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

Test plan to verify B-PON interoperability

ITU-T G-series Recommendations – Supplement 44

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Supplement 44 to ITU-T G-series Recommendations

Test plan to verify B-PON interoperability

Summary

This supplement defines a test plan whose purpose is to verify interoperability between an OLT and an ONU in the ITU-T G.983-series of Recommendations which refer to a Broadband Passive Optical Network (B-PON). When testing peer-to-peer interoperability, such as between SONET/SDH ADMs, both network elements are usually considered to reside at the same hierarchical level, but in a technology such as B-PON, with a master/slave relationship, it is more appropriate to evaluate interoperability relative to a baseline, or master, equipment. In this supplement, the OLT is regarded as the baseline equipment, against which the ONU is evaluated. This is not to be understood as an assertion that the OLT is necessarily right in the event of incompatibility, merely to reflect the reality that a network operator is likely to have OLTs in place and is interested in qualifying additional ONUs for use on these OLTs. From this perspective, the unit under test is an ONU.

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

In this supplement, the manufacturers are referred to as the OLT vendor and the ONU vendor respectively, while tests are deemed to be conducted by a test operator. The term *ONU* includes ONTs as well, and the term *OLT* includes the entire network element at the head end of the PON, not just the G.983 interface.

Source

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FOREWORD

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Supplement 44 to ITU-T G-series Recommendations

Test plan to verify B-PON interoperability

1 Scope

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

- An interoperability test project includes only features and capabilities that are claimed to be supported by both the OLT and the ONU. To apply a single interoperability test plan to all equipment combinations, the test report lists features and capabilities that are not claimed to be supported by one or both of the equipments, but tests of such cases are not to be regarded as failures. The reader of the test report determines the importance of a not-supported feature.
- An interoperability test plan evaluates the ability of an OLT and an ONU to deliver subscriber services. Services are standardized to a greater or lesser extent; the definition of a DS1 leaves very little to the imagination. 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 supplement is based on ITU-T G.983-series Recommendations – and other – standards, and expects that deviation 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 80°F (16 to 27°C) and the relative humidity in the range of 20% to 60%. If testing is performed under different environmental conditions, then any such deviations should be clearly noted in the resulting test report. If different environmental conditions are required for a specific test case within this supplement, then these conditions will be explicitly stated in the test case.

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3 Abbreviations and acronyms

This Supplement uses the following abbreviations and acronyms:

AAL	ATM Adaptation Layer
ABR	Available Bit Rate
ABT/DT	ATM Block Transfer Delayed Transmission
ABT/IT	ATM Block Transfer Immediate Transmission
AGC	Automatic Gain Control
AN	Access Node
ANI	Access Node Interface
APON	ATM over Passive Optical Network
ARC	Alarm Reporting Control
ATC	ATM Transfer Capability
ATM	Asynchronous Transfer Mode
AVC	Attribute Value Change
BER	Bit Error Rate
BES	Block Errored Second
B-ISDN	Broadband Integrated Services Digital Network
B-PON	Broadband Passive Optical Network
BRI	Basic Rate Interface
CBR	Constant Bit Rate
CES	Circuit Emulation Service
CMR	Cycle Master Role
CoS	Class of Service
CRC	Cyclic Redundancy Check
CSS	Controlled Slip Second
CTP	Connection Termination Point
DBA	Dynamic Bandwidth Assignment
DBDT	Draw Break Dial tone Test
DBR	Deterministic Bit Rate

DHCP	Dynamic Host Configuration Protocol
DSL	Digital Subscriber Line
DTMF	Dual Tone Multi-Frequency
ELCP	Emulated Loop Control Protocol
ES	Errored Second
EUT	Equipment Under Test
FSAN	Full Service Access Network
FTTB	Fibre to the Building
FTTB _{Business}	Fibre to the Business
FTTC	Fibre to the Curb
FTTC _{ab}	Fibre to the Cabinet
FTTH	Fibre to the Home
GEM	G-PON Encapsulation Method
GFR	Guaranteed Frame Rate
HN	Home Network
IP	Internet Protocol
ISDN	Integrated Services Digital Network
ITL	Independent Test Laboratory
LAN	Local Area Network
LCD	Loss of Cell Delineation
LCT	Local Craft Terminal
LES	Loop Emulation Service
LIM	Line Interface Module
LOA	Loss of Alignment
LOL	Loss of Link
LOS	Loss of Signal
LSB	Least Significant Bit
LT	Line Terminal
MAC	Media Access Control
ME	Managed Entity
MIB	Management Information Base
MLT	Mechanized Loop test
MoCA	Multimedia Over Coaxial Alliance
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
OOS	Out Of Service
OPM	Optical Power Meter
OpS	Operations System
ORL	Optical Return Loss
PCR	Peak Cell Rate
PEE	Physical Equipment Error
PESQ	Perceptual Evaluation of Speech Quality
PHY	Physical Interface
PLOAM	Physical Layer Operations, Administration and Maintenance
PM	Performance Management
PMD	Physical Media Dependent
PON	Passive Optical Network
PPTP	Physical Path Termination Point
PVC	Permanent Virtual Channel
QoS	Quality of Service
QRSS	Quasi-Random Signal Source
REI	Remote Error Indication
RF	Radio Frequency
RGW	Residential Gateway
RM	Resource Management
SBR	Statistical Bit Rate
SDH	Synchronous Digital Hierarchy
SDP	Session Description Protocol
SDT	Structured Data Transfer
SES	Severely Errored Second
SLC	Subscriber Line Card
SLC	Subscriber Loop Carrier
SLCH	Subscriber Line Card Holder
SN	Serial Number
SNI	Service Node Interface

SONET	Synchronous Optical Network
SSCS	Service-Specific Convergence Sublayer
TC	Transmission Convergence
TCA	Threshold Crossing Alert
T-CONT	Transmission Container
TDM	Time Division Multiplex
TE	Terminal Equipment
TIMS	Transmission Impairment Measurement Set
UAS	UnAvailable Second
UBR	Unspecified Bit Rate
UNI	User Network Interface
UPC	Usage Parameter Control
VBR	Variable Bit Rate
VC	Virtual Channel
VCC	Virtual Channel Connection
VCI	Virtual Channel Identifier
VF	Voice Frequency
VP	Virtual Path
VPC	Virtual Path Connection
VPI	Virtual Path Identifier
xDSL	x Digital Subscriber Line

4 Interoperability guidelines

4.1 Overview

In preparation for interoperability test cycles, this clause provides ONU and OLT vendors with implementation guidelines created to enable multi-vendor interoperability. Interoperability testing between the ONU and OLT uses ITU-T G.983-series Recommendations as the guidelines for all tests. This clause identifies the functionality to be implemented based on these specifications. Both vendors should complete PICS documents for both [ITU-T G.983.1] and [ITU-T G.983.2] as a first step in planning the test campaign.

4.2 PON initialization and management

4.2.1 PON initialization

An ONU must be able to successfully initialize with the OLT using the startup methods identified in [ITU-T G.983.1].

4.2.2 Support of equipment management entities

The ONU/OLT should support OMCI and the managed entities defined in [ITU-T G.983.2]. The test plan assumes that OMCI is supported.

4.2.3 Key churning

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

4.3 AAL1 circuit emulation

AAL1 ability to transport unstructured and structured DS1 service is evaluated. AAL1 is also evaluated for the ability to provide voice service and the applicable class services.

4.4 AAL2 loop emulation services

AAL2 is evaluated for the ability to provide voice service and the applicable class services.

4.5 AAL5 data services

Bridging, MAC learning and throughput are evaluated to determine the PON system capacity and compliance.

4.6 Video services

Amplitude modulated/vestigial sideband (AM/VSB) as well as high definition television services are provided over the same single fibre on the 1550 nm wavelength. The single cable interface to the residence uses a 75-ohm coaxial network already installed in most homes. The signal between frequencies 47 MHz through 870 MHz is passed through the PON system to the end user.

4.7 Multiple services testing

All services running concurrently will be evaluated with exception for priority restrictions on service handling. No service shall interfere with any other service provided for by the PON system.

5 Test configuration and equipment

5.1 Network configuration

Figure 1 shows the test configuration for the interoperability testing of the OLT and ONU. Analogue POTS phones and TMS 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.

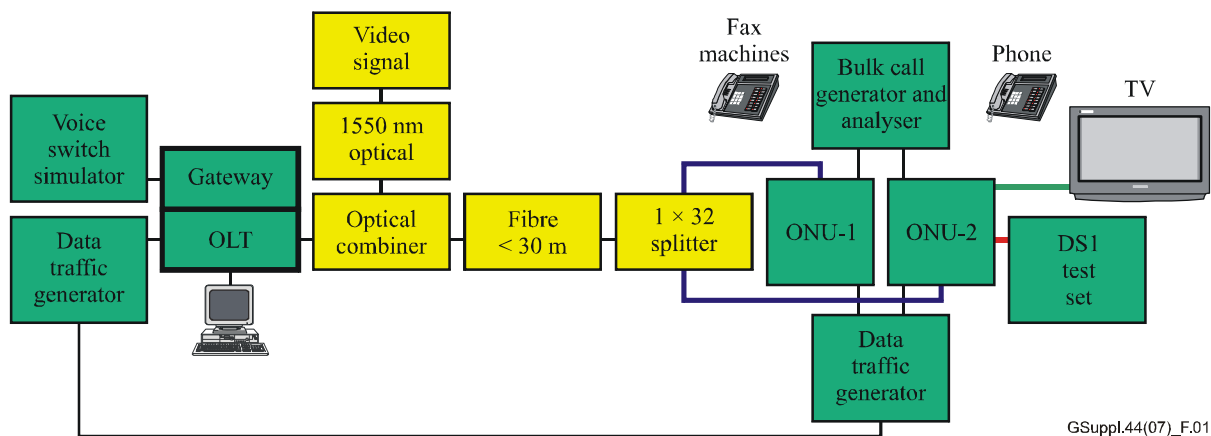


Figure 1 – Default test setup

5.2 Equipment requirements

The following test equipment is required:

Telephones – At least two telephones should be available.

Bulk call generator – The recommended number of lines should equal the number of POTS lines that 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, 14.4 kbit/s group 3 as well as to V.34 28.8 kbit/s.

ATM/data test equipment – A single test unit with two interfaces should be available. ATM equipment should have the capability to test IP/AAL5 and verify QoS for CBR, VBR, UBR and UBR+ across a range of packet sizes.

Modem – PC with modem connected either externally or internally.

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.

5.3 Network equipment matrix

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

Equipment type	Quantity	Manufacturer	Model	Software version	Hardware revision	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						
Data switch						

5.4 Vendor features comparison matrix

B-PON 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. Based on the G.983.1 Protocol Implementation Conformance Statement (PICS) (Amendment 1 to [ITU-T G.983.1]) and the G.983.2 PICS document (Appendix VII to [ITU-T G.983.2]). 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.983 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.

6 Optical compatibility verification

The tests in this area verify fundamental PMD/TC layer conformance to [ITU-T G.983.1] and [ITU-T G.983.3] 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).

6.1 Mean launch power

This clause provides test cases for measuring the OLT and ONU transmitter launch power.

6.1.1 ONU mean launch power – Tx Off

Test case # 6.000

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 grant from the OLT or for the start of the ranging process (if unranged)).

Standard: Clause 8.2.6.3 of [ITU-T G.983.1].

Preconditions:

The test described in this clause 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 levelling is supported), an optical filter to isolate the oscilloscope from the OLT transmitter) is available.

Test setup:

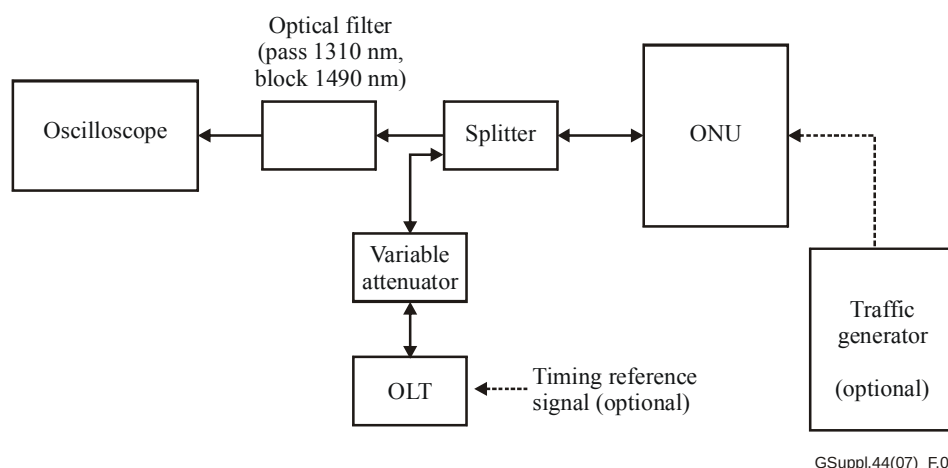


Figure 2 – ONU mean launched power test configuration – ONU ranged, TX off

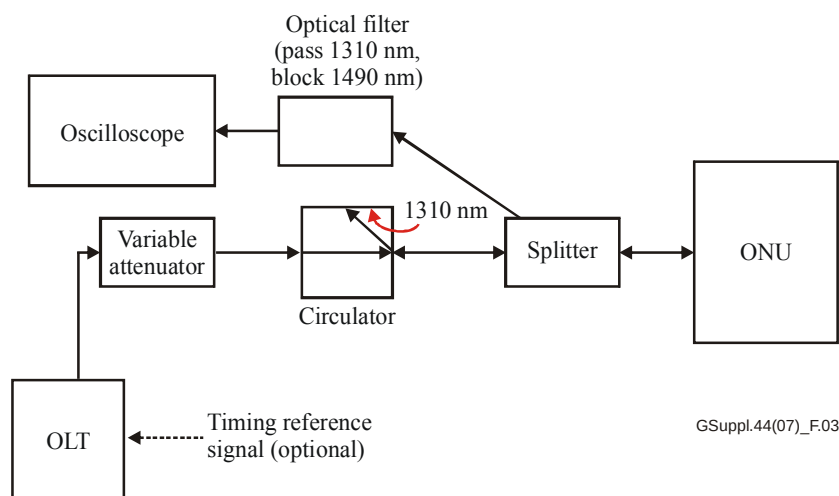


Figure 3 – Disabled ONU mean launched power test configuration – ONU Un-ranged

- 1) Follow local procedures for cleaning all fibre connectors before making any fibre connections and configure the system as shown in Figure 3.
- 2) Note that the configuration of the traffic generator shown in Figure 3 is not of particular importance and could be omitted entirely, instead relying on (scrambled) idle data in the upstream.

- 3) Several correction factors will need to be determined for use in calculating the actual output power level from the measured value. These include:
- The insertion loss of the splitter for the output fibre connected to the oscilloscope (i.e., the difference between the input optical power to the splitter and the output power from that output fibre).
 - The insertion loss (in the 1310 nm region) of the optical filter used to isolate the oscilloscope from the 1490 nm signal transmitted by the OLT¹.
 - The level displayed on the oscilloscope when there is no input signal.

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

Test equipment:

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

Test procedure:

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

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.

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) Configure the OLT to periodically generate "Serial_number_mask" PLOAM messages and ranging grants, 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 (Note)
Ranged ONU Tx-off					
Unranged ONU Tx-disabled					
NOTE – See pass/fail criteria below.					

Pass/fail criteria:

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

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

ONU output power levels with no input to the transmitter are specified in [ITU-T G.983.1], for non-video overlay B-PON systems. For video wavelength overlay applications, transmit power level requirements are specified in Appendix I to [ITU-T G.983.3] (specified as tentative/example values) or in Appendix VI to [ITU-T G.983.3] (for 622/155 Mbit/s (D/U) systems).

The maximum ONU output power level with no input to the transmitter is the minimum OLT receiver sensitivity, less 10 dB. These values for B-PON ONUs are shown below:

Rate	Class A	Class B	Class B+ (G.983.3 Amd.2)	Class C
155 Mbit/s	N/A (G.983.1) –38.5 dBm (G.983.3 w/overlay)	–40 dBm	–41 dBm (w/overlay) –42 dBm (w/o overlay)	–43 dBm

Last modified: August 8 2006

6.1.2 ONU mean launch power – Tx enabled

Test case # 6.010

Purpose:

To determine the mean launched power level of the ONU transmitter when it is in the transmit-enabled state and in the presence of the specified worst-case reflection (note that if the ONU transmitter can be externally controlled to transmit continuously, the procedure described in clause 6.1.3 may be used instead).

Standard: Clause 8.2.6.3 of [ITU-T G.983.1] or [ITU-T G.983.3].

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 fibre carrying the bidirectional traffic between the OLT and the ONU;
- 2) isolate the variable reflection generator from the downstream path; and
- 3) isolate ONU-to-power-measurement-equipment optical paths,

must have minimal polarization dependent loss and be calibrated at a wavelength approximately equal to that of the ONU's output (or have minimal wavelength dependence).

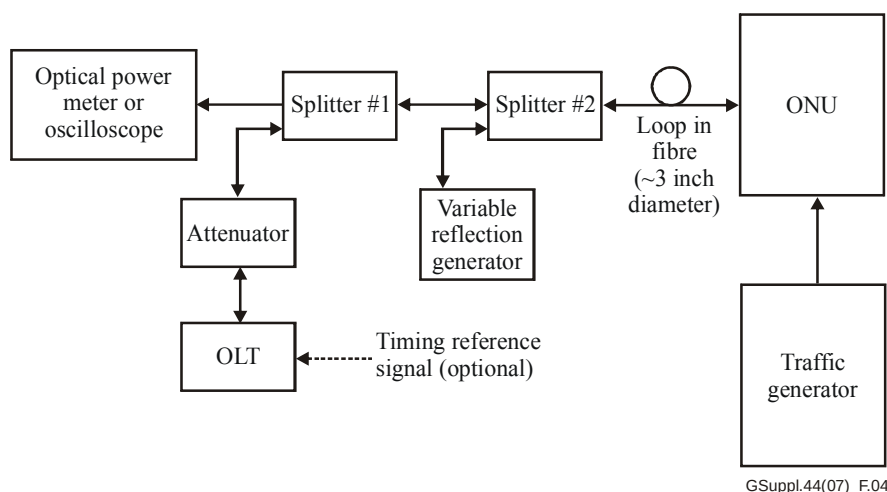


Figure 4 – ONU mean launched power test configuration² – Test setup

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

NOTE 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).

NOTE 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, C).

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

Power meter vs oscilloscope considerations:

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

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

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

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

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).

² The loop in the fibre 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 fibre (rather than the core) is dissipated before reaching the measurement equipment. This is important for the output power measurement because that power is not useful in a real-world situation (i.e., it leaks away before the signal gets to the receiver), but might otherwise make it through the short fibre used in the test and make the transmitter look hotter than it effectively is.

Correction factors:

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

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

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

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

Test equipment:

- 1) Optical power meter or oscilloscope.
- 2) Optical splitters.
- 3) Optical attenuator.
- 4) Variable reflection generator.
- 5) Traffic generator (e.g., ATM or Ethernet).
- 6) Optical reflectance meter.

Test procedure:

- 1) Record the power measured by the power meter or calculated from the high and low levels measured on the oscilloscope, as illustrated in Table 2.
- 2) Disconnect, clean and reconnect the fibre at the ONU's input/output connector, and repeat these steps until 5 values have been recorded.³
- 3) Add any applicable correction factors, calculate the average output optical power, and compare the individual and average power results to the applicable specification.

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

³ The primary purpose of making multiple measurements of the output optical power is to verify the reproducibility of the connection between the equipment under test and the optical fibre. Significant variations in the measured power level could indicate a low-quality or damaged connector. In addition, any single measurement that is greater than the maximum power allowed by the specification would indicate a non-conformance to that specification (even if the average of the five measurements is within the specified range).

Table 2 – ONU mean launched power test results

Trial	Measured output power [dBm]	Correction factors [dB]	Corrected output power [dBm]	Maximum and average output power [dBm]	Pass/fail result (Note)
1					
2					
3					
4					
5					
1					
2					
...					
1					
2					
...					
NOTE – See pass/fail criteria below.					

Pass/fail criteria:

Allowable transmit power levels are a function of:

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

Average output power levels are specified in [ITU-T G.983.1] for non-video overlay B-PON systems. For video wavelength overlay applications, transmit power level requirements are specified in Appendix I to [ITU-T G.983.3] (as tentative values) or Appendix VI to [ITU-T G.983.3] (for 622/155 Mbit/s (D/U) systems).

B-PON ONU transmit power criteria are specified in clause 8.2.6 of [ITU-T G.983.1] and clause 8.3.6 of [ITU-T G.983.3]. The ONU mean launched power specifications are as shown below:

Rate	Class A	Class B	Class B+	Class C
155 Mbit/s	–7.5 to 0 dBm (if G.983.3)	–4 to 2 dBm or –5.5 to +2 dBm (if G.983.3)	+4 to –2 dBm (G.983.3)	–2 to 4 dBm (or if overlay per G.983.3 Amd.2)

Test report: Pass _____ Fail _____ Not supported _____

Observations: None

Last modified: August 8 2006

6.1.3 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 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 programme.

Test case # 6.020

Purpose:

To determine the mean launched power level of the OLT optical transmitter in the presence of the specified worst-case reflection (note that this procedure can also be used to determine the mean launched power level of an ONU transmitter if that transmitter can be externally controlled to transmit continuously (i.e., placed in a special test mode); otherwise, see clause 6.1.2 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: Clause 8.2.6.3 of [ITU-T G.983.1] or [ITU-T G.983.3].

Preconditions:

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.

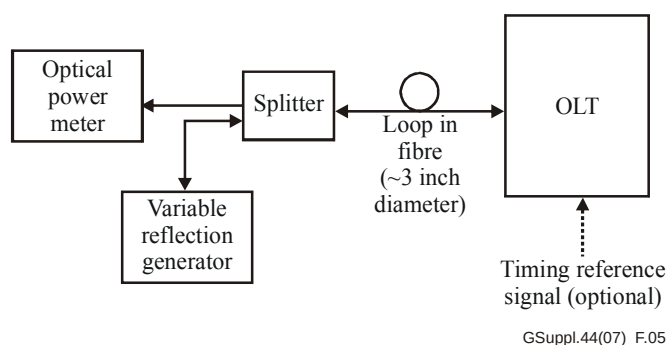


Figure 5 – OLT mean launched power test configuration – Test setup

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

NOTE 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 dB⁴. In general, the ORL can be verified by inserting a reflection meter between the splitter and the transmitter under test.

NOTE 3 – Determine the insertion loss of the splitter for the output fibre connected to the power meter (i.e., the difference between the input optical power to the splitter and the output power from that output fibre) for use in correcting the power measurements obtained during the tests.

NOTE 4 – Although the data pattern for this test is specified 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 A transmitter has to meet its output power, spectral characteristics and eye-related specifications in the presence of a –15 dB reflectance (placed immediately downstream from the input/output connector), per clause 8.2.6.7 of [ITU-T G.983.1].

- 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 fibre at the OLT's input/output connector, and repeat these steps until 5 values have been recorded.⁵
- 3) Add any applicable correction factors, calculate the average output optical power, and compare the individual and average power results to the applicable specification.

Table 3 – OLT mean launched power test results

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

Pass/fail criteria:

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

Generally speaking, OLTs are expected to comply with the transmit power specifications of [ITU-T G.983.1] or [ITU-T G.983.3].

Test report: Pass _____ Fail _____ Not supported _____

Observations: None

Last modified: August 8 2006

6.2 Receiver sensitivity

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

6.2.1 ONU receiver sensitivity

Test case # 6.030

Purpose:

This test case assesses whether the ONU is able to operate at a bit error rate (BER) at or below 10^{-10} when the received signal is at the minimum acceptable average power specified in the ITU-T

⁵ The primary purpose of making multiple measurements of the output optical power is to verify the reproducibility of the connection between the equipment under test and the optical fibre. Significant variations in the measured power level could indicate a low-quality or damaged connector.

G.983-series of Recommendations. 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].

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

Standard: Clause 8.2.8 of [ITU-T G.983.1].

Preconditions:

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.

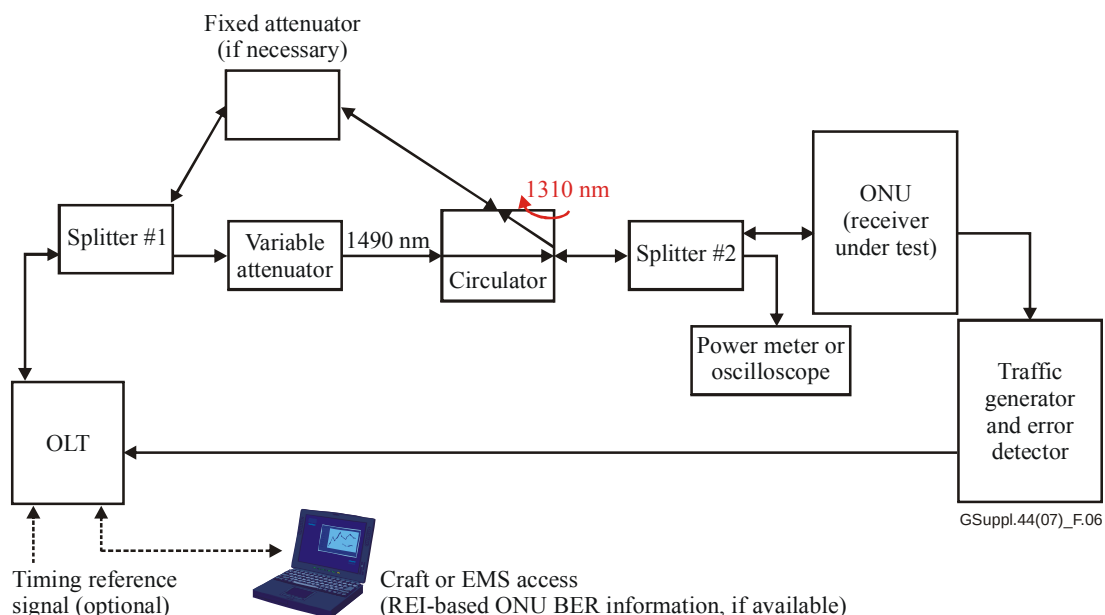


Figure 6 – Receiver sensitivity test configuration – Test setup

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

NOTE 2 – Configure the system as shown in Figure 6 and select the fixed attenuator so that the power of the signal reaching the OLT receiver (travelling in the non-test direction) is well within its specified limits, and set the variable attenuator such that the power of the signal reaching the ONU receiver is within that receiver's limits.

NOTE 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 bit error performance.

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

$$\text{BER} \simeq \text{PL} / [\text{PT} \times \text{N}]$$

where:

PL = Packets lost

PT = Packets transmitted

N = # of bits within a packet, if errored, would result in discarding the packet

"N" typically will not include the ATM or 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 ATM transport of a 512 byte Ethernet frame encapsulated via RFC 2684 LCC encapsulated:

$$\begin{aligned} \text{N} &= 8 \times [512 + 8 \text{ (AAL5 trailer)} + 3 \text{ (LCC header)} + 5 \text{ (SNAP header)}] \\ &= 8 \text{ bits/byte} \times 528 \text{ bytes} = 4224 \text{ bits} \end{aligned}$$

This formula is derived by expressing the packet loss probability [P(PL)] as a function of the bit error probability [P(B)]. Specifically, $P(\text{PL}) = 1 - (1 - P(\text{B}))^N$. $P(\text{PL})$ can be approximated by PL/PT (# lost packets/# packets transmitted). Hence, $\text{PL}/\text{PT} \approx N \times \text{BER}$ and $\text{BER} \approx \text{PL}/(\text{PT} \times \text{N})$.

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 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 fibres, typically needs to be applied.

Test equipment: See Figure 6.

Test procedure:

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

- 1) 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 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.
- 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)⁶.
- 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), 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.
- 8) Plot the recorded BER versus received power data equivalent to that shown in Figure 7. (Note that the y-axis scale used for this graph paper is not a standard linear or log scale. Instead, it is a scale that is based on the complementary error ("Q") function and is specifically derived for plotting BER versus received power data for typical optical receivers per [TIA-526-3]).
- 9) Fit a line through the data points and determine the power level at which that line crosses the BER level of 10^{-10} .
- 10) 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 Amendment 2 to ITU-T Rec. G.957 for more on aging effects).

A test results table is provided in Table 4 as a tabular illustration of the measurement steps described in the test procedure.

⁶ 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 4 – Receiver sensitivity test results

Measured power [dBm]	Correction factors [dB]	Received power [dBm]	Packets sent	Packets errored or lost	BER (Note 1)	Calc. sens. [dBm] and pass/fail results (Note 2)

NOTE 1 – The number of bits per packet (for use in the denominator of the BER calculation) is _____ (see the discussion in the "test setup" clause above regarding the determination of the appropriate value).

NOTE 2 – See pass/fail criteria below.

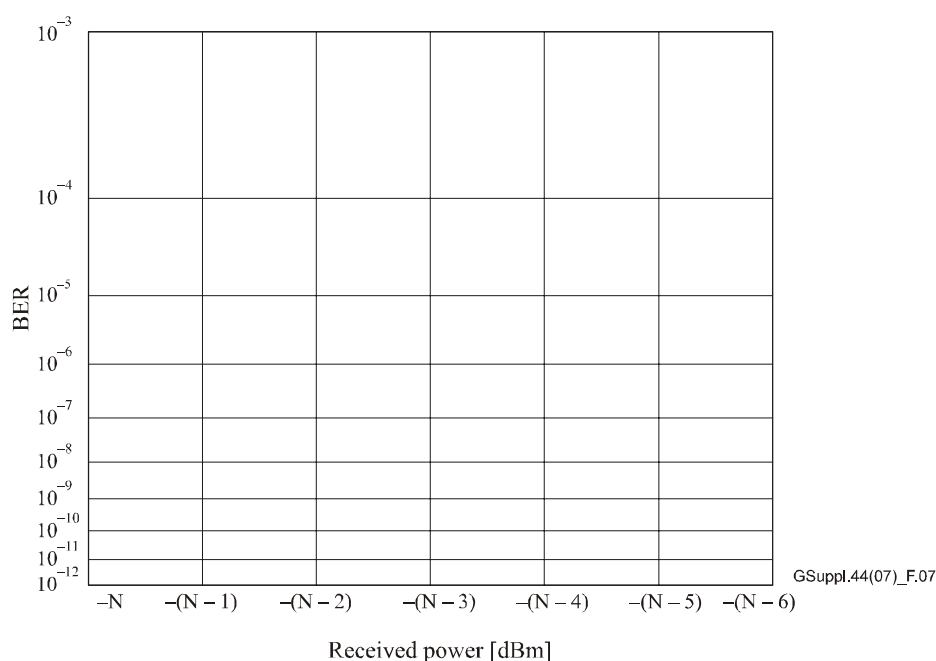


Figure 7 – BER versus received power plotting paper

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.

B-PON receiver sensitivity criteria are specified in clause 8.2.8 of [ITU-T G.983.1].

Downstream rate	Class A	Class B	Class B+ (G.983.3)	Class C
622 Mbit/s	–28 dBm	–28 dBm	–28 dBm	–33 dBm

Test report: Pass _____ Fail _____ Not supported _____

Observations: None

Last modified: August 8 2006

6.2.2 OLT receiver sensitivity

Test case # 6.040

Purpose:

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

Standard: Clause 8.2.8 of [ITU-T G.983.1].

Preconditions:

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 clause 6.2.1, with OLT substituted for ONU. Note that the power correction factor equivalent to $\Delta P_{\text{On/Off}}$ (see clause 6.1.2) 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.

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 clause 8.2.8 of [ITU-T G.983.1].

The OLT receiver sensitivity criteria, defined in clause 8.2.8 of [ITU-T G.983.1], are:

Upstream rate	Class A	Class B	Class B+ (G.983.3)	Class C
155 Mbit/s	N/A	-30 dBm	-31 dBm (w/overlay), -32 dBm (w/o video overlay)	-33 dBm

Test report: Pass _____ Fail _____ Not supported _____

Observations: None

Last modified: August 8 2006

6.3 Receiver overload

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

Receiver overload is measured against a signal with worst-case G.983 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.

6.3.1 ONU receiver overload

Test case # 6.050

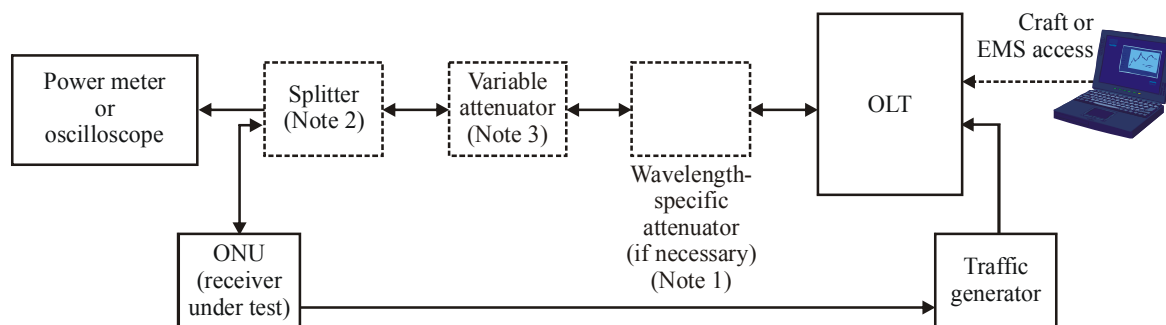
Purpose:

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: Clause 8.2.8 of [ITU-T G.983.1].

Preconditions:

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.



GSuppl.44(07)_F.08

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

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

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

Figure 8 – Receiver overload test configuration – Test setup

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

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

Traffic capacity, error measurement, BER calculation and power measurement issues: See clause 6.2.1.

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).⁷
- 6) Calculate the power level of the signal at the ONU receiver and (if OLT-based retrieval of ONU BER performance data is not available) the approximate BER at that power level.
- 7) If any packets were errored (or lost) at the test power level (or REI data received by the OLT indicated that errors occurred), increase the attenuation by approximately 0.2 dB and return to step 4 (note that for most receivers, the BER versus received power curve is expected to be very steep at high power levels and therefore it may be necessary to utilize small changes in the received power. In addition, it may not be necessary to plot the results as indicated in the following step).
- 8) Plot the recorded BER versus received power data on graph paper equivalent to that shown in Figure 7 (note that the y-axis scale used for this graph paper 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} .

⁷ 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.

Table 5 – Receiver overload test results

Measured power [dBm]	Correction factors [dB]	Received power [dBm]	Packets sent	Packets errored or lost	BER (Note 1)	Calc. sens. [dBm] and pass/fail results (Note 2)
NOTE 1 – The number of bits per packet (for use in the denominator of the BER calculation) is _____ (see "setup" in clause 6.2.1 above regarding the determination of the appropriate value).						
NOTE 2 – See pass/fail criteria 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.

Receiver overload criteria are specified in clause 8.2.8 of [ITU-T G.983.1].

Downstream Rate	Class A	Class B	Class B+ (G.983.3)	Class C
622 Mbit/s	–6 dBm	–6 dBm	–6 dBm	–11 dBm

Test report: Pass _____ Fail _____ Not supported _____

Observations: None

Last modified: August 8 2006

6.3.2 OLT receiver overload**Test case # 6.060****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: Clause 8.2.8 of [ITU-T G.983.1].

Preconditions:

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 clause 6.3.1, with OLT substituted for ONU.

Pass/fail criteria:

In the context of an ONU-centric interoperability test plan, measuring OLT receiver overload is an in-service quality verification check. As such the measurement results are compared to receiver overload previously collected during the benchmarking of the baseline OLT. Degradations greater

than 2 dB from the benchmark receiver overload are effectively a "fail" and indicate that investigative/corrective action should be undertaken before proceeding with additional testing.

Generally speaking, OLTs are expected to comply with the receiver overload specifications of clause 8.2.8 of [ITU-T G.983.1].

The OLT receiver overload specifications defined in clause 8.2.8 of [ITU-T G.983.1] are that the BER must be 10^{-10} or better when the power at the OLT receiver is as shown below.

Upstream Rate	Class A	Class B	Class B+ (G.983.3)	Class C
155 Mbit/s	N/A	−8 dBm	−6 dBm (w/overlay), −9 dBm (w/o video overlay)	−11 dBm

Test report: Pass _____ Fail _____ Not supported _____

Observations: None

Last modified: August 8 2006

7 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 (i.e., a single ONU interoperating with the OLT).

7.1 ONU startup

Method A: Preconfigured, the serial number of the ONU is registered at the OLT.

Method B: Discovered, the serial number of the ONU is not registered at the OLT. It requires an automatic detection mechanism of the serial number (or soft-coded unique number) of the ONU.

For either method A or method B, ranging of an ONU may be initiated in two possible ways:

- The network operator enables the ranging 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 ranging 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.

7.1.1 Cold PON and cold ONU-Method A

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

Test case # 7.010

Initialization, cold PON, cold ONU, method A.

Purpose:

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

Standard: Clause 8.4 of [ITU-T G.983.1].

Preconditions:

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

Test equipment: None.

Test setup:

Default test setup as shown in Figure 1.

Test procedure:

Method A – Autoranging with pre-provisioned ONU serial numbers:

- 1) Power up ONU1.
- 2) After the ONU1 completes its boot process, connect ONU1 to the fibre.
- 3) ONU shall range in 30 seconds.
- 4) Disconnect ONU1 from the fibre and power down.

Repeat for ONU2 and ONU3.

Method A – Manual initiate range with pre-provisioned ONU serial numbers:

- 1) Power Up ONU1.
- 2) After the ONU1 completes its boot process, connect ONU1 to the fibre.
- 3) Manually start the ranging process.
- 4) ONU shall range in 30 seconds.
- 5) Disconnect ONU1 from the fibre and power down.

Repeat for ONU2 and ONU3.

Pass/fail criteria:

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

Test report: Pass _____ Fail _____ Not supported _____

Observations: Elapsed time, power on to ranging complete (minimum average, maximum).

Last modified: August 8 2006

7.1.2 Cold PON and cold ONU-method B

Test case # 7.020

Initialization, cold PON, cold ONU, method B.

Purpose:

To verify that the OLT initializes the ONU when the ONU is not registered in OLT prior to startup.

Standard: Clause 8.4 of [ITU-T G.983.1].

Preconditions:

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

Test equipment: None.

Test setup:

Default test setup as shown in Figure 1.

Test procedure:

Method B – Autoranging without pre-provisioned ONU serial numbers:

- 1) Power Up ONU1.

- 2) After the ONU1 completes its boot process, connect ONU1 to the fibre.
- 3) ONU shall range in 30 seconds.
- 4) Disconnect ONU1 from the fibre and power down.

Repeat for ONU2 and ONU3.

Method B – Manual initiate ranging without pre-provisioned ONU serial numbers:

- 1) Power Up ONU1.
- 2) After the ONU1 completes its boot process, connect ONU1 to the fibre.
- 3) Manually start the ranging process.
- 4) ONU shall range in 30 seconds.
- 5) Disconnect ONU1 from the fibre and power down.

Repeat for ONU2 and ONU3.

Pass/fail criteria:

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

Test report: Pass _____ Fail _____ Not supported _____

Observations: Elapsed time, power on to ranging complete (minimum average, maximum).

Last modified: August 5 2005

7.1.3 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 come back to the PON while traffic is running on the PON.

7.1.3.1 Warm PON and cold ONU-Method A

Test case # 7.030

Purpose:

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

Standard: Clause 8.4 of [ITU-T G.983.1].

Preconditions:

Three ONUs not connected to the PON and powered down, an additional ONU connected and ranged. The OLT contains the 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 to the OLT during all test iterations.

Test procedure:

Method A – Autoranging with pre-provisioned ONU serial numbers:

- 1) Power up ONU1.
- 2) After ONU1 completes its boot process, connect ONU1 to the fibre.
- 3) ONU1 shall range in 30 seconds.

- 4) Disconnect ONU1 from the fibre and power down.

Repeat for ONU2 and ONU3.

Method A – Manual initiate range with pre-provisioned ONU serial numbers:

- 1) Power up ONU1.
- 2) After ONU1 completes its boot process connect ONU1 to the fibre.
- 3) Manually start the ranging process.
- 4) ONU1 shall range in 30 seconds.
- 5) Disconnect ONU1 from the fibre and power down.

Repeat for ONU2 and ONU3.

Pass/fail criteria:

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

Test report: Pass _____ Fail _____ Not supported _____

Observations: Elapsed time, power on to ranging complete (minimum average, maximum).

Last modified: August 5 2005

7.1.3.2 Warm PON and Cold ONU-Method B

Test case # 7.040

Purpose:

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

Standard: Clause 8.4 of [ITU-T G.983.1].

Preconditions:

Three ONUs not connected to the PON and powered down, an 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:

Method B – Autoranging without pre-provisioned ONU serial numbers:

- 1) Connect ONU1 to fibre and power up.
- 2) ONU shall range within 30 seconds.
- 3) Power down and disconnect ONU1 fibre.
- 4) PON in cold state – ONU1 in cold state.

Repeat for ONU2 and ONU3.

Method B – Manual initiate ranging without pre-provisioned ONU serial numbers:

- 1) Connect ONU1 to fibre and power up.
- 2) Manually start ranging.
- 3) ONU shall range within 30 seconds.

4) Power down and disconnect ONU1 fibre.

Repeat for ONU2 and ONU3.

Pass/fail criteria:

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

Test report: Pass _____ Fail _____ Not supported _____

Observations: Elapsed time, power on to ranging complete (minimum, average, maximum).

Last modified: August 5 2005

7.1.4 ONU ranging various cable lengths

The following test cases verify startup interoperability between OLTs and ONUs for ranging at various fibre lengths. The tests are iterations of test cases 7.010 and 7.020 with different ODN characteristics.

Test cases are performed with 10 km and 20 km of fibre between the OLT and the splitter.

Test setup:

The basic test setup for the ONU startup tests is shown in Figure 9 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 fibre between the OLT and the splitter.

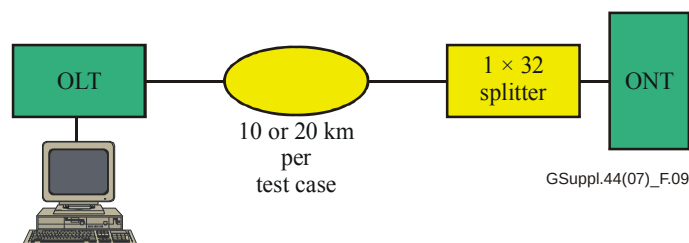


Figure 9 – Test setup

7.1.4.1 Cold PON and cold ONU – Method A – 10 km

Test case # 7.050

Purpose:

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

Standard: Clause 8.4 of [ITU-T G.983.1].

Preconditions:

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

Test equipment: None

Test setup:

10 km test setup as shown in clause 7.1.4.

Test procedure:

Method A – Autoranging with pre-provisioned ONU serial numbers:

1) Connect ONU1 to fibre and power up.

- 2) ONU shall range within 30 seconds.
- 3) Power down and disconnect ONU1 fibre.

Repeat for ONU2 and ONU3.

Method A – Manual initiate range with pre-provisioned ONU serial numbers:

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

Repeat for ONU2 and ONU3.

Pass/fail criteria:

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

Test report: Pass _____ Fail _____ Not supported _____

Observations: Elapsed time, power on to ranging complete (minimum, average, maximum).

Last modified: August 5 2005

7.1.4.2 Cold PON and cold ONU – Method B – 10 km

Test case # 7.060

Purpose:

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

Standard: Clause 8.4 of [ITU-T G.983.1].

Preconditions:

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

Test equipment: None

Test setup:

10 km. Test setup as shown in clause 7.1.4.

Test procedure:

Method B – Autoranging without pre-provisioned ONU serial numbers:

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

Repeat for ONU2 and ONU3.

Method B – Manual initiate ranging without pre-provisioned ONU serial numbers:

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

Repeat for ONU2 and ONU3.

Pass/fail criteria:

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

Test report: Pass _____ Fail _____ Not supported _____

Observations:

Elapsed time, power on to ranging complete (minimum, average, maximum).

Last modified: August 5 2005

7.1.4.3 Cold PON and cold ONU – Method A – 20 km

Test case # 7.070

Purpose:

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

Standard: Clause 8.4 of [ITU-T G.983.1].

Preconditions:

Three ONUs not connected to the PON and powered down. OLT contains the serial numbers of the ONUs under test. EMS or craft terminal on the OLT to recognize the presence of the ONU. There is 20 km of fibre cable between the OLT and the 1 × 32 splitter.

Test equipment: None

Test setup:

20 km test setup as shown in clause 7.1.4.

Test procedure:

Method A – Autoranging with pre-provisioned ONU serial numbers:

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

Repeat for ONU2 and ONU3.

Method A – Manual initiate range with pre-provisioned ONU serial numbers:

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

Repeat for ONU2 and ONU3.

Pass/fail criteria:

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

Test report: Pass _____ Fail _____ Not supported _____

Observations: Elapsed time, power on to ranging complete (minimum, average, maximum).

Last modified: August 5 2005

7.1.4.4 Cold PON and Cold ONU – Method B – 20 km

Test case # 7.080

Purpose:

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

Standard: Clause 8.4 of [ITU-T G.983.1].

Preconditions:

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

Test equipment: None

Test setup:

20 km test setup as shown in clause 7.1.4.

Test procedure:

Method B – Autoranging without pre-provisioned ONU serial numbers:

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

Repeat for ONU2 and ONU3.

Method B – Manual initiate ranging without pre-provisioned ONU serial numbers:

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

Repeat for ONU2 and ONU3.

Pass/fail criteria:

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

Test report: Pass _____ Fail _____ Not supported _____

Observations: Elapsed time, power on to ranging complete (minimum, average, maximum).

Last modified: August 5 2005

7.2 TC-layer OAM operation

7.2.1 LOS or LCD detection

Test case # 7.090**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: Table 15 of [ITU-T G.983.1].

Preconditions: ONU ranged

Test equipment: None

Test procedure:

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

Pass/fail criteria:

Fail if OLT fails to declare or clear LOS or LCD.

Test report: Pass _____ Fail _____ Not supported _____

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

Last modified: August 5 2005

7.2.2 Reaction to Deactivate_PON_ID message

Test case # 7.100

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 fibre of a ranged ONU.

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

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

Standard: Tables 16 and 17 of [ITU-T G.983.1].

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.

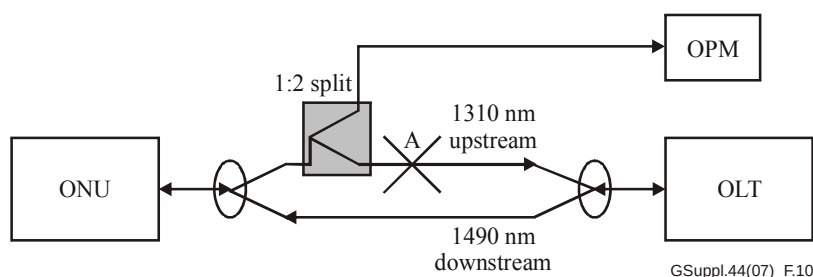


Figure 10 – Reaction to Deactivate_PON_ID test setup

Because the test relies largely on non-standardized behaviour, the vendors should establish a protocol before executing this test. It is of interest to know the OLT's behaviour at loss of upstream signal (e.g., LOS or LOA, soak time), the ONU's behaviour upon deactivation (e.g., extinguishing

of an online indicator), and the OLT's behaviour in attempting to re-range the ONU (e.g., automatic restart after N seconds delay).

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

Test procedure:

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

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: August 5 2005

7.2.3 Emergency stop behaviour

Test case # 7.110

Test setup:

Default test setup as shown in Figure 1.

Purpose:

[ITU-T G.983.1] provides a *Disable_serial_number* message. Triggering this message is proprietary to the OLT vendor. Upon receipt of this message, the ONU stops responding to grants.

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

Since emergency stop is expected to be triggered by 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: Tables 16 and 17 of [ITU-T G.983.1].

Preconditions: Same as test case 7.100.

Test equipment: Same as test case 7.100.

Test 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 send an e-stop message with a matching Serial-number and the enable field set to disabled to the ONU.
- 3) Confirm that upstream optical power drops to zero. Until the OLT sends to the ONU an *Enable* e-stop message with matching serial number, no upstream power should be observed.
- 4) Force the OLT to forget the disabled state of the ONU, e.g., through OLT reinitialization. The reinitialized OLT is expected to attempt to re-range the ONU normally, and the ONU is expected not to respond.
- 5) [ITU-T G.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.
- 6) Invoke the OLT's mechanism to send to the ONU an *Enable* e-stop message with matching serial number. Confirm that the ONU returns to normal service.
- 7) Repeat step 1 through 4 above, followed by step 6 with the OLT configured to enable the serial numbers of all ONUs on the ODN that had previously been denied upstream access. Resulting in the OLT transmitting a *Disable_serial_number* PLOAM message with a 0x0F value in the *Disable/Enable* field.

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: August 5 2005

7.2.4 ONU reaction to PEE message from OLT

Test case # 7.120

Test setup:

Default test setup as shown in Figure 1.

Purpose:

There may or may not be a black-box way to cause the OLT to generate the PEE message downstream. The ONU's response upon receipt of a PEE message is undefined, but may include illuminating an indicator and may include service conditioning (e.g., DS1 AIS, release of POTS calls).

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.

Standard: Tables 16 and 17 of [ITU-T G.983.1].

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

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

Test procedure:

- 1) Invoke the OLT's mechanism to generate a PEE message to the ONU (all ONUs).
- 2) Verify that the ONU's response is in accordance with the vendor's specifications.

- 3) Release PEE from the OLT.
- 4) Verify that the ONU returns to normal service after a nominal three seconds.

Pass/fail criteria:

Failure to perform as specified by the vendors.

Test report: Pass _____ Fail _____ Not supported _____

Observations:

Record the predicted and observed behaviour.

Last modified: August 5 2005

7.2.5 OLT reaction to PEE message from ONU

Test case # 7.130

Test setup:

Default test setup as shown in Figure 1.

Purpose:

There may or may not be a black-box way to cause the ONU to generate the PEE message upstream. 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.

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.

Standard: Tables 15 and 17 of [ITU-T G.983.1].

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

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

Test procedure:

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

Pass/fail criteria:

Failure to perform as specified by the vendors.

Test report: Pass _____ Fail _____ Not supported _____

Observations:

Record the predicted and observed behaviour.

Last modified: August 5 2005

7.2.6 Reaction to unsupported/unknown messages transmitted by OLT

Test case # 7.140

Test setup:

Default test setup as shown in Figure 1.

Purpose:

There may or may not be a black-box way to cause the OLT to transmit an unsupported message to the ONU. If there is, this test case confirms that the ONU responds with a Message_error message and that its behaviour is otherwise unaffected.

Standard: Tables 16 and 17 of [ITU-T G.983.1].

Preconditions: ONU ranged.

Test equipment: None

Test procedure:

- 1) In accordance with procedures agreed by the vendors, generate all possible unknown and unsupported messages from the OLT to the ONU. In each case, record the ONU's response.

Pass/fail criteria:

Fail if the unsupported message is an essential part of a capability that is claimed to be supported by both ONU and OLT. Fail if the ONU hangs, crashes, or changes the state or attribute values of any equipment or service.

Test report: Pass _____ Fail _____ Not supported _____

Observations:

Record predicted and observed behaviour.

Last modified: August 5 2005

7.2.7 R-INH generation (dying gasp)**Test case # 7.150****Test setup:**

Default test setup as shown in Figure 1.

Purpose:

R-INH is a PLOAM-layer notification that indicates an ONU is about to shut down intentionally; it is not clear when this might actually occur. Dying gasp is a similar notification sent by the ONT/ONU_{B-PON} ME; the circumstances are not specified, but the name suggests unintentional shutdown. After sending one (or both) 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 black-box way to reliably generate either or both of these messages, the ONU vendor should specify it. The OLT vendor should specify the black-box observables to be expected upon receiving these messages, e.g., log entry, notification, state change.

Standards: Tables 15 and 17 of [ITU-T G.983.1], and clauses 7.1.1 and 7.1.8 of [ITU-T G.983.2].

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.

Test procedure:

- 1) In accordance with procedures specified by the ONU vendor, create the conditions necessary to stimulate an R-INH or dying gasp alarm, e.g., by removing power. Observe the OLT's behaviour.

- 2) Restore the ONU by releasing the conditions created in step 1, e.g., by restoring power. Verify that the OLT ranges the ONU and restores it to normal operation.

Pass/fail criteria:

Fail if the ONU and OLT do not perform according to the vendors' documentation.

Test report: Pass _____ Fail _____ Not supported _____

Observations:

Record the ONU's mechanism for stimulating the alarm, and which (either or both) messages are transmitted. Record the OLT's behaviour (e.g., alarm declared, service conditioning).

Last modified: August 5 2005

7.2.8 REI operation

Test case # 7.160

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, and the ONU, covers all cells transmitted on the PON, including idle cells and cells directed to other ONUs. REI intervals are not necessarily synchronized (or even identical) between ONUs but, over the long term, the error count should be consistent, as reported by each ONU. Differences in REI may indicate problems with an ONU or with a particular optical drop.

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

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

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

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

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

Standard: Tables 15 and 17 of [ITU-T G.983.1].

Preconditions: ONU ranged.

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

Test 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 Mbit/s PON is 62 per 100 ms, scaling proportionately with BER interval, PON speed and BER.
- 6) Observe the OLT's behaviour, including soaking, leading to a possible alarm, and accumulation leading to a PM TCA.
- 7) Stop injecting errors and observe the OLT's behaviour, including soaking prior to clearing a possible alarm.

Pass/fail criteria:

Fail if the ONU does not report an accurate count of bit errors.

Test report: Pass _____ Fail _____ Not supported _____

Observations:

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

Last modified: August 5 2005

7.3 Security functionality

7.3.1 Local craft terminal access support

Test Case # 7.170

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. ITU-T G.983-series of Recommendations allows for more than one. If there are in fact multiple LCT ports, repeat the test for each.

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

This is an interoperability topic because an uncontrollable LCT in the field represents a security risk, and because the LCT is likely to be the only way to set or change an ONU's password.

Standard: Clause 7.3.54 of [ITU-T G.983.2].

Preconditions: ONU ranged.

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

Test procedure:

- 1) Perform a MIB upload operation from the OLT. Verify that the LCT PPTP is not included.
- 2) Connect the PC serial port or terminal server to the ONU craft port.
- 3) If the administrative state of the local craft terminal ME is locked, unlock it from the OLT via OMCI.
- 4) Log on to the craft port of the ONU according to the practice defined by the ONU vendor.

- 5) Verify that commands supported by the ONU may be interactively entered. This is not an exhaustive test; password management is the focus of interoperability and may be appropriate for the commands to be exercised in this test step.
- 6) From the OLT, lock the administrative state of the local craft terminal. Verify that the session is terminated by the ONU and that login to the ONU craft port is no longer possible.
- 7) While the LCT is administratively locked, remove the ONU from the PON. Characterize whether craft access is available to the detached ONU.
- 8) Power cycle the ONU while it is detached from the PON. Characterize whether craft access is available.

Pass/fail criteria:

Fail if MIB upload includes the LCT PPTP. Fail if locking the PPTP LCT UNI ME does not disable craft access.

Test report: Pass _____ Fail _____ Not supported _____

Observations:

Note whether ONU complies with vendor documentation. Record the behaviour of the ONU with a locked LCT when it is disconnected from the PON and when it reboots while disconnected.

Last modified: August 5 2005

7.3.2 Setting and retrieving ONU PLOAM password

Test case # 7.180

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 deny service and/or issue a security alert if the ONU's password does not match its expected value.

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

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

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

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

Standard: Table 17 and clause 8.3.5.7 of [ITU-T G.983.1]. 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 clause 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.

Test procedure:

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

Pass/fail criteria:

Fail if OLT requests password and ONU does not respond correctly. Fail if password mismatch does not behave according to the vendors' specification.

Test report: Pass _____ Fail _____ Not supported _____

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

Last modified: August 5 2005

7.3.3 POTS voice services with churning enabled

Test case # 7.190

Test setup:

Default test setup as shown in Figure 1.

Purpose:

Provision POTS services on a churned VP. Use VF test sets to confirm that voice and signalling is unaffected by churning and key updates.

Since churning errors are likely to be intermittent, this is a statistical test, run with a bulk call generator. To increase the sample size, it is desirable to place calls on as many ports in parallel as possible.

Standard: Clause 8.3.5.6 of [ITU-T G.983.1].

Preconditions: ONU ranged. OLT, ONU and switch simulator provisioned for POTS service.

Test equipment:

POTS switch simulator connected at OLT gateway, bulk call generator connected to one or more POTS ports at ONU.

Test procedure:

- 1) Perform bulk call generation, recording both call failures (signalling problems) and talk path signal quality (data problems). Because the ONU's interface is analogue, bit errors on POTS data may be hard to assess, but would at least be expected to appear as idle channel noise and/or impulse noise. This will form a baseline to use as a comparison for when