ONUs are set for part-time-on-hook transmission. Called party line set for distinctive ringing.

Test Equipment:
Switch or switch simulator
Caller ID test equipment or ability to verify caller ID.

Test Procedure
1. Line-1 phone calls line-2 phone
2. After the first ring, verify that caller's telephone number are shown on the caller ID display on phone line-2
3. Line-2 phone goes off-hook
4. Verify the talk path
6. Line-1 phone goes on-hook
7. Verify the call is released
8. Vary the distinctive ring pattern and repeat call sequence 100 times

Pass-fail criteria:
Caller ID is displayed correctly, variety of ringing patterns used to verify caller ID transmission occurs at first non-ringing interval that exceeds 500msec.

Test report: Pass _____ Fail _____ Not Supported _____

Observation:

Last Modified: July 25, 2006

7.1.1.7 MLT

Test Case # 7.180

Test Setup:
EMS or console capability to instruct the OLT to send a test command to the ONU
Ability to introduce varying voltages (AC and DC), resistances, and REN values to the POTS interfaces

Purpose:
Validate the OLT/ONU ability to perform MLT, mechanized loop test, and report the results of these tests. Per G.983, these tests can respond with pass, fail, or not completed as well as the measured values. Thresholds for pass fail are incorporated into the test command. The ONU may report only the pass/fail based on these thresholds or may include the actual values measured. As a part of the test results record which method is supported, if values are included in the result what was the test value and the reported measurement by the ONU. The ONU vendor needs to specify the parameters relative to these tests, that the ONU will tolerate. Warning that in the case of the voltage tests, the voltages may be hazardous to personnel or potentially destructive to the ONU.

Standard: G.983.2 7.3.26, I.1.7, II.1.6, II.2.27, II.2.28, II.2.45
G.983.8

GR-909 section 12

Preconditions: ONU ranged, with POTS services provisioned

Test Equipment: VOM
AC variac or suitable means to induce a varied range of AC voltages
DC power supply capable of up to 200 volts
Range of resistors, wattage dependent upon ONU's loop current feed capabilities
Range of REN loads, North America standard 7000 ohms @ 20Hz, RC network with a C = 8µF, R= 6930 ohms

Procedure:
In sequence issue test commands for:
all MLT tests
hazardous potential
foreign EMF
resistive faults
receiver off-hook
ringer
NT1 dc signature test

1. Based on the supported thresholds apply voltages, resistance, or REN loading at below and above the selected thresholds. These values are to be applied tip to ground, ring to ground, and tip to ring.
2. Record the values used as well as the values reported by the ONU

Pass-fail criteria: Fail if:
a. Gives a response of command not supported on a selection indicated as valid by the vendors.
b. The results indicates pass or fail, contrary to that indicated as the threshold set down in the OMCI command message. Note a 20% tolerance is typical in these measurements.
c. The ONU is damaged by potentials indicated as safe by the vendor.

Test report: Pass _____ Fail _____ Not Supported _____

Observations:

		Threshold Setting	Value Used			Value Measured		
			T-G	R-G	T-R	T-G	R-G	T-R
Hazardous Potential	AC							
	DC							
Foreign EMF	AC							
	DC							
Resistive Fault								
Receiver off-hook								
REN								
NT1								

Last Modified: July 25, 2006

7.1.1.8 Draw Break Dial Tone Test – DBDT

Test Case # 7.190

Test Setup:
EMS or console capability to instruct the OLT to send a test command to the ONU
Connectivity to a switch or switch simulator

Purpose:
Validate the OLT/ONU ability to perform DBDT test. This test will command the ONU to cause an off-hook condition on a POTS line, measure the time delay to detect dial tone at that line and characteristics of the dial tone.

It is important that the switch or switch simulator characteristics be known as a part of this test. So that thresholds sent in the test command are set to the appropriate values based on the switch performance.

Standard: G.983.2 7.3.26, I.1.7, II.1.6, II.2.27, II.2.28, II.2.45
G.983.8
GR-909 section 12

Preconditions: ONU ranged, with POTS services provisioned

Test Equipment: Switch or switch simulator

Procedure:
Issue test command for DBDT with time settings for slow dial tone, no dial tone, slow break dial tone, and no break dial tone. Dial tone detection level is dependent upon the switch dial tone send level. All switches do not provide the same level of dial tone. Other parameters include dial pulse or DTMF and the digit to be dialed
Based on the settings examine the response for dial tone delay, break dial tone delay, dial tone frequencies, and dial tone level.
Record the switch or switch characteristics as well as the results from this test. The test should be repeated to on each ONU line as well enough times to form an acceptable minimum, maximum and mean average.

Pass-fail criteria: Fail if:
1. Gives a response of command not supported on a selection indicated as valid by the vendors.
2. The results indication are contrary to the thresholds determined from the switch characteristics.

Test report: Pass _____   Fail _____   Not Supported _____

Observations:

	Switch Characteristics	Result of Test
Dial tone delay		
Break Dial tone Delay		
DTMF/DP digit		
Dial tone level		

Last Modified: July 25, 2006

7.1.1.9 Fax and Modem Test Group

This test suite contains test cases to verify that fax and voice-band modem data can be transported over the PON system without degradation. The ECM error correction feature of fax machines, if available, should be disabled during the fax test. Modem compression, V.42bis should be disabled during the modem test.

7.1.1.9.1 Fax Test V.32bis

Test Case # 7.200

Test Setup
Default test setup as shown in Figure 1

Purpose:
Verify that a fax machine connected to an ONU can send a fax to another fax machine connected to another ONU across the OLT using 14.4Kbps V.32bis transmission.

Standard:

Preconditions:
Initial state is OLT and ONU are powered and ranged, ONU POTS is provisioned for voice

Test Equipment:
Switch or switch simulator
2 fax machines capable of V.32bis signaling

Test Procedure
1. Take fax line-1 off-hook
2. Verify the dial tone
3. Dial the fax number of line-2
4. Verify that the line-2 fax rings and answers the call automatically
5. Verify the fax tone handshake completes successfully negotiated baud rate is 14.4Kbps
6. Send a text page
7. Verify line-2 receives the fax
8. Line-1 fax goes on-hook
9. Verify the call is released

Pass-fail criteria:
Test Page is transmitted correctly at the rate of 14.4Kbps

Test report: Pass _____ Fail _____ Not Supported _____

Observation:

Last Modified: July 25, 2006

7.1.1.9.2 Fax Test V.34

Test Case # 7.210

Test Setup
Default test setup as shown in Figure 1

Purpose:
Verify that a fax machine connected to an ONU can send a fax to another fax machine using 33.6Kbps V.34 transmission.

Standard:

Preconditions:

Initial state is OLT and ONU are powered and ranged, ONU POTS is provisioned for voice

Test Equipment:
Switch or switch simulator
2 FAX machines capable of V.34 signaling

Test Procedure
1. Take fax line-1 off-hook
2. Verify the dial tone
3. Dial the fax number of line-2
4. Verify that the line-2 fax rings and answers the call automatically
5. Verify the fax tone handshake completes successfully negotiated baud rate is 14.4Kbps
6. Send a text page
7. Verify line-2 receives the fax
8. Line-1 fax goes on-hook
9. Verify the call is released

Pass-fail criteria:
Test Page is transmitted correctly at the rate of 28.8Kbps

Test report: Pass _____ Fail _____ Not Supported _____

Observation:

Last Modified: July 25, 2006

7.1.1.9.3 Modem Test ONU over OLT

Test Case # 7.220

Test Setup
Default test setup as shown in Figure 1

Purpose:
This test case tests that a modem connected to an ONU can communicate to another modem connected to another ONU over the OLT.

Standard:

Preconditions:
ONU ranged, ONU POTS provisioned.
Data test set connected to ONUs via V.90/92 modems.

Test Equipment:

Test Procedure
1. Connect modem-1 to line-1 test and dial modem-2 on line-2
2. Verify that the modem connection is set up properly and is at least 33600bps
3. Transfer 1MB file from modem-1 to modem-2
4. Verify file transfer is successful and no retries are observed.
5. Verify the throughput is at least 90% of the connection rate
6. Modem-1 releases the modem connection
7. Verify the connection is released successfully from modem-2

Pass-fail criteria:
Record the data rate achieved

Test report: Pass _____ Fail _____ Not Supported _____

Observation:

Last Modified: July 25, 2006

7.1.1.10 Multiple POTS Ports Test Group

These test suites test the capability of an ONU to support multiple POTS lines. This test suite requires the ONU to support more than 1 POTS port. Successful execution of this suite requires that the class 5 switch or simulator, voice gateway, OLT and ONU be able to track multiple POTS connections without mutual interference or overlap.

7.1.1.10.1 POTS Lines Sequencing

Test Case # 7.230

Test Setup
Default test setup as shown in Figure 1

Purpose:
This test case tests all the analog ports to verify that calls can be initiated from each POTS line, and terminated on the correct POTS line.

Standard:

Preconditions:
ONU ranged, all POTS lines to the ONU provisioned.

Test Equipment:
Switch or switch simulator
Load box/call generator.

Test Procedure
1. Originating from each ONU POTS line place a call to another line
2. Verify the voice path for each call placed
3. Repeat the sequence be sure to validate that every line can receive and place a call

Pass-fail criteria:
All POTS line operate properly placing and receiving calls to the properly identified port.

Test report: Pass _____ Fail _____ Not Supported _____

Observation:

Last Modified: July 25, 2006

7.1.1.11 Multiple ONU Test Group

These test cases cover 3 ONUs on the PON. All ONUs have identical configuration.

7.1.1.11.1 Voice Performance Monitoring

Test Case # 7.240

Test Setup
Default test setup as shown in Figure 1

Purpose:
Verify that the statistical information associated with voice performance for the ONU is viewable on the OLT.

Standard:

Preconditions:
Initial state is OLT and ONU are powered and ranged, with POTS service provisioned

Test Equipment:

Test Procedure
1. Run command to view voice PM. statistics for the ONU
2. Verify that at minimum voice port underflows/overflows and active seconds are present.

Pass-fail criteria:
Voice statistics reflect upstream and downstream counts

Test report: Pass _____ Fail _____ Not Supported _____

Observation:

Last Modified: July 25, 2006

7.1.2 Voice over IP

VoIP specification is in process and test cases will be added here as the definition firms up.

7.1.2.1 H.248

7.1.2.2 SIP

7.2 Data Test Cases

7.2.1 Ethernet Test Group

These test cases verify that ONU Ethernet services are configurable from the OLT as identified in 983.2, sections 7.3.29-7.3.36.

7.2.1.1 GEM Inter-working TP for Ethernet using CoS1

Test Case # 7.300

Test Setup
Default test setup as shown in Figure 1

Purpose:
Verify that an inter-working Ethernet GEM port is configurable and operable using a CoS1 descriptor tailored to manage a 100Mbps data transmission.

Standard: IEEE-802.3

Preconditions:
Initial state is OLT and ONU are powered and ranged, data is provisioned on the ONU

Test Equipment:
Ethernet data transmission test equipment.

Test Procedure
1. Configure MAC Bridge Service Profile using default parameters
2. Configure GAL Ethernet profile with a 256 byte Max Payload size
3. Configure a CoS1 traffic descriptor for 100Mbps
4. Configure inter-working GEM TP for MAC bridge LAN service
5. Configure OLT side test equipment to generate 100Mbps Ethernet line rate downstream. Configure ONU side test equipment to generate 100 Mbps or the Maximum configured rated for traffic upstream
6. Verify that downstream/upstream discards are not present. Ensure that upstream transmission conforms to the traffic descriptor monitored on the OLT side.
7. Verify that the ONU forward the data traffic only to the specified Mac address configured in the test equipment.

Pass-fail criteria:
Traffic should pass only on the Mac Address display in the forward data base table

Test report: Pass _____ Fail _____ Not Supported _____

Observation:

Last Modified: Aug. 21, 2006

7.2.1.2 Delete Ethernet GEM IW TP

Test Case # 7.310

Test Setup
Default test setup as shown in Figure 1

Purpose:
Ensure that an Ethernet GEM port can be removed from service by the OLT.

Standard: IEEE-802.3

Preconditions:
Initial state is OLT and ONU are powered and ranged, data is provisioned on the ONU

Test Equipment:
Ethernet data transmission test equipment.

Test Procedure
1. From the OLT, delete the Ethernet GEM Interworking TP
2. Query the system to verify that the GEM IW TP is no longer present

Pass-fail criteria:

Test report: Pass _____ Fail _____ Not Supported _____

Observation:

Last Modified: Aug. 21, 2006

7.2.1.3 GEM Inter-working TP for Ethernet using CoS2

Test Case # 7.320

Test Setup
Default test setup as shown in Figure 1

Purpose:
Verify that an inter-working Ethernet GEM port is configurable and operable using a CoS2 descriptor tailored to manage a 100Mbps data transmission.

Standard: IEEE-802.3

Preconditions:
Initial state is OLT and ONU are powered and ranged, data is provisioned on the ONU

Test Equipment:
Ethernet data transmission test equipment.

Test Procedure
1. Configure MAC Bridge Service Profile using default parameters
2. Configure GAL Ethernet profile with a 256 byte Max Payload size
3. Configure a CoS2 traffic descriptor for 100Mbps
4. Configure inter-working GEM TP for MAC bridge LAN service
5. Configure OLT side test equipment to generate 100Mbps Ethernet line rate downstream. Configure ONU side test equipment to generate 100 Mbps or the Maximum configured rated for traffic upstream

6. Verify that downstream/upstream discards are not present. Ensure that upstream transmission conforms to the traffic descriptor monitored on the OLT side.
7. Verify that the ONU forward the data traffic only to the specified Mac address configured in the test equipment.

Pass-fail criteria:
Traffic should pass only on the Mac Address display in the forward data base

Test report: Pass _____ Fail _____ Not Supported _____

Observation:

Last Modified: Aug. 21, 2006

7.2.1.4 GEM Inter-working TP for Ethernet using CoS3

Test Case # 7.330

Test Setup
Default test setup as shown in Figure 1

Purpose:
Verify that an GEM inter-working TP for Ethernet is configurable and operable using a CoS3 descriptor tailored to manage a 100 Mbps data transmission.

Standard: IEEE-802.3

Preconditions:
ONU ranged, Ethernet service provisioned and set to 100Mb full duplex

Test Equipment:
Ethernet data transmission test equipment.

Test Procedure
1. Configure MAC Bridge Service Profile using default parameters
2. Configure GAL Ethernet profile with a 256 byte Max Payload size
3. Configure a CoS3 traffic descriptor for 100Mbps
4. Configure inter-working GEM TP for MAC bridge LAN service
5. Configure OLT side test equipment to generate 100Mbps Ethernet line rate downstream. Configure ONU side test equipment to generate 100 Mbps or the Maximum configured rated for traffic upstream
6. Verify that downstream/upstream discards are not present. Ensure that upstream transmission conforms to the traffic descriptor monitored on the OLT side.
7. Verify that the ONU forward the data traffic only to the specified Mac address configured in the test equipment.

Pass-fail criteria:
There should be no downstream/upstream packet discards.

Test report: Pass _____ Fail _____ Not Supported _____

Observation:

Last Modified: Aug. 21, 2006

7.2.1.5 GEM Inter-working TP for Ethernet using CoS4

Test Case # 7.340

Test Setup

Default test setup as shown in Figure 1

Purpose:
Verify that a GEM inter-working TP for Ethernet is configurable and operable using a CoS4 descriptor tailored to manage a 100 Mbps data transmission.

Standard: IEEE-802.3

Preconditions:
Initial state is OLT and ONU are powered and ranged, data is provisioned on the ONU

Test Equipment:
Ethernet data transmission test equipment.

Test Procedure
1. Configure MAC Bridge Service Profile using default parameters
2. Configure GAL Ethernet profile with a 256 byte Max Payload size
3. Configure a CoS4 traffic descriptor for 100Mbps
4. Configure inter-working GEM TP for MAC bridge LAN service
5. Configure OLT side test equipment to generate 100Mbps Ethernet line rate downstream. Configure ONU side test equipment to generate 100 Mbps or the Maximum configured rated for traffic upstream
6. Verify that downstream/upstream discards are not present. Ensure that upstream transmission conforms to the traffic descriptor monitored on the OLT side.
7. Verify that the ONU forward the data traffic only to the specified Mac address configured in the test equipment.

Pass-fail criteria:
There should be no downstream/upstream discards are present.

Test report: Pass _____ Fail _____ Not Supported _____

Observation:

Last Modified: Aug. 21, 2006

7.2.1.6 Bridge Configuration on Ethernet ANI

Test Case # 7.380

Test Setup
Default test setup as shown in Figure 1

Purpose:
Verify that bridging is configurable from the OLT.

Standard: IEEE-802.3

Preconditions:
ONU ranged, data provisioned on the ONU

Test Equipment:
Ethernet data transmission test equipment.

Test Procedure
1. Configure the MAC bridge service profile with spanning tree and learning enabled
2. Configure GAL Ethernet profile with a 256 byte Max Profile size
3. Configure a CoS1 traffic descriptor for 100Mbps
4. Configure GEM inter-working TP for MAC bridge LAN service
5. Configure OLT side test equipment to generate 5Mbps Ethernet downstream traffic. Configure ONU side test equipment to generate 100 Mbps upstream

6. Verify that downstream/upstream discards are not present. Ensure that upstream transmission conforms to the traffic descriptor monitored on the OLT side
7. Verify that the ONU forwards the data traffic only to the specified Mac address configured in the test equipment
8. Traffic should pass only on the Mac Address display in the forward data base table (unicast traffic)
9. Configure the MAC bridge service profile with spanning tree enable and learning disabled
10. Configure the GEM inter-working TP for MAC bridge LAN service
11. Configure OLT side test equipment to generate 100Mbps ATM line rate downstream. Configure ONU side test equipment to generate 100 Mbps upstream
12. Verify that downstream/upstream discards are not present. Ensure that upstream transmission conforms to the traffic descriptor monitored on the OLT side.
13. Verify that the ONU forward the data traffic on the root Mac address

Pass-fail criteria:
Traffic should pass only on the Mac Address display in the forward data base table.

Test report: Pass _____ Fail _____ Not Supported _____

Observation:

Last Modified: Aug. 21, 2006

7.2.1.7 Throughput test on Ethernet UNI for varying packet sizes

Test Case # 7.390

Test Setup
Default test setup as shown in Figure 1

Purpose:
To characterize the Ethernet throughput for various packet sizes

Standard: IEEE-802.3

Preconditions:
Initial state is OLT and ONU are powered
ONU-OLT Eth/bridge configuration active.
Upstream bandwidth grant and downstream maximum bandwidth for 100 Mbps assigned to the ONU under test.

Test equipment:
Data traffic simulator
Backhaul data traffic switch

Test Procedure
1. Set up the traffic generator to run upstream data only with varying packet sizes of 64, 128, 256, 512, 1024, 1218 and 1522 bytes. Record the maximum data throughput rate at which 0 packet loss is obtained.
2. Repeat step 1 for data traffic in the downstream direction only. Record the maximum data throughput rate at which 0 packet loss is obtained.
3. Repeat step 1 for bidirectional data traffic, i,e., both upstream/downstream directions. Record the maximum data throughput rate at which 0 packet loss is obtained.

Pass-fail criteria:
Data should meet or exceed a BER of 10^{-8}

Test report: Pass _____ Fail _____ Not Supported _____
Observation:

Last Modified: July 25, 2006

7.2.1.8 Ethernet throughput, fixed size packets

Test case # 7.400

Purpose:
To characterize the upstream, downstream and combined throughput of an Ethernet service under fixed packet size loads. Though this is not necessarily representative of real traffic situations, it provides a ready benchmark against which further assessments of interoperability can be made.
The test packet sizes are 64, 128, 256, 512, 1024, 1280 and 1518 bytes. There is no objection to 1522 byte packets if the system can support them without fragmentation; the throughput difference is expected to be insignificant. If switched digital video is a feature of interest, 1358-byte packets should also be tested. Each test should be run for packets of each size; if the throughput is essentially equal to the theoretical maximum (measured rate above 99%), the interested parties may agree not to run some of the intermediate cases. Ethernet overhead penalties imply a maximum theoretical throughput as follows:

Packet size	Throughput
64 bytes	76 Mb/s
128	86
256	93
512	96
1024	98
1280	98
1358	99
1518	99

For a given packet size, maximum achievable throughput is deemed to occur at a packet loss rate corresponding to a BER of 10^{-8}. Ignoring overheads for simplicity, and assuming that the throughput is a minimum of 20 Mb/s, 10^8 bits are transmitted in 5 seconds, yielding the expectation of one error. Several such intervals must be assessed to achieve statistical confidence. It is suggested that throughput be determined by the maximum rate at which no more than one lost packet per minute is achieved. If the measured throughput is substantially greater than 20 Mb/s, the measurement interval can be corresponding reduced.
Note: commercially available test equipment (eg Spirent SmartBits) has built-in search algorithms, which are expected to be satisfactory even if they do not precisely match the description above.

Standard: IETF RFC 2544

Preconditions:
ONU ranged, provisioned for 100 Mb/s Ethernet service. If the ONU or OLT offer only 10 Mb/s Ethernet service, adjust the test case accordingly. All supported features should be enabled during the test, for example, LAN bridging, VLAN tag stripping, PPP filtering. However, initialization, eg learning the LAN bridge table, should be done before the test begins.
No other traffic is to be carried during the test, either on the Ethernet or on other services provided by the OLT/ONU combination.
This is not a test of traffic policing, so if traffic descriptors are used, they should be provisioned to values large enough to ensure that they do not inhibit throughput (eg 100 Mb/s). Likewise, a single GEM port should suffice for throughput characterization.

Test Equipment:
Ethernet test set at ONT and at OLT

Procedure:
1. Perform the following steps for upstream traffic only, for downstream traffic only, and for simultaneous traffic in both directions (equal packet size).
2. For each packet size of interest, adjust the throughput to determine the threshold at which packet loss occurs. Record the result.
3. By pre-agreement, the test may be repeated with some features turned off.

Pass-fail Criteria: None – characterization result only

Observations: Record the features that were enabled for the test. Record throughput rates for each direction individually and combined, for each packet size.

Related test cases: 7.390

Last Modified: July 25, 2006

Note: IEEE 802.3 specifies a BER not to exceed 10^{-8} for copper interfaces. If the copper can tolerate 10^{-8}, there is clearly no need for substantially better performance elsewhere in the network, ie on the pon. In other sections of 802.3, this value is used as a suggested criterion for measurements, but there is no requirement. In this test case, the value should also be understood as a suggested criterion, not as a hard requirement.

7.2.1.9 Multiple Port-IDs configured for Ethernet

Test Case # 7.410

Test Setup
Default test setup as shown in Figure 1

Purpose:
Verify that the ONU can support multiple Port-IDs on its Ethernet Mac Bridge configuration.

Standard: IEEE-802.3

Preconditions:
ONU ranged. ONU-OLT Eth/bridge configuration active.
Upstream data grant and downstream PCR for 100 Mbps assigned to the ONU under test.

Test Equipment:
Data traffic simulator
Backhaul data traffic switch

Test Procedure
1. Configure a CoS2 traffic descriptor 3 Mbps
2. Configure 8 GEM inter-working TP for MAC bridge LAN.
3. Configure OLT side test equipment to generate 8 separate downstream traffic streams. Configure ONU side test equipment to generate 8 separate 3 Mbps streams or the maximum configured rated for traffic upstream
4. Verify that downstream/upstream discards are not present. Ensure that upstream transmission conforms to the traffic descriptor monitored on the OLT side.
5. Verify that the ONU forward the data traffic only to the specified 8 source- destination MAC address configured in the test equipment
6. Traffic should pass only on the MAC address display in the forward data base table.

Pass-fail criteria:
Traffic should pass only on the MAC address display in the forward data base table.

Test report: Pass _____ Fail _____ Not Supported _____

Observation:

Last Modified: July 25, 2006

7.2.1.10 Bridge PM

Test Case # 7.420

Test Setup
Default test setup as shown in Figure 1

Purpose:
Verify that bridge is operational using statistics available on the ONU.

Standard: IEEE-802.3

Preconditions:
Initial state is OLT and ONU are powered
ONU-OLT Eth/bridge configuration active.
Upstream data grant and downstream PCR for 100 Mbps assigned to the ONU under test.

Test Equipment:
Data traffic simulator
Backhaul data traffic switch

Test Procedure
1. Get the MAC bridge port designation data ME (PM statistics).
2. Verify that bridge port state is listening or forwarding
3. Get the MAC bridge port designation data ME (PM statistics) at least 60 seconds after test case 7.380, 7.390, 7.400, and 7.410 is completed

Pass-fail criteria:
Bridge PM statistics accurately show counts, OLT and ONU indicate same results.

Test report: Pass _____ Fail _____ Not Supported _____

Observation:

Last Modified: July 25, 2006

7.2.1.11 Ethernet Carrier Loss

Test Case # 7.430

Test Setup
Default test setup as shown in Figure 1

Purpose:
Verify that a no carrier alarm is reported upstream to the OLT.

Standard: IEEE-802.3

Preconditions:
ONU ranged, ONU-OLT Eth/bridge configuration active.

Test Equipment:
Data traffic simulator
Backhaul data traffic switch

Test Procedure
1. Connect a valid operation 10/100BaseT device to the Ethernet port
2. Disconnect Ethernet cable
3. ONU reports upstream LAN-LOS.
4. OLT receive alarm LAN-LOS
5. Reconnect Ethernet cable
6. ONU reports clear alarm indication, normal operation
7. OLT received alarm clear from ONU

Pass-fail criteria:
Alarm is reported and cleared.

Test report: Pass _____ Fail _____ Not Supported _____

Observation:

Last Modified: July 25, 2006

7.2.1.12 UPC Monitoring

Test Case # 7.440

Test Setup
Default test setup as shown in Figure 1

Purpose:
Verify that UPC statistics associated with the VP profile on the ONU can be monitored from the OLT.

Standard:

Preconditions:
Initial state is OLT and ONU are powered
ONU-OLT Eth/bridge configuration active.
Upstream data grant and downstream PCR for 100 Mbps assigned to the ONU under test.

Test Equipment:
Data traffic simulator
Backhaul data traffic switch

Test Procedure
1. Query UPC on the ONU from the OLT
2. Verify that the ONU passed cell count, CLP0 cell count and tagged CLP0 cell count increments while running traffic from test case 7.420

Pass-fail criteria:
PM counts are reported accurately between ONU and OLT

Test report: Pass _____ Fail _____ Not Supported _____

Observation:

Last Modified: July 25, 2006

7.2.1.13 Ethernet GEM Port PM

Test Case # 7.450

Test Setup
Default test setup as shown in Figure 1

Purpose:
Verify that Ethernet interface counters are viewable and that no error indications are present.

Standard: IEEE-802.3

Preconditions:

Initial state is OLT and ONU are powered
ONU-OLT Eth/bridge configuration active.
Upstream data grant and downstream PCR for 100 Mbps assigned to the ONU under test.

Test Equipment:
Data traffic simulator
Backhaul data traffic switch

Test Procedure
1. Query Ethernet interface counters on the ONU from the OLT
2. Verify that Ethernet interface counters are present and that no error counters are incrementing while running test case7.420

Pass-fail criteria:
PM counts are reported accurately between ONU and OLT

Test report: Pass _____ Fail _____ Not Supported _____

Observation:

Last Modified: July 25, 2006

7.2.2 DSL Test Group

7.2.2.1 VDSL2

7.2.3 MoCA

7.2.3.1 Inter-working MoCA CoS1

Test Case # 7.464

Test Setup
Default test setup as shown in Figure 1

Purpose:
Verify that an inter-working data cross connect is configurable and operable using a CoS1 descriptor tailored to manage a 100Mbps data transmission.

Standard:

Preconditions:
Initial state is OLT and ONU are powered and ranged, data is provisioned on the ONU

Test Equipment:
data transmission test equipment.

Test Procedure
1. Configure MAC bridge service profile using default parameters
2. Configure a GAL Ethernet Profile with a 256 byte Maximum Payload size
3. Configure a CoS1 traffic descriptor for 100Mbps
4. Configure GEM inter-working TP for MAC bridge LAN service
5. Configure OLT side test equipment to generate 100Mbps Ethernet line rate downstream. Configure ONU side test equipment to generate 100 Mbps or the Maximum configured rated for traffic upstream
6. Verify that downstream/upstream discards are not present. Ensure that upstream transmission conforms to the traffic descriptor monitored on the OLT side.

7. Verify that the ONU forward the data traffic only to the specified Mac address configured in the test equipment.

Pass-fail criteria:
Traffic should pass only on the Mac Address display in the forward data base table

Test report: Pass _____ Fail _____ Not Supported _____

Observation:

Last Modified: August 25, 2006

7.2.3.2 Delete MoCA Cross Connect

Test Case # 7.461

Test Setup
Default test setup as shown in Figure 1

Purpose:
Ensure that a data connection can be removed from service by the OLT.

Standard:

Preconditions:
Initial state is OLT and ONU are powered and ranged, data is provisioned on the ONU

Test Equipment:
Data transmission test equipment.

Test Procedure
1. From the OLT, delete the data cross connect
2. Query the system to verify that the Cross Connect is no longer present

Pass-fail criteria:

Test report: Pass _____ Fail _____ Not Supported _____

Observation:

Last Modified: August 25, 2006

7.2.3.3 Inter-working MoCA CoS2

Test Case # 7.463

Test Setup
Default test setup as shown in Figure 1

Purpose:
Verify that an inter-working data cross connect is configurable and operable using a CoS2 descriptor tailored to manage a 100Mbps data transmission.

Standard:

Preconditions:
Initial state is OLT and ONU are powered and ranged, data is provisioned on the ONU

Test Equipment:
data transmission test equipment.

Test Procedure
1. Configure MAC bridge service profile using default parameters
2. Configure a GAL Ethernet Profile with a 256 byte Maximum Payload size
3. Configure a CoS2 traffic descriptor for 100Mbps
4. Configure GEM inter-working TP for MAC bridge LAN service
5. Configure OLT side test equipment to generate 100Mbps Ethernet line rate downstream. Configure ONU side test equipment to generate 100 Mbps or the Maximum configured rated for traffic upstream
6. Verify that downstream/upstream discards are not present. Ensure that upstream transmission conforms to the traffic descriptor monitored on the OLT side.
7. Verify that the ONU forward the data traffic only to the specified Mac address configured in the test equipment.

Pass-fail criteria:
Traffic should pass only on the Mac Address display in the forward data base

Test report: Pass _____ Fail _____ Not Supported _____

Observation:

Last Modified: August 25, 2006

7.2.3.4 Inter-working MoCA CoS3

Test Case # 7.460

Test Setup
Default test setup as shown in Figure 1

Purpose:
Verify that an inter-working data cross connect is configurable and operable using a CoS3 descriptor tailored to manage a 100 Mbps data transmission.

Standard:

Preconditions:
ONU ranged, MoCA service provisioned and set to 100Mb full duplex

Test Equipment:
Ethernet data transmission test equipment.

Test Procedure
1. Configure MAC bridge service profile using default parameters
2. Configure a GAL Ethernet Profile with a 256 byte Maximum Payload size
3. Configure a CoS3 traffic descriptor for 100Mbps
4. Configure GEM inter-working TP for MAC bridge LAN service
5. Configure OLT side test equipment to generate 100Mbps Ethernet line rate downstream. Configure ONU side test equipment to generate 100 Mbps or the Maximum configured rated for traffic upstream
6. Verify that downstream/upstream discards are not present. Ensure that upstream transmission conforms to the traffic descriptor monitored on the OLT side.
7. Verify that the ONU forward the data traffic only to the specified Mac address configured in the test equipment.

Pass-fail criteria:
There should be no downstream/upstream packet discards.

Test report: Pass _____ Fail _____ Not Supported _____

Observation:

Last Modified: August 25, 2006

7.2.3.5 Inter-working MoCA CoS4

Test Case # 7.462

Test Setup
Default test setup as shown in Figure 1

Purpose:
Verify that an inter-working data cross connect is configurable and operable using a CoS4 descriptor tailored to manage a 100 Mbps data transmission.

Standard:

Preconditions:
Initial state is OLT and ONU are powered and ranged, data is provisioned on the ONU

Test Equipment:
Ethernet data transmission test equipment.

Test Procedure
1. Configure MAC bridge service profile using default parameters
2. Configure a GAL Ethernet Profile with a 256 byte Maximum Payload size
3. Configure a CoS4 traffic descriptor for 100Mbps
4. Configure GEM inter-working TP for MAC bridge LAN service
5. Configure OLT side test equipment to generate 100Mbps Ethernet line rate downstream. Configure ONU side test equipment to generate 100 Mbps or the Maximum configured rated for traffic upstream
6. Verify that downstream/upstream discards are not present. Ensure that upstream transmission conforms to the traffic descriptor monitored on the OLT side.
7. Verify that the ONU forward the data traffic only to the specified Mac address configured in the test equipment.

Pass-fail criteria:
There should be no downstream/upstream discards are present.

Test report: Pass _____ Fail _____ Not Supported _____

Observation:

Last Modified: August 25, 2006

7.2.3.6 Bridge Configuration on MoCA UNI

Test Case # 7.465

Test Setup
Default test setup as shown in Figure 1

Purpose:
Verify that bridging is configurable from the OLT.

Standard:

Preconditions:

ONU ranged, data provisioned on the ONU

Test Equipment:
data transmission test equipment.

Test Procedure
1. Configure the MAC bridge service profile with spanning tree and learning enabled
2. Configure the GAL Ethernet Profile with a 256 byte maximum payload size
3. Configure a CoS1 traffic descriptor for 100Mbps
4. Configure GEM inter-working TP for MAC bridge LAN service
5. Configure OLT side test equipment to generate 5Mbps Ethernet downstream traffic. Configure ONU side test equipment to generate 100 Mbps upstream
6. Verify that downstream/upstream discards are not present. Ensure that upstream transmission conforms to the traffic descriptor monitored on the OLT side
7. Verify that the ONU forward the data traffic only to the specified Mac address configured in the test equipment
8. Traffic should pass only on the Mac Address display in the forward data base table (unicast traffic)
9. Configure the MAC bridge service profile with spanning tree enable and learning disabled
10. Configure GEM inter-working TP for MAC bridge LAN service
11. Configure OLT side test equipment to generate 100Mbps Ethernet line rate downstream. Configure ONU side test equipment to generate 100 Mbps upstream
12. Verify that downstream/upstream discards are not present. Ensure that upstream transmission conforms to the traffic descriptor monitored on the OLT side.
13. Verify that the ONU forward the data traffic on the root Mac address

Pass-fail criteria:
Traffic should pass only on the Mac Address display in the forward data base table.

Test report: Pass _____ Fail _____ Not Supported _____

Observation:

Last Modified: August 25, 2006

7.2.3.7 Throughput test on MoCA UNI for varying packet sizes

Test Case # 7.466

Test Setup
Default test setup as shown in Figure 1

Purpose:

Standard:

Preconditions:
Initial state is OLT and ONU are powered
ONU-OLT data bridge configuration active.
Upstream data grant and downstream PCR for 130 Mbps assigned to the ONU under test.

Test equipment:
Data traffic simulator
Backhaul data traffic switch

Test Procedure
1. Set up the traffic generator to run upstream data only with varying packet sizes of 64, 128, 256, 512, 1024, 1218 and 1522 bytes. Record the maximum data throughput rate at which 0 packet loss is obtained.
2. Repeat step 1 for data traffic in the downstream direction only. Record the maximum data throughput rate at which 0 packet loss is obtained.
3. Repeat step 1 for bidirectional data traffic, i,e., both upstream/downstream directions. Record the maximum

data throughput rate at which 0 packet loss is obtained.

Pass-fail criteria:
Data should meet or exceed a BER of 10^{-8}

Test report: Pass _____ Fail _____ Not Supported _____
Observation:

Last Modified: August 25, 2006

7.2.3.8 MoCA throughput, fixed size packets

Test case # 7.467

Purpose:
To characterize the upstream, downstream and combined throughput of a data service under fixed packet size loads. Though this is not necessarily representative of real traffic situations, it provides a ready benchmark against which further assessments of interoperability can be made.
The test packet sizes are 64, 128, 256, 512, 1024, 1280 and 1518 bytes. There is no objection to 1522 byte packets if the system can support them without fragmentation; the throughput difference is expected to be insignificant. If switched digital video is a feature of interest, 1358-byte packets should also be tested. Each test should be run for packets of each size; if the throughput is essentially equal to the theoretical maximum (measured rate above 99%), the interested parties may agree not to run some of the intermediate cases. Ethernet overhead penalties imply a maximum theoretical throughput as follows:

Packet size	Throughput
64 bytes	136 Mb/s
128	154
256	167
512	172
1024	176
1280	176
1358	178
1518	178

For a given packet size, maximum achievable throughput is deemed to occur at a packet loss rate corresponding to a BER of 10^{-8}. Ignoring overheads for simplicity, and assuming that the throughput is a minimum of 20 Mb/s, 10^8 bits are transmitted in 5 seconds, yielding the expectation of one error. Several such intervals must be assessed to achieve statistical confidence. It is suggested that throughput be determined by the maximum rate at which no more than one lost packet per minute is achieved. If the measured throughput is substantially greater than 20 Mb/s, the measurement interval can be corresponding reduced.
Note: commercially available test equipment (eg Spirent SmartBits) has built-in search algorithms, which are expected to be satisfactory even if they do not precisely match the description above.

Standard: IETF RFC 2544

Preconditions:
ONU ranged, provisioned for 180 Mb/s data service. If the ONU or OLT offer only 10 Mb/s Ethernet service, adjust the test case accordingly. All supported features should be enabled during the test, for example, LAN bridging, VLAN tag stripping, PPP filtering. However, initialization, eg learning the LAN bridge table, should be done before the test begins.
No other traffic is to be carried during the test, either on the MoCA interface or on other services provided by the OLT/ONU combination.
This is not a test of traffic policing, so if traffic descriptors are used, they should be provisioned to values large enough to ensure that they do not inhibit throughput.

Test Equipment:
Data test set at ONT and at OLT

Procedure:
1. Perform the following steps for upstream traffic only, for downstream traffic only, and for simultaneous traffic in both directions (equal packet size).
2. For each packet size of interest, adjust the throughput to determine the threshold at which packet loss occurs. Record the result.
3. By pre-agreement, the test may be repeated with some features turned off.

Pass-fail Criteria: None – characterization result only

Observations: Record the features that were enabled for the test. Record throughput rates for each direction individually and combined, for each packet size.

Related test cases:

Last Modified: July 10, 2006

Note: IEEE 802.3 specifies a BER not to exceed 10^{-8} for copper interfaces. If the copper can tolerate 10^{-8}, there is clearly no need for substantially better performance elsewhere in the network, ie on the PON. In other sections of 802.3, this value is used as a suggested criterion for measurements, but there is no requirement. In this test case, the value should also be understood as a suggested criterion, not as a hard requirement.

7.2.3.9 Multiple Cross Connect configured for MoCA

Test Case # 7.468

Test Setup
Default test setup as shown in Figure 1

Purpose:
Verify that the ONU can support multiple cross connects on its Mac Bridge configuration.

Standard:

Preconditions:
ONU ranged. ONU-OLT Ethernet bridge configuration active.
Upstream data grant and downstream peak data rate set for 180 Mbps and assigned to the ONU under test.

Test Equipment:
Data traffic simulator
Backhaul data traffic switch

Test Procedure
1. Configure a CoS2 traffic descriptor 16 Mbps
2. Configure 8 GEM inter-working termination points for MAC bridge LAN.
3. Configure OLT side test equipment to generate 8 separate downstream traffic stream. Configure ONU side test equipment to generate 8 separate 16 Mbps or the maximum configured rated for traffic upstream
4. Verify that downstream/upstream discards are not present. Ensure that upstream transmission conforms to the traffic descriptor monitored on the OLT side.
5. Verify that the ONU forwards the data traffic only to the specified 8 source- destination MAC address configured in the test equipment
6. Traffic should pass only on the MAC address display in the forward data base table.

Pass-fail criteria:
Traffic should pass only on the MAC address display in the forward data base table.

Test report: Pass _____ Fail _____ Not Supported _____

Observation:

Last Modified: August 25, 2006

7.2.3.10 Bridge PM

Test Case # 7.469

Test Setup
Default test setup as shown in Figure 1

Purpose:
Verify that bridge is operational using statistics available on the ONU.

Standard:

Preconditions:
Initial state is OLT and ONU are powered
ONU-OLT Eth/bridge configuration active.
Upstream data grant and downstream peak data rate for 180 Mbps assigned to the ONU under test.

Test Equipment:
Data traffic simulator
Backhaul data traffic switch

Test Procedure
1. Get the MAC bridge port designation data ME (PM statistics).
2. Verify that bridge port state is listening or forwarding
3. Get the MAC bridge port designation data ME (PM statistics) at least 60 seconds after test case and 7.468 is completed

Pass-fail criteria:
Bridge PM statistics accurately show counts, OLT and ONU indicate same results.

Test report: Pass _____ Fail _____ Not Supported _____

Observation:

Last Modified: August 25, 2006

7.2.3.11 MoCA Carrier Loss

Test Case # 7.470

Test Setup
Default test setup as shown in Figure 1

Purpose:
Verify that a no carrier alarm is reported upstream to the OLT.

Standard:

Preconditions:
ONU ranged, ONU-OLT Eth/bridge configuration active.

Test Equipment:
Data traffic simulator
Backhaul data traffic switch

Test Procedure
1. Connect a valid operation RGW device to the MoCA port
2. Disconnect the RGW
3. ONU reports upstream LAN-LOS.
4. OLT receive alarm LAN-LOS
5. Reconnect the RGW
6. ONU reports clear alarm indication, normal operation
7. OLT received alarm clear from ONU

Pass-fail criteria:
Alarm is reported and cleared.

Test report: Pass _____ Fail _____ Not Supported _____

Observation:

Last Modified: July 10, 2006

7.2.3.12 UPC Monitoring

Test Case # 7.471

Test Setup
Default test setup as shown in Figure 1

Purpose:
Verify that UPC statistics associated with the GEM Port on the ONU can be monitored from the OLT.

Standard:

Preconditions:
Initial state is OLT and ONU are powered
ONU-OLT MAC Bridge configuration active.
Upstream data grant and downstream peak data rate for 180 Mbps assigned to the ONU under test.

Test Equipment:
Data traffic simulator
Backhaul data traffic switch

Test Procedure
1. Query UPC on the ONU from the OLT
2. Verify that the ONU satisfies traffic descriptor requirements while running traffic from test case 7.467 and 7.468

Pass-fail criteria:
PM counts are reported accurately between ONU and OLT

Test report: Pass _____ Fail _____ Not Supported _____

Observation:

Last Modified: August 25, 2006

7.2.3.13 MoCA PM

Test Case # 7.472

Test Setup
Default test setup as shown in Figure 1

Purpose:
Verify that Ethernet interface counters are viewable and that no error indications are present.

Standard:

Preconditions:
Initial state is OLT and ONU are powered
ONU-OLT Eth/bridge configuration active.
Upstream data grant and downstream peak data rate for 180 Mbps assigned to the ONU under test.

Test Equipment:
Data traffic simulator
Backhaul data traffic switch

Test Procedure
1. Query MoCA interface counters on the ONU from the OLT
2. Verify that MoCA interface counters are present and that no error counters are incrementing while running test case 7.467 and 7.468

Pass-fail criteria:
PM counts are reported accurately between ONU and OLT

Test report: Pass _____ Fail _____ Not Supported _____

Observation:

Last Modified: July 10, 2006

7.2.3.14 MoCA WAN Channel Frequency

The ONT shall only support 1-channel MoCA operation for the following traffic: Local WAN channel in 1.00Ghz. Ensure it works with RGW which on pre-setting frequency band.

Test Case # 7.473

Test Setup
Default test setup as shown in Figure 1

Preconditions
1. Range the ONT with OLT.
2. After unit initialization, both data ports are disabled.
3. Enable MoCA interface

Test Procedure
1. Enable MoCA port
2. Verify RGW is synch up with ONT WAN channel frequency 1000MHZ band
3. Monitor the Coax WAN Ethernet channel frequency band via RGW's system monitoring

Pass-fail criteria:
The Coax WAN Ethernet channel is synched up and connected. The frequency is shown in 1000MHZ band.

Test report: Pass _____ Fail _____ Not Supported _____

Observation:

Last Modified: July 10, 2006

7.2.3.15 Transmitted Power

The ONT MoCA node at the F-type connector shall support transmit power up to +2 dBm (nominal) at frequencies between 1000MHz and 1500MHz into an impedance of 75 ohms.

Test Case # 7.474

Test Setup
Default test setup as shown in Figure 1

Preconditions
1. Use RF power meter to measure the output power.

Test Procedure
1. Use Digital analyzer to measure the output power from the F connector of the ONT at frequency 1000Mhz into an impedance 75 ohms.

Pass-fail criteria:
The result should meet the spec.

Test report: Pass _____ Fail _____ Not Supported _____

Observation:

Last Modified: July 10, 2006

7.2.3.16 CMR Slave Mode

The MoCA port shall always operate as a slave MoCA node within the MoCA network. This corresponds to a network coordinator ratio of 0% and means the ONT must interoperate with another MoCA node that is not provisioned as a slave and thus has a network coordinator ratio >0% (CMR ratio)

Test Case # 7.474

Test Setup
Default test setup as shown in Figure 1

Preconditions

Test Procedure
1. The ONU, by default, always acts as “slave” which has 0% of CMR.
2. While traffic is running, modify the CMR to be slave from master for RGW (if that option is available).
3. Run system monitoring to monitor the Coax WAN link establishment.

Pass-fail criteria:
The ONT can’t communicate with another MoCA device that has a network coordinator ratio 0%.

Test report: Pass _____ Fail _____ Not Supported _____

Observation:

Last Modified: July 10, 2006

7.2.3.17 Encryption Key

The MoCA port shall always support a MoCA 40-byte Encryption Key. When Privacy Mode is Enabled, the password is used for encrypting/scrambling MAC layer messages. When privacy in Enabled for the ONU, this mode must be enabled for all nodes on the WAN MoCA network, and all these Nodes must have the same password to communicate with each other, otherwise, data shall not be valid.

Test Case # 7.475

Test Setup
Default test setup as shown in Figure 1

Preconditions

Test Procedure
1. Modify privacy encryption code to be 40 bytes of all ones for RGW.
2. Verify the communication between two MoCA devices – RGW and INT are paused due to encryption code mismatch.

Pass-fail criteria:
The mismatch encryption password would cause two MoCA devices to stop communicating with each other.

Test report: Pass _____ Fail _____ Not Supported _____

Observation:

Last Modified: July 10, 2006

7.3 Video Test Cases

These test cases verify that the ONU video services are configurable from the OLT as identified in G.983.8 section 7.6.

7.4 Multi-service provisioning and verification

7.4.1 Multi-service application using Ethernet and Voice

Test Case # 7.480

Test Setup
Default test setup as shown in Figure 1

Purpose:
This test case is exclusive to ONUs that support voice and data. Verify that Ethernet and voice transmissions are operable with no loss of voice quality.

Standard:

Preconditions:
Initial state is OLT and ONU are powered and ranged with voice and data provisioned, use same data provisioning from earlier in test plan for 100Mb traffic

Test Equipment:

Test Procedure
1. If not automatically configured by line card type, configure at least two priority queues with one of higher precedence than the other
2. Configure the POTS connection. If required ensure that the GEM Port points to higher priority queue
3. Configure the Ethernet connection. If required, ensure that the GEM Port points to lower priority queue
4. Start Ethernet transmission by generating traffic
5. Run PESQ to verify the voice quality is not affected by the data transmission

Pass-fail criteria:
Run a PESQ test and confirm a minimum level of 4.0

Test report: Pass _____ Fail _____ Not Supported _____

Observation:

Last Modified: July 25, 2006

7.4.2 Multi-service application using MoCA and Voice

Test Case # 7.480.5

Test Setup
Default test setup as shown in Figure 1

Purpose:
This test case is exclusive to ONUs that support voice and data. Verify that data and voice transmissions are operable with no loss of voice quality.

Standard:

Preconditions:
Initial state is OLT and ONU are powered and ranged with voice and data provisioned, data provisioning for max downstream of 180Mbps, upstream dependent upon PON link rate.

Test Equipment:

Test Procedure
1. If not automatically configured by line card type, configure at least two priority queues with one of higher precedence than the other
2. Configure the POTS connection. If required ensure that the GEM Port-ID points to higher priority queue
3. Configure the data connection. If required, ensure that the GEM Port-ID points to lower priority queue
4. Start data transmission by generating traffic
5. Run PESQ to verify the voice quality is not affected by the data transmission

Pass-fail criteria:
Run a PESQ test and confirm a minimum level of 4.0

Test report: Pass _____ Fail _____ Not Supported _____

Observation:

Last Modified: July 25, 2006

7.5 OMCI service-related fault and performance management

7.5.1 General

7.5.2 CPS Performance Monitoring

Test Case # 7.500

Test Setup
Default test setup as shown in Figure 1

Purpose:
Verify that the statistical information associated with CPS for the ONU is viewable on the OLT.

Standard:

Preconditions:
Initial state is OLT and ONU are powered, data is provisioned

Test Equipment:

Test Procedure
1. Run command to view CPS PM. statistics for the ONU
2. Verify that at minimum CPS in/out packet counts, parity errors, sequence errors, offset mismatch and offset errors, HEC errors, oversized SDU, HEC overlap errors, UUI errors and CID errors counters are present

Pass-fail criteria:

Test report: Pass _____ Fail _____ Not Supported _____

Observation:

Last Modified: Aug. 5, 2005

8 System and performance tests

GPON systems utilize point-to-multipoint communications links. The test cases of sections 5, 6, and 7 are primarily focused on OLT interoperability with a single EUT (i.e., ONU) on the ODN. Test cases in this section check for interoperability issues that arise when multiple (≥ 8) ONUs are connected to the PON. Potentially ONUs other than EUTs (e.g., ONUs that are 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 place 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 insure that any identified unexpected behaviors or performance issues are not the result of problems with the non-EUT ONU. This may require apriori 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 the section 6 (ONU Turn-up and Management) and Section 7 (Service-related Functionality) is reexamined 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 behavior, 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 behavior when supporting a loaded PON interface. In addition, OLT behavior 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 fiber 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. 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 far from the (e.g., 10 or 20 km) the OLT. This ODN test configuration also provides both minimum and maximum signal levels, and minimum and maximum delays on the same PON interface.

Error! Reference source not found. 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 level and delay characteristics.

Standards: G.984.3 Amd1.

Preconditions:
1. Some number “k” ONUs (k ≥ 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.

[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.

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 Setup: The EUT ONU will be tested using the four ODN test configurations provided in Appendix A.
1. For ODN test configurations #1 (Section A.1) and #2 (Section A.2), select either a single stage or a multi-stage variation.
2. Follow local procedures for cleaning all fiber connectors before making any fiber 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 Section 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.[10]
5. Power down the ONUs, remove the ONU S/N 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 6. 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		"	
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"

instructions.

is the number of ONUs on the ODN.

Test report: Pass _____ Fail _____ Not Supported _____

Observation:

Last Modified: August 21, 2006

8.3 Warm PON, Multi-ONU

The test cases in this section examine the affects of adding a Cold ONU to a Warm PON for the four ODN test configurations specified in Appendix A.

8.3.1 Warm PON, Cluster ODN

Test Case # 8.20

Purpose: This test case verifies proper operation of some number "M" (M ≥ 8) warm ONUs after the addition of one EUT ONU to ODN test configuration #1 (Section A.1 – *Near Cluster*) and ODN test configuration #2 (Section A.2 – *Far Cluster*). The focus of this test case is verifying activation of the cold ONU on a Warm PON, plus spot checking for service disruptions on the Warm ONU. A more robust examination of service disruption is examined in other (yet to be provided) test cases.

Standards: Section 10 of 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 (Section A.1 – *Near Cluster*) is adjusted to avoid overloading either the OLT or ONU receivers. See the results from Section 5.3 to determine the receiver overload thresholds.
3. Some number "k-1" ONUs (k ≥ 8) connected to ODN test configuration #1 (Section A.1 – *Near Cluster*), 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. Per the procedures of test case of Section 7.3.1.7, *Ethernet Throughput*, 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 Setup:
1. The EUT ONU will be tested using the ODN test configuration #1 (Section A.1 – *Near Cluster*) and then using ODN test configuration #2 (Section A.2 – *Far Cluster*).
2. Follow local procedures for cleaning all fiber connectors before making any fiber 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 Section 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 unpowered 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 S/N 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 (Section A.2 – *Far Cluster*).

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

Table 7. Warm PON – Cluster ODN Test Results

ODN #	Measurement #	$T_{measured}$	T_{CF}	T_{ACT} ($T_{measured}$-T_{CF})	Impacts on Existing Traffic?
1	1				
	2		"		
	3		"		
	4		"		
	5		"		
2	1		"		
	2		"		
	3		"		
	4		"		
	5		"		
			"		
			"		
			"		
			"		
			"		
			"		
			"		
			"		
			"		
			"		

* "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 become 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 (Section A.3 – *Near EUT, Far Cluster*) and ODN test configuration #4 (Section A.4 – *Far EUT, Near Cluster*). The focus of this test case is verifying activation of the cold ONUs on a Warm PON, plus spot checking for service disruptions on the Warm ONU. A more robust examination of service disruption is examined in other <*yet to be provided*> test cases. 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 Section 8.3, with difference being the "M" ONUs in the following test cases are in the Cold condition.

Standards: Section 10 of G.984.3.

Preconditions:
1. Some number "M" ONUs (M ≥ 8), 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 (Section A.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 Section 5.3 to determine the receiver overload thresholds.
3. Per the procedures of test case of Section 7.3.1.7, *Ethernet Throughput*, 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 Setup:
1. The EUT ONU will be tested using the ODN test configuration #3 (Section A.3 – *Near EUT, Far Cluster*) and then using ODN test configuration #4 (Section A.4 – *Far EUT, Near Cluster*).
2. Follow local procedures for cleaning all fiber connectors before making any fiber 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 (Section A.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 Section 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" unpowered 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 S/N 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 (Section A.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 8. Warm PON – Min-Max ODN Test Results

ODN #	Measurement #	Sum of ONUs T_{ACT}	Impacts on Existing Traffic? *
3	1		
	2		
	3		
	4		
	5		

ODN #	Measurement #	Sum of ONUs T_{ACT}	Impacts on Existing Traffic? *
4	1		
	2		
	3		
	4		
	5		

* "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 it 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 section examine ONU and OLT receiver performance under the "Min-Max" Multi-ONU ODN configurations of Appendix A, (i.e., test configuration #3 [Section A.3 – *Near EUT, Far Cluster*] and test configuration #4 [Section A.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 Section 8.2.2, with difference being 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 (Section A.3 – *Near EUT, Far Cluster*), with a total of "M" ONUs on the far end of the PON interface (where M ≥ 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.

Standards: Section 8.2.8 of G.984.2.

Preconditions:

1. Some number "M" ONUs (M ≥ 8) connected to the far end of ODN test configuration #3 (Section A.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. Per the procedures of test case of Section 7.3.1.7, *Ethernet Throughput*, 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 Setup:

1. The EUT ONU will be tested using the ODN test configuration #3 (Section A.3 – *Near EUT, Far Cluster*).
2. Follow local procedures for cleaning all fiber connectors before making any fiber 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 (Section A.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 Section 5.1.
2. Traffic Generator/Error Detector

Test Procedure:

1. With "M" activated ONUs connected to the far end of ODN test configuration #3 (Section A.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 unpowered 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 Section 5.3.
4. Apply power to the EUT ONU (now connected to the ODN) while monitoring the bi-directional 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 S/N 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 9. Receiver Performance - Near EUT Test Results

Measurement #	**EUT T_{ACT}**	**Impacts on Existing Traffic? ***
1		
2		
3		
4		
5		
	Upstream	**Downstream**
EUT BER		
"M" ONU BER Impacts? (Y/N)		

* "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 become 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 (Section A.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.

Standards: Section 8.2.8 of G.984.2.

Preconditions:

1. Some number "M" ONUs (M ≥ 8) connected to the near-end of ODN test configuration #4 (Section A.4 – *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. Per the procedures of test case of Section 7.3.1.7, *Ethernet Throughput*, 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 Setup:

1. The EUT ONU will be tested using the ODN test configuration #4 (Section A.4 – *Far EUT, Near Cluster*).
2. Follow local procedures for cleaning all fiber connectors before making any fiber 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 (Section A.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 Section 5.1.
2. Traffic Generator/Error Detector

Test Procedure:

1. With "M" activated ONUs connected to the near-end of ODN test configuration #4 (Section A.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 unpowered EUT ONU to the far end of the ODN.
3. Apply power to the EUT ONU (now connected to the ODN) while monitoring the bi-directional 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 10. Receiver Performance - Far EUT Test Results

Measurement #	EUT T_{ACT}	Impacts on Existing Traffic? *
1		
2		
3		
4		
5		
	Upstream	**Downstream**
EUT BER		
"M" ONU BER Impacts? (Y/N)		

* "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 ONU. Due to uncertainties in the measurement process (e.g., when the discovery process begins, when the EUT ONU become 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

8.5 Voice and Data Service Stability

Test Case # 8.60

Purpose: This test case verifies proper operation of the EUT ONU with the reference OLT in delivering voice and data services when connected to ODN test configuration #2 (Section A.2 – *Far Cluster*). Voice quality performance is assessed both from a connection establishment perspective and a speech quality perspective. Ethernet data service traffic performance is also examined in parallel with the voice service performance. Service stability is assessed by considering a relatively long duration test (i.e., at least 100,000 voice call attempts). The offered traffic load is intended to be *below* the PON interface bandwidth maximum (avoiding "oversubscription"/bandwidth contention).

Standard: GR-909-CORE, Section 5.2 (*Packet Voice Criteria)* and GR-511-CORE (*Service Standards* – North America).

Preconditions:

1. Some number "k" active ONUs (k ≥ 8) connected to ODN test configuration #2 (Section A.1 – *Far Cluster*), 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. "kv" voice connections (DTMF signaling option enabled) are provisioned across "k" ONUs, each of which provides some number "v" voice ports. It is recommended that testing be performed using waveform

CODECs[11] (e.g., G.711, G.726, G.727), unless the intended application requires the use of speech compression CODECs (e.g., G.723, G.728, G.729).
3. At least “k” bi-directional, best effort (e.g., ATM UBR or Ethernet user_priority=0), data connections are provisioned to consume at least 90% (but not more than 100%) of the *unused* upstream and downstream PON bandwidth, simulating a highly utilized PON interface. Data connections (and associated traffic bandwidth) are uniformly distributed across all “k” ONUs.
4. An EMS or craft interface on the OLT to monitor ONU status on the PON interface.

Test Setup:

1. The EUT ONU will be tested using ODN test configuration #2 (Section A.2 – *Far Cluster*).
2. Connect a Traffic Generator/Error Detector to at least one UNI port of every ONU on the ODN and to the SNI (directly or indirectly) of the OLT.
3. Connect a voice bulk call generator to the voice ports of all “k” ONUs. Configure the bulk call generator parameters as follows: (1) call duration for one voice port pair should be set to long duration (e.g., 8 hours) (2) For the remainder of the voice port pairs, set the call duration for on the order of 30-60 seconds (including measurement time) (3) Select a test run time such that at least 100,000 call attempts are made when aggregated across the “kv” ONU voice ports[12].
4. Voice switch or switch simulator connected (directly or indirectly) to the OLT via the SNI.
5. Follow local procedures for cleaning all fiber connectors before making any fiber connections.

Test Equipment:

1. Voice Bulk Call Generator with PESQ (P.862) listener speech quality measurement (or functional equivalent).
2. Traffic Generator/Error Detector
3. Voice switch or switch simulator
4. Ethernet Switch or IP Router – if the OLT does not have an integrated voice gateway function, then an external Ethernet Switch or IP Router may be required to separate the voice and data streams at the OLT’s SNI. If an external Ethernet Switch or IP Router is used, care should be taken to insure the forwarding device does not impact the ONU-OLT voice and data service performance measurement.

Test Procedure:

1. Enable the Traffic Generator/Error Detector to generate a constant rate data stream at the peak information/cell rate of each provisioned data connection. Ensure that none of the offered traffic rates exceeds the ONU’s data throughput, as measured in Section 7.3 (otherwise packet loss is likely to occur).
2. Enable the Voice Bulk Call Generator to begin its call runs, measuring voice quality on at least one voice connection through the EUT ONU (ideally on all voice connections through all ONUs). PESQ (P.862) objective perceptual voice listening-quality measurements are recommended.
3. Upon completion of the voice bulk call run, record the traffic statistics for the “k” data connections as measured by the Traffic Generator/Error Detector (e.g., average packet rate, packet delay, packet loss). Record the voice call connection and voice quality statistics as measured by the Voice Bulk Call Generator.

Pass Fail Criteria:

1. The PESQ listening-quality score on each originating line (when averaged over every success call attempt) shall be 4 or higher when operating with the waveform CODECs.
2. Voice Call Setup Performance shall meet the criteria established in national standards. Criteria for North American call setup performance are given below (per the service standards of GR-511-CORE):

Parameter	Criteria	Comment
average Dial Tone Delay	≤ 600 ms	When average across all call attempts on any given line

[11] It is generally understood that waveform CODECs are required to provide carrier-grade, wireline, speech quality over a wide range of connection types (local, national, international). Speech compression CODECs introduce conversation quality impairments through (1) information loss in the speech compression process, (2) reduced conversational delay budget, and (3) an increased likelihood of transcoding as the connection transverses different carrier networks.

[12] Assuming 4 as a typical number of voice ports per ONU and that at least 8 ONUs are available on the PON interface, 100,000 call attempts would require on the order of 2 days with a 30 second call duration and a minimal (e.g., 2 seconds) inter-call gap.

Delayed Dial Tone (DDT) Events	≤ 1.5% of total call attempts	DTT event defined as dial tone delayed > 3 seconds (including no dial tone)
Cut-off Calls Events	the probability that a stable call is cut off shall not exceed 0.000125 (long-term average no more than one cutoff in 8000 calls)	A cutoff call occurs when an established connection is broken for some reason other than an on-hook by one of the parties.

3. While there are no performance guarantees for best effort data connections, it is expected that the average frame/cell rate of each data connection should be very near the connection's provisioned peak information/cell rate with little or no packet loss.

Test report: Pass _____ Fail _____ Not Supported _____

Observation:
Record the average 1-way voice bearer path (speech) delay through the PON system include the method of transport, codec type, and TCONT rate allotted.

Last Modified: November 27, 2005

8.6 Warm PON, High Utilization

Test Case # 8.70

Purpose: This test case verifies the addition of a one or more EUT ONUs to a highly utilized Warm PON does disrupt operation of existing services. The case test uses the same configuration as the Voice and Data Services Stability test case. The test case effectively repeats test case 8.20 (Warm PON, Cluster ODN) under more realistic traffic conditions. This test case differs from test case 8.20 both in the amount of traffic on the PON interface and the way the Cold EUT ONU is added to the ODN.

Standard: Section 10 of G.984.3.

Preconditions:

1. At least one EUT ONU not powered and not connected to the ODN.
2. Some number "k-1" active ONUs (k ≥ 8) connected to ODN test configuration #2 (Section A.1 – *Far Cluster*).
3. "(k-1)v" voice connections (DTMF signaling option enabled) are provisioned across "k-1" ONUs, each of which provides some number "v" voice ports. It is recommended that testing be performed using waveform CODECs (e.g., G.711, G.726, G.727), unless the intended application requires the use of speech compression CODECs (e.g., G.723, G.728, G.729).
4. At least "k-1" bi-directional, best effort (e.g., ATM UBR or Ethernet user_priority=0), data connections are provisioned to consume at least 90% (but not more than 100%) of the *unused* upstream and downstream PON bandwidth, simulating a highly utilized PON interface. Data connections (and associated traffic bandwidth) are uniformly distributed across all "k-1" ONUs.
5. An EMS or craft interface on the OLT to monitor ONU status on the PON interface.

Test Setup:

1. The EUT ONU will be tested using ODN test configuration #2 (Section A.2 – *Far Cluster*).
2. Connect a Traffic Generator/Error Detector to at least one UNI port of every ONU on the ODN and to the SNI (directly or indirectly) of the OLT.
3. Connect a voice bulk call generator to the voice ports of all "k" ONUs. Configure the bulk call generator parameters as follows: (1) Call duration on the order of 30 seconds (including measurement time) (2) Select a test run time of at least 60 minutes.
4. Voice switch or switch simulator connected (directly or indirectly) to the OLT via the SNI.
5. Follow local procedures for cleaning all fiber connectors before making any fiber connections.

Test Equipment:

1. Voice Bulk Call Generator with PESQ (P.862) listener speech quality measurement (or functional equivalent).
2. Traffic Generator/Error Detector
3. Voice switch or switch simulator
4. ATM/Ethernet Switch or IP Router – if the OLT does not have an integrated voice gateway function, then an external ATM/Ethernet Switch or IP Router may be required to separate the voice and data streams at the OLT's SNI. If an external ATM/Ethernet Switch or IP Router is used, care should be taken to insure the forwarding device does not impact the ONU-OLT voice and data service performance measurement.

Test Procedure:

1. Enable the Traffic Generator/Error Detector to generate a constant rate data stream at the peak information/cell rate of each provisioned data connection. Ensure that none of the offered traffic rates exceeds the ONU's data throughput, as measured in Section 7.3 (otherwise packet loss is likely to occur).
2. Enable the Voice Bulk Call Generator to begin its call runs, measuring voice quality on at least one voice connection (ideally on all voice connections through all ONUs). PESQ (P.862) objective perceptual voice listening-quality measurements are recommended.
3. After a background traffic observation period of approximately 10 minutes apply power to the Cold EUT ONU, allowing adequate time for the ONU to reach its *Initial-state (O1)* (fully booted, but no received signal detected). Connect the powered EUT ONU to the ODN.
4. Observe the time for the cold EUT ONU to reach the *Operating-state* (O5) while monitoring the data and voice connections for service disruptions (e.g., sudden packet loss, dropped voice calls, voice quality impacts) caused by the addition of the cold EUT ONU to the Warm.
5. Remove the ONU S/N information from the OLT and repeat steps 1 through 4 for a total of five measurements.

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

Table 1: Warm PON -High Utilization Test Results

Measurement #	T_{ACT}	Impacts on Existing Traffic? *
1		
2		
3		
4		
5		

* "Traffic Impacts" include sudden packet loss, dropped voice calls, drop in voice quality scores 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 become 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: November 27, 2005

9 Fault recovery

While some fault condition recovery is considered in the service-related functionality section, 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.

9.1 PON (optical network) faults

This section 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 fiber disconnect and OLT PON interface pack pulls. In addition the ability to recover from various optical signal degrade events are 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 section are summarized below:

	Loss of Signal			**Uni-Directional Low Signal**	
Effecting	**Fiber Pull**	**OLT TX Pack Pull**	**Bi-Directional 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 uni-directional low signal degradation conditions. “Gracious recovery” after removal of the fault condition is examined with a voice and data services load on the system, was specified in Section 8.5.

9.1.1 ONU Fiber Pull – Single Fault to One ONU

This test verifies the ONU can range and recover after fiber pulls and all services are functioning. All ONUs not affected by the injected fault shall continue to maintain normal functions.

Test Case # 9.30

Test Setup:
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 A.

Purpose:
Verify that a fiber break impacting one ONU does not affect the operation of the system, OLT, nor other ONUs.

Standard:

Preconditions: [These preconditions are derived from those in Section 8.5]

1. Some number “k” active ONUs (k ≥ 8) connected to ODN test configuration #2 (Section A.1 – *Far Cluster*), 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. “kv” voice connections (DTMF signaling option enabled) are provisioned across “k” ONUs, each of which provides some number “v” voice ports. It is recommended that testing be performed using waveform CODECs (e.g., G.711, G.726, G.727), unless the intended application requires the use of speech compression CODECs (e.g., G.723, G.728, G.729).
3. At least “k” bi-directional, best effort (e.g., ATM UBR or Ethernet user_priority=0), data connections are provisioned to consume at least 90% (but not more than 100%) of the *unused* upstream and downstream PON

bandwidth, simulating a highly utilized PON interface. Data connections (and associated traffic bandwidth) are uniformly distributed across all “k” ONUs.
4. An EMS or craft interface on the OLT to monitor ONU status on the PON interface.

Test Equipment:
1. Voice Bulk Call Generator with PESQ (P.862) listener speech quality measurement (or functional equivalent).
2. Traffic Generator/Error Detector
3. Voice switch or switch simulator
4. ATM/Ethernet Switch or IP Router – if the OLT does not have an integrated voice gateway function, then an external ATM/Ethernet Switch or IP Router may be required to separate the voice and data streams at the OLT’s SNI. If an external ATM/Ethernet Switch or IP Router is used, care should be taken to insure the forwarding device does not impact the ONU-OLT voice and data service performance measurement.

Test Procedure
1. Verify that the ONU is currently in a fully ranged state with all services functioning.
2. Cause a fiber fault (LOS or fiber break) to the EUT ONU.
3. Verify the remaining portions of the operating system are fully functional without errors.
4. Remove Fault
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: (1) After the fault condition is removed the ONU shall re-range and all services shall be functioning within 3 minutes (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 fiber pull condition.

Last Modified: July 10, 2006

9.1.2 ONU Fiber Pull – Fiber Fault to “N” ONUs (PON Network)

This test verifies the OLT can range and recover after PON fiber pulls affecting “N” ONUs served by a single PON. Ensure that functionality for all services restore.

Test Case # 9.40

Test Setup:

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 A.

Purpose:
Determine that system can restore after a fiber break to multiple ONUs.

Standard:

Preconditions:
See those specified in Section 9.1.1.

Test Equipment:
See the equipment specified in Section 9.1.1.

Test Procedure
1. Verify that all ONU are in a fully ranged state with all services functioning.
2. Cause a fiber fault (LOS or fiber break) effecting all ONU.

3. Remove the fault condition
4. Record the time for all ONUs to fully activate and return all services to normal (i.e., pre-fault condition) operation..

Pass-fail criteria: NONE

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 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 fiber pull condition.

Last Modified: July 10, 2006

9.1.3 OLT PON Transmitter Pack Pull

This test case will verify the ONU successfully ranges when an OLT pack is pulled from its chassis and all services are functioning. 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 # 9.50

Test Setup:
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 A.

Purpose:
Determine that system can restore after replacement of the OLT PON transceiver pack that serves multiple ONUs.

Standard:

Preconditions:
See those specified in Section 9.1.1.

Test Equipment:
See the equipment specified in Section 9.1.1.

Test Procedure
1. Verify that all ONU are in a fully ranged state with all 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 all services to normal (i.e., pre-fault condition) operation..

Pass-fail criteria: NONE

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 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 fiber pull condition..

Last Modified: July 10, 2006

9.1.4 ONU PON Transmitter Pack Pull

This test case will verify the ONU successfully re-ranges when its non-integrated ODN circuit pack is pulled from ONU chassis and all supported services are functioning.

Test Case # 9.60

Test Setup:
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 A.

Purpose:
Determine that the EUT ONU can restore after replacement of the ONU non-integrated PON (ODN) transceiver pack.

Standard:

Preconditions:
See those specified in Section 9.1.1.

Test Equipment:
See the equipment specified in Section 9.1.1.

Test Procedure
1. Verify that all ONU are in a fully ranged state with all 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 all services 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 all services 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: July 10, 2006

9.1.5 Optical Signal Fault –Degradation from the OLT to a Single ONU

This test case increases the loss on the single ODN splitter leg (in both directions of transmission) until a loss of signal condition is created 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 # 9.70

Test Setup:
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 A.

Purpose:
Determine that optical signal degradation to one ONU does not affect the operation of the system, OLT, nor other

ONUs.

Standard:

Preconditions:
See those specified in Section 9.1.1.

Test Equipment:
See the equipment specified in Section 9.1.1.

Test Procedure
1. Verify that the ONU is currently in a fully ranged state with all services functioning.
2. Insert an optical loss in the fiber to the EUT ONU.
3. Verify 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: After the fault condition is removed the ONU shall re-range and all services shall be functioning within 3 minutes

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: July 10, 2006

9.1.6 Optical Signal Fault – Degradation from the from OLT to Multiple ONUs

This test case increases the loss on the OLT feeder fiber (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 # 9.80

Test Setup:
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 A.

Purpose:
Determine that 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 Section 9.1.1.

Test Equipment:
See the equipment specified in Section 9.1.1.

Test Procedure
1. Verify that the all ONUs are in a fully ranged state with all 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 services to normal (i.e., pre-fault condition) operation..

Pass-fail criteria: NONE.

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 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: July 10, 2006

Note: The optical signal faults induced in Sections 9.1.6 through 9.1.9 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 fiber (in downstream direction only) to the EUT ONU until a loss of signal condition is created on 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 # 9.90

Test Setup:
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 A. Replace the variable attenuator of ODN configuration #3 and #4 with the splitter #1/variable attenuator/circulator/fixed attenuator combination in Figure 6.

Purpose:
Determine that a directional optical signal degradation to one ONU does not affect the operation of the system, OLT, nor other ONUs.

Standard:

Preconditions:
See those specified in Section 9.1.1.

Test Equipment:
See the equipment specified in Section 9.1.1.

Test Procedure
1. Verify that the ONU is in a fully ranged state with all services functioning.
2. Inject optical loss in one direction of transmission in the fiber towards the EUT ONU.
3. Verify 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 all services to normal (i.e., pre-fault condition) operation.

Pass-fail criteria: After the fault condition is removed the ONU shall re-range and all services shall be functioning within 3 minutes

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: July 10, 2006

9.1.8 Optical Signal Fault –Directional Failure – Degradation from the from OLT to Multiple ONUs

Using an optical circulator this test case increases the loss on the OLT feeder fiber (in 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 services to the all ONUs are restored.

Test Case # 9.100

Test Setup:
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 A.

Purpose:
Determine that 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 Section 9.1.1.

Test Equipment:
See the equipment specified in Section 9.1.1.

Test Procedure
1. Verify that the all ONUs are in a fully ranged state with all 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 services to normal (i.e., pre-fault condition) operation.

Pass-fail criteria: NONE.

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 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: July 10, 2006

9.1.9 Optical Signal Fault –Directional Failure – Degradation from a Single ONU to the OLT

Using an optical circulator this test case increases the upstream (1310 nm) 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 services to the EUT ONU are restored. All ONUs not affected by the injected fault are expected to maintain normal functions.

Test Case # 9.110

Test Setup:
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 A. Replace the variable attenuator of ODN configuration #3

and #4 with the splitter #1/variable attenuator/circulator/fixed attenuator combination in Figure 6

Purpose:
Determine that a directional optical signal degradation from one ONU does not affect the operation of the system, the OLT, nor other ONUs.

Standard:

Preconditions:
See those specified in Section 9.1.1.

Test Equipment:
See the equipment specified in Section 9.1.1.

Test Procedure
1. Verify that the ONU is in a fully ranged state with all services 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 all services to normal (i.e., pre-fault condition) operation

Pass-fail criteria: After the fault condition is removed the ONU shall re-range and all services shall be functioning within 3 minutes <3 minutes is a provisional value pending additional input from the FSAN community.>

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: July 10, 2006

9.1.10 Optical Signal Fault –Directional Failure – Degradation from Multiple ONUs to the OLT

Using an optical circulator this test case increases the upstream (1310 nm) from all ONUs until a loss of signal condition is created on the OLT. The excessive attenuation condition is then removed. The test then verifies that services to all ONU are restored.

Test Case # 9.115

Test Setup:
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 A.

Purpose:
Determine that 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 Section 9.1.1.

Test Equipment:
See the equipment specified in Section 9.1.1.

Test Procedure
1. Verify that the all ONUs are in a fully ranged state with all 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 services to normal (i.e., pre-fault condition) operation..

Pass-fail criteria: NONE.

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 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: July 10, 2006

9.2 Equipment faults

Test cases in this section examine the ability the system to restore services to a single or multiple ONUs after a manually reboot or loss of power event,

9.2.1 ONU Rebooting – Manual – No Loss of Power

This is a test to verify the ONU can range and recover after ONU reboot. All services 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 Setup:
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 A.

Purpose:
Determine that the OLT and ONU can recover without error from the reboot of an ONU.

Standard:

Preconditions:
See those specified in Section 9.1.1.

Test Equipment:
See the equipment specified in Section 9.1.1.

Test Procedure
1. Verify that the ONU is in a fully ranged state with all services functioning.
2. Manually reboot the ONU.
3. After the ONU fully initializes, record the time for the EUT ONU to fully activate and return all services to normal (i.e., pre-fault condition) operation.
4. Verify all previously provisioned ONU services are restored to the normal operation.

Pass-fail criteria: After the reboot the ONU shall re-range and all services shall be functioning within 3 minutes

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: July 10, 2006

9.2.2 Loss and Restoral of Power to Single ONU - Reboot

This is a test to verify the ONU can range and recover after loss of service to a single ONU. All services 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 Setup:
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 A.

Purpose:
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 Section 9.1.1.

Test Equipment:
See the equipment specified in Section 9.1.1.

Test Procedure
1. Verify that the ONU is in a fully ranged state with all services 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 all services to normal (i.e., pre-fault condition) operation.
5. Verify all previously provisioned ONU services are restored to the normal operation.

Pass-fail criteria: After the reboot the ONU shall re-range and all services shall be functioning within 3 minutes

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: July 10, 2006

9.2.3 Loss and Restoral of Power to Multiple ONUs - Reboot

This is a test to verify the ONU can range and recover after loss of service to multiple ONUs. All services on the ONUs will be verified to be functioning properly.

Test Case # 9.220

Test Setup:
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 A.

Purpose:
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 Section 9.1.1.

Test Equipment:
See the equipment specified in Section 9.1.1.

Test Procedure
1. Verify that all ONUs are in fully ranged state with all services functioning.
2. Remove power 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 services to normal (i.e., pre-fault condition) operation.
5. Verify all previously provisioned ONU services are restored to the normal operation.

Pass-fail criteria: NONE

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 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: July 10, 2006

9.2.4 Loss and Restoral of Power to OLT

This is a test to verify the ONU can range and recover after loss of service to an OLT. All services on the OLT to all ONUs will be verified to be functioning properly.

Test Case # 9.230

Test Setup:
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 A.

Purpose:
Determine that system can restore after a loss of power to an OLT that serves multiple ONUs.

Standard:

Preconditions:
See those specified in Section 9.1.1.

Test Equipment:
See the equipment specified in Section 9.1.1.

Test Procedure
1. Verify that all ONUs are in fully ranged state with all services functioning.
2. Remove the power to the OLT that is the host for the PON and ONUs.
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 services to normal (i.e., pre-fault condition) operation..
5. Verify all previously provisioned ONU services are restored to the normal operation.

Pass-fail criteria: NONE

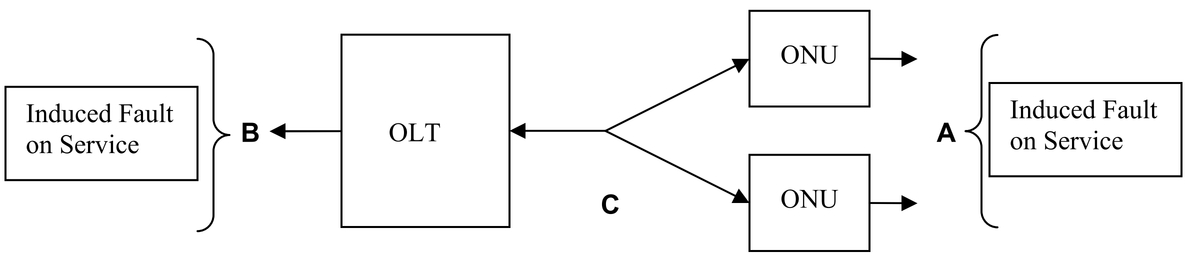
Test report: Pass _____ Fail _____ Not Supported _____

Observation: After the OLT fault condition is removed record the time for all ONUs to fully activate and return all services to normal (i.e., pre-fault condition) operation.

Last Modified: July 10, 2006

9.3 Service-related faults

The impact of faults related to individual services on the interoperability of the system is exercised in this section. Faults are induced on either end of the system at points A or B in the figure below. The impact of the fault on the system (C) is determined.



Note that when a service fault is induced at either A or B the effect at the far end (B or A) is not determined. In the case of voice service that reaction will depend on the interface provided, e. g. and IDLC interface, VOIP, soft switch, etc. and cannot be specified in this interoperability test plan.

9.3.1 Voice - Tip/Ring Faults at ONU

Test Case # 9.300

Test Setup:
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 A.

Purpose:
Determine that faults on the Voice service interface on the ONU does not affect other services, the OLT operation and ONUs in the system.

Standard:

Preconditions:
See those specified in Section 9.1.1.

Test Equipment:
See the equipment specified in Section 9.1.1.

Test Procedure
1. Verify that the ONU is currently in a fully ranged state with all services functioning.
2. Cause a voice service Fault on EUT ONU tip/ring output.

Faults can be:
- Tip/Ring short to Ground
- Tip/Ring Shorted together
- Battery on Tip/Ring

3. Verify that only the voice service faulted is affected. The data and video services shall remain in service without errors..
4. Remove fault condition.
5. Verify the voice service restores (assumes that the voice switch platform has automatic restoral) when the fault is removed.

Pass-fail criteria:

Test report: Pass _____ Fail _____ Not Supported _____

Observation:

Last Modified: July 10, 2006

9.3.2 Data

9.3.2.1 Ethernet

9.3.2.1.1 Ethernet Data Faults at ONU

Test Case # 9.310

Test Setup:
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 A.

Purpose:
Determine that faults on the Ethernet data interface on the ONU does not affect other services, the OLT operation, and ONUs in the system.

Standard:

Preconditions:
See those specified in Section 9.1.1.

Test Equipment:
See the equipment specified in Section 9.1.1.

Test Procedure
1. Verify that the ONU is currently in a fully ranged state with all services functioning.
2. Cause a data service Fault on EUT ONU Ethernet output.
   Faults can be:
   - Ethernet wires short to Ground
   - Ethernet wires Shorted together
   - Battery on Ethernet wires
   - LOS on Ethernet

3. Verify that only the data service faulted is affected. The voice and video overlay services (if present) shall remain in service without errors.
4. Remove Fault.
5. Verify the data service restores when the fault is removed.

Pass-fail criteria:

Test report: Pass _____ Fail _____ Not Supported _____

Observation:

Last Modified: July 10, 2006

9.3.2.2 MoCA

9.3.2.2.1 MoCA Limited Link Alarm

The ONU shall raise a MoCA-Limited Link alarm when any single or combination of the following conditions occur. If the measured Transmit MoCA (PHY) rate between the ONU and the Network Coordinator is less than the Target MoCA Rate. If the measured Receive MoCA (PHY) rate between the ONU and the Network Coordinator is less than the Target MoCA.

Test Case # 9.400

Test Setup
Default test setup as shown in Figure 1

Preconditions
1. Continue from the previous test setup.

Test Procedure
1. Add Cable loop length and Splitter attenuation (around 60db attenuation) on the link between RGW and MoCA port that would cause PHY rate to drop below the target rate threshold.
2. The link shall be able to establish at a rate that is less than target rate.
3. Run system monitoring for RGW to monitor target rate
4. Verify the traffic remains intact

Pass-fail criteria:
The two MoCA devices should be established link below target rate 180Mbps. There is limited link alarm associated with MoCA link and traffic remains in service.

Test report: Pass _____ Fail _____ Not Supported _____

Observation:

Last Modified: July 10, 2006

9.3.2.2.2 MoCA Alarm Hierarchy

The ONT's MoCA alarms shall support the following hierarchy and the higher alarm should mask the lower alarm when ther are reported. MoCA - Loopback (Highest Priority), MoCA-LOL, MoCA-Limited Link (Lowest Priority)

Test Case # 9.410

Test Setup
Default test setup as shown in Figure 1

Preconditions
1. Continue from the previous test setup.

Test Procedure
1. Cause a limited link alarm
2. Cause a LOL alarm

3. Observed the Limited link alarm is cleared immediately after LOL is raised.

Pass-fail criteria:
The higher level alarm – MoCA LOL suppress the lower level – Limited link

Test report: Pass _____ Fail _____ Not Supported _____

Observation:

Last Modified: July 10, 2006

9.3.2.2.3 MoCA ARC OFF

When the ARC attribute is changed from ON to OFF, the Tellabs ONU shall immediately report all Active alarms to the OLT for the given ARC attribute.

Test Case # 9.420

Test Setup
Default test setup as shown in Figure 1

Preconditions
1.

Test Procedure
1. Set alarm reporting to be enabled which shall turn ARC OFF
2. Cause a LOL alarm per test case 7.XXX
3. Verify the alarm is raised and the bitmask is created and sent to the OLT.

Pass-fail criteria:
With ARC on, all active alarms are raised and reported to the OLT.

Test report: Pass _____ Fail _____ Not Supported _____

Observation:

Last Modified: July 10, 2006

9.3.2.2.4 MoCA ARC ON

When the ARC attribute is changed from OFF to ON, the ONU shall immediately clear all Active alarms to the OLT for the given ARC attribute.

Test Case # 9.430

Test Setup
Default test setup as shown in Figure 1

Preconditions
1.

Test Procedure
1. Set alarm reporting to be disabled which shall turn ARC ON
2. Cause a LOL alarm per test case 7.XXX
3. Verify the alarm is raised but no bitmask is created.

Pass-fail criteria:
With ARC on, all alarms are raised on the ONU are not sent to the OLT. All active alarms shall be cleared from the OLT.

Test report: Pass _____ Fail _____ Not Supported _____

Observation:

Last Modified: July 10, 2006

9.3.2.2.5 MoCA Port Disabled

The MoCA operational status for the ONT's MoCA Port shall be reported as DISABLED during any of the following:

- The MoCA Admin state is set to Disabled
- The ONU detects a MoCA-LOL Alarm for the MoCA Port
- The ONU detects a MoCA Loopback Condition for the MoCA Port
- Upon expiry of the MoCA AC FAIL Timer in when the ONU is in battery mode. At this time, the ONU's MoCA Port will be powered down.
- Prior to expiry of the MoCA AC restore Timer in normal mode (e.g. After the ONU changes from battery mode to normal mode). At this time the ONU's MoCA Port will be powered down.

Test Case # 9.440

Test Setup
Default test setup as shown in Figure 1

Preconditions
1.

Test Procedure
1. Set alarm reporting to be enabled which shall turn ARC OFF
2. Disable the MoCA port and verify the operational state is changed to disabled
3. Enable the MoCA port and then induce a LOL alarm (by pulling out cable) and verify the operational state is changed to disabled.
4. Enable the MoCA port and then pull AC power. Verify the operational state is changed to disabled after the expiration of AC power fail timer. The port remains in disabled state prior to expiration of the MoCA AC restore timer.

Pass-fail criteria:
The MoCA operational state is shown disabled on all abnormal conditions stated above.

Test report: Pass _____ Fail _____ Not Supported _____

Observation:

Last Modified: July 10, 2006

10 Optional functionality

10.1 Dynamic bandwidth allocation

10.2 AES encryption

10.3 Forward Error Correction

10.4 Duplex PON operation

Appendix AODN 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 sections of this document.

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 fiber 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 from the (e.g., 10 or 20 km) the OLT.

For simplicity, the Distribution Fiber is effectively assumed to be zero length, with only short (≤ 30 m) "Termination (drop) Fibers" subtending from the last splitter stage. More typical Distribution Fiber lengths are in the 500-1000 m range. Variations in ONU signal levels and delays introduced by variability in the Distribution fiber 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 8 ONUs on the ODN is recommended.

Appendix A.1 Configuration #1 - Near Cluster

This ODN configuration considers the situation where a group of customers are located very near the OLT. A variable attenuator is shown in Figure 9 to avoid overloading the OLT and ONU receivers. Both single stage and multi-stage variations are provided.

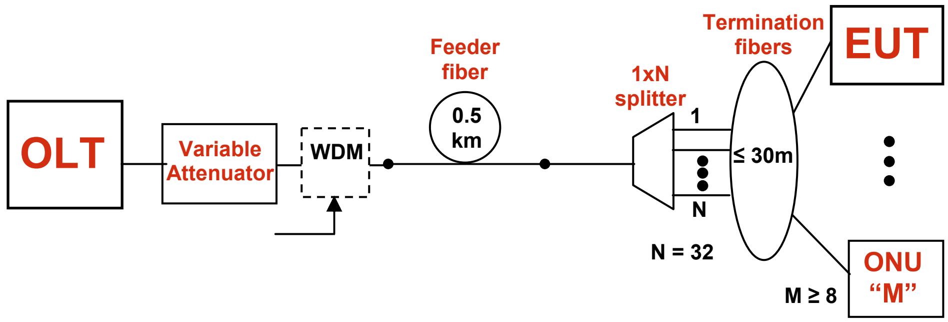


Figure 9. ODN Configuration #1a - Near Cluster, Single Stage ODN

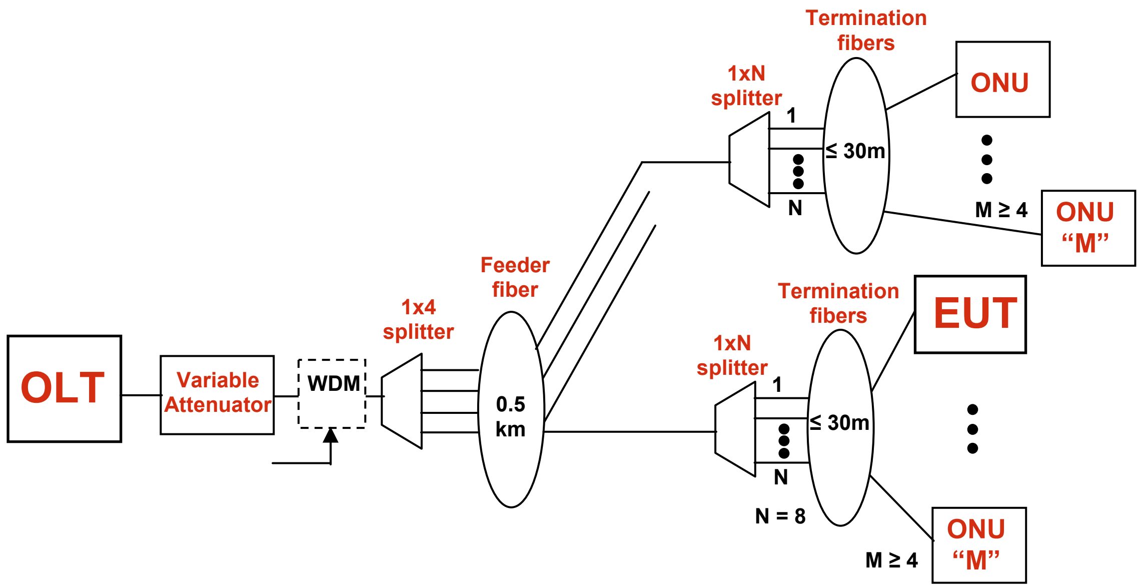


Figure 10. ODN Configuration #1b - Near Cluster, Multi-Stage ODN

Appendix A.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 fiber ("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.

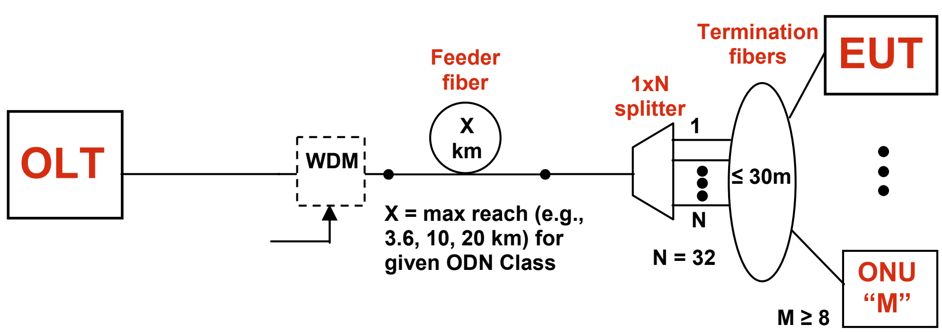


Figure 11. ODN Configuration #2a - Far Cluster, Single Stage ODN

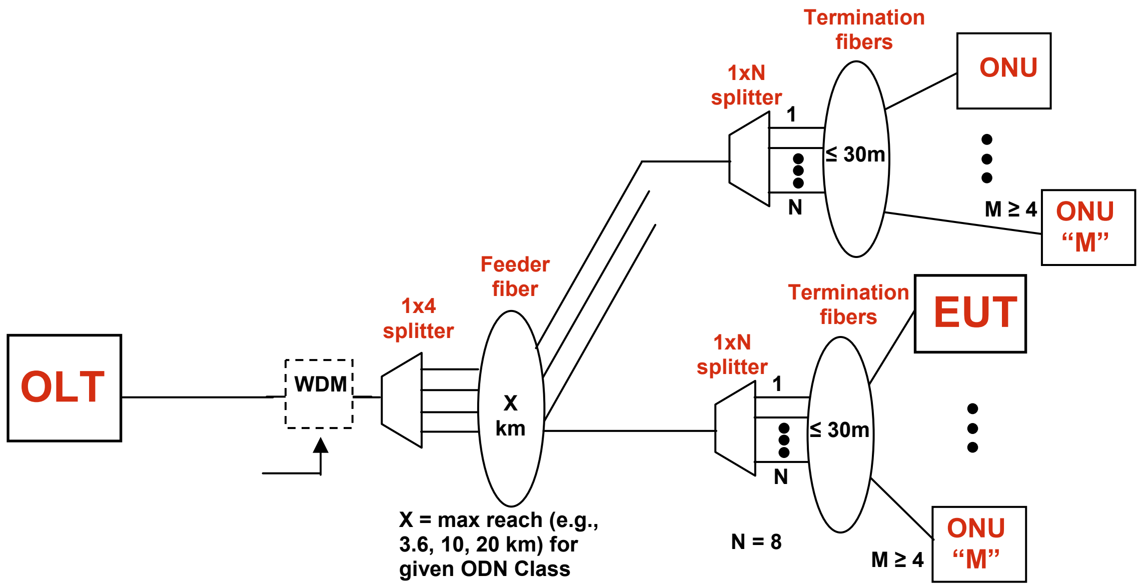


Figure 12. ODN Configuration #2b - Far Cluster, Multi-Stage ODN

Appendix A.3 Configuration #3 - Near EUT, Far Cluster

This is the first of two "Min-Max" ODN test configurations that provides 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.

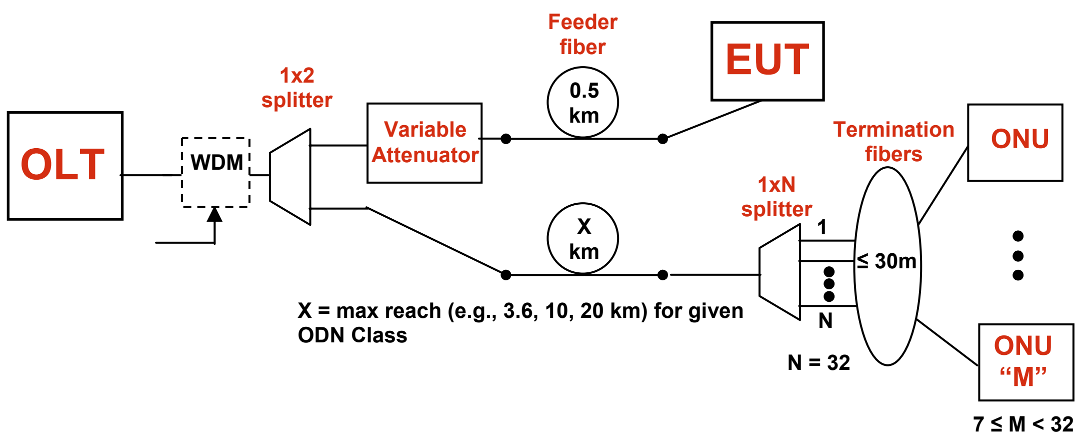


Figure 13. ODN Configuration #3 – Near EUT, Far Cluster

Appendix A.4 Configuration #4 - Far EUT, Near Cluster

This is the second of two "Min-Max" ODN test configurations that provides 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.

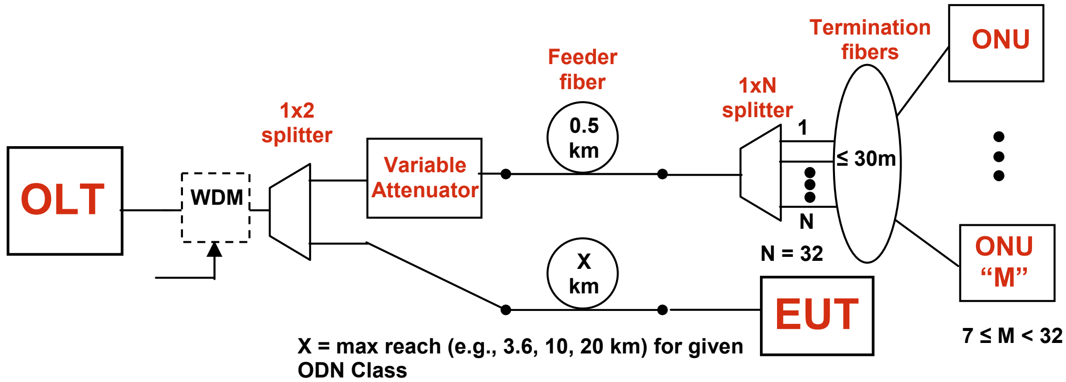


Figure 14. ODN Configuration #4 – Far EUT, Near Cluster

Appendix B References

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[2] AF-VTOA-0078.000 (1997), *Circuit Emulation Service Interoperability Specification Version 2.0*
[3] AF-VTOA-0089.000 (1997), *Voice and Telephony Over ATM-ATM Trunking using AAL1 for Narrowband Services Version 1.0*
[4] G.983.1 (01/05) *Broadband optical access systems based on Passive Optical Networks (PON)*
[5] G.983.2 (06/02) *ONT management and control interface specification for ATM PON*
[6] G.983.2 (06/02) *ONT management and control interface specification for B-PON*
[7] G.983.2 (03/03) Amendment 1
[8] G.983.2 (01/05) Amendment 2
[9] G.983.3 (03/01) *A broadband optical access system with increased service capability by wavelength allocation*
[10] G.983.3 (06/02) Amendment 1
[11] G.983.4 (11/01) *A broadband optical access system with increased service capability using dynamic bandwidth assignment*
[12] G.983.4 (12/03) Amendment 1 New Annex A - Performance monitoring parameters
[13] G.983.4 (01/05) Corrigendum 1
[14] G.983.5 (01/02) *A broadband optical access system with enhanced survivability*
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[16] G.983.7 (11/01) *ONT management and control interface specification for dynamic bandwidth assignment (DBA) B-PON system*
[17] G.983.8 (03/03) *B-PON OMCI support for IP, ISDN, video, VLAN tagging, VC cross-connections and other select functions*
[18] G.983.9 (06/04) *B-PON ONT management and control interface (OMCI) support for wireless Local Area Network interfaces*
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[20] G.983.1 *Protocol Implementation Conformance*
[21] G.983.2 *Protocol Implementation Conformance*
[22] G.984.1 (3/03) *Gigabit-capable Passive Optical Networks (GPON): General characteristics*
[23] G.984.2 (3/03) *Gigabit-capable Passive Optical Networks (GPON): Physical Media Dependent (PMD) layer specification*
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Appendix C Acronyms

AN	Access Node
ANI	Access Node Interface
AVC	Attribute Value Change
BER	Bit Error Rate
BES	Block Error Second
B-ISDN	Broadband Integrated Services Digital Network
CBR	Constant Bit Rate
CES	Circuit Emulation Service
CRC	Cyclic Redundancy Check
CSS	Controlled Slip Second
DBA	Dynamic Bandwidth Allocation
DBR	Deterministic Bit Rate
DSL	Digital Subscriber Line
ELCP	Emulated Loop Control Protocol
ES	Error Second
EUT	Equipment Under Test
FEC	Forward Error Correction
FSAN	Full Service Access Network
FTTB	Fibre to the Building
FTTBusiness	Fibre to the Business
FTTC	Fibre to the Curb
FTTCab	Fibre to the Cabinet
FTTH	Fibre to the Home
GFR	Guaranteed Frame Rate
HN	Home Network
IP	Internet Protocol
ISDN	Integrated Services Digital Network
ITL	Independent Test Laboratory
LAN	Local Area Network
LIM	Line Interface Module
LSB	Least Significant Bit
LT	Line Terminal
MAC	Media Access Control
ME	Managed Entity
MIB	Management Information Base
MSB	Most Significant Bit
MTU	Maximum Transmission Unit
NT	Network Terminal
OAM	Operations, Administration and Maintenance
OAN	Optical Access Network
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
OpS	Operations System
PHY	Physical Interface
PMD	Physical Media Dependent
PON	Passive Optical Network
QoS	Quality of Service
RGW	Residential Gateway
RM	Resource Management
SBR	Statistical Bit Rate
SDH	Synchronous Digital Hierarchy

SDP	Simple Device Protocol
SDT	Structured Data Transfer
SES	Severely Error Second
SLC	Subscriber Loop Carrier
SNI	Service Node Interface
SONET	Synchronous Optical Network
TC	Transmission Convergence
TCA	Threshold Crossing Alert
TE	Terminal Equipment
TIMS	Transmission Impairment Measurement Set
UAS	Unavailable Seconds
UNI	User Network Interface
UPC	Usage Parameter Control
xDSL	x Digital Subscriber Line