DSL Consortium

VDSL2 Rate vs. Reach Interoperability Test Suite (V2RR)

Version 1.2.0

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Modification Report

Version	Date	Editor(s)	Comments
1.2.0	March 24, 2008	Tyler Clark	Fixed grammatical errors. Edited 24 AWG loops. Changed ADSL2 noise to ADSL2+ noise. Changed profile parameters table. Modified procedured and tables to record actual interleaving delays. Updated discussions.
1.1.0	March 19, 2008	Tyler Clark	Changed default loops for group 1. Added INP to table results.
1.0.0	July 26, 2006	Matthew Langlois Tyler Clark	Initial draft.

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The University of New Hampshire would like to acknowledge the efforts of the following individuals in the development of this test suite.

Matthew Langlois	University of New Hampshire
Tyler Clark	University of New Hampshire
Tim Clark	University of New Hampshire
Tomas Elder	University of New Hampshire

Table of Contents

Introduction

Overview

The University of New Hampshire's InterOperability Laboratory (UNH-IOL) is an institution designed to improve the interoperability of standards based products by providing an environment where a product can be tested against other implementations of a standard. This suite of tests has been developed to help implementers evaluate the functioning of their VDSL2 implementations.

The tests do not determine if a product conforms to the specifications, nor are they purely interoperability tests. Rather, they provide a method to isolate problems within a device. Successful completion of all tests contained in this suite does not guarantee that the tested device will operate with other devices. However, successful completion of these tests should provide a reasonable level of confidence that the device under test will function well in most multi-vendor environments.

Organization of Tests:

Each test contains an identification section that describes the test and provides cross-reference information. The discussion section covers background information and specifies why the test is to be performed. Tests are grouped in order to reduce setup time in the lab environment. Each test contains the following information:

Test number

The Test Number associated with each test follows a simple grouping structure. Listed first is the Test Group Number followed by the test's number within the group. This allows for the addition of future tests to the appropriate groups of the test suite without requiring the renumbering of the subsequent tests.

Purpose

The purpose is a brief statement outlining what the test attempts to achieve. This also includes background information on why one needs to perform such a test to show that the device complies with the standard.

References

The references section lists standards and other documentation that might be helpful in understanding and evaluating the test and results.

Resource requirements

The requirements section specifies the hardware, and test equipment that will be needed to perform the test. The items contained in this section are special test devices or other facilities, which may not be available on all devices.

Last modification

This specifies the date of the last modification to this test.

Test setup

The setup section describes the configuration of the test environment. Small changes in the configuration should be included in the test procedure.

Discussion

The discussion section is optional. It is a general discussion of the test and relevant section of the specification, including any assumptions made in the design or implementation of the test as well as known limitations.

Procedure

The procedure section of the test description contains the step-by-step instructions for carrying out the test. It provides a cookbook approach to testing, and may be interspersed with test metrics.

Test metrics
The test metrics section lists occurring events that can be examined by the tester to verify that the DUT is operating properly. When multiple values are possible for a specific event, this section provides a short discussion on how to interpret them. The determination of passing or failing a certain test is often based on the successful (or unsuccessful) detection of a certain predetermined event.

Possible problems
This section contains a description of known issues with the test procedure, which may affect test results in certain situations.

References

[1] International Telecommunication Union Standardization Sector (ITU-T). Series G: Transmission Systems and Media, Digital Systems and Networks: Digital section and digital line system – Access networks. "Very high speed digital subscriber line transceivers 2 (VDSL2)", ITU-T Recommendation G.993.2, February 2006.

[2] American National Standards Institute, Inc., Standards Committee T1 – American National Standard for Telecommunications T1.424-2004, "Interface Between Networks and Customer Installation Very-high-bit-rate Digital Subscriber Lines (VDSL) Metallic Interface (DMT based)", June 2004.

[3] American National Standards Institute, Inc., Standards Committee T1 – Telecommunications. Standard/Recommendation T1.413-1998, Network and Customer Installation Interfaces – "Asymmetric Digital Subscriber Line (ADSL) Metallic Interface", November 1998.

[4] International Telecommunication Union Standardization Sector (ITU-T). Series G: Transmission Systems and Media, Digital Systems and Networks: Digital section and digital line system – Access networks. "Asymmetric digital subscriber line (ADSL) transceivers", ITU-T Recommendation G.992.1, June 1999.

[5] American National Standards Institute, Inc., Standards Committee T1 – Telecommunications. Standard/Recommendation T1.417-2001, "Spectrum Management For Loop Transmission Systems", January 2001.

[6] International Telecommunication Union Standardization Sector (ITU-T). Series G: Transmission Systems and Media, Digital Systems and Networks: Digital section and digital line system – Access networks. "Asymmetric digital subscriber line (ADSL) transceivers – 2 (ADSL2)", ITU-T Recommendation G.992.3, July 2002.

[7] International Telecommunication Union Standardization Sector (ITU-T). Series G: Transmission Systems and Media, Digital Systems and Networks: Digital section and digital line system – Access networks. "Asymmetric digital subscriber line (ADSL) transceivers – extended bandwidth ADSL2 (ADSL2+)", ITU-T Recommendation G.992.5, May 2003.

[8] International Telecommunication Union Standardization Sector (ITU-T). Series G: Transmission Systems and Media, Digital Systems and Networks: Digital section and digital line system – Access networks. "Test procedures for Digital Subscriber Line (DSL) transceivers," ITU-T Recommendation G. 996.1, February 2001.

[9] DSL Forum Technical Report 067 (TR-067), "ADSL Interoperability Test Plan", May 2004.

[10] DSL Forum Working Text 114 (WT-114), "VDSL2 Performance Test Plan" , February 7, 2008

Terms, Definitions and Abbreviations

Definitions

All-digital mode	VDSL2 mode of operation that provides data services only. Underlying services are not present, although bandwidth for underlying services may or may not be provided.
Band plan* [1]	The partitioning of the frequency spectrum into non-overlapping frequency bands, each of which is allocated for either upstream or downstream transmission
Bridged taps	Sections of unterminated twisted-pair cables connected in parallel across the cable under consideration.
Channel configuration parameters	Parameters related to configuration of the specific data channel under test.
Crest factor	Peak-to-rms-voltage ratio.
Downstream	VTU-O to VTU-R direction.
Line configuration parameters	Parameters related to configuration of the physical layer.
Loading coils	Inductors placed in series with the cable at regular intervals in order to improve the voiceband response; removed for DSL use.
Net data rate	Data rate that is available for user data in any one direction.
Showtime* [1]	The state of both VTU-O and VTU-R that is reached after the initialization procedure has been completed in which bearer channel data are transmitted.
Single latency	Simultaneous transport of one or more bearer channels through either a high or low latency path.
Splitter* [1]	A filter that separates VDSL2 signals from the voiceband or ISDN signals (frequently called a POTS or ISDN splitter, even though the voiceband signals may comprise more than POTS).
Underlying service	Low frequency legacy services such as POTS and ISDN that may be present on the same pair as VDSL2.
Upstream	VTU-R to VTU-O direction.
VDSL2 automode	The term used to describe a specific mode of operation in which the VTU-O and VTU-R support one or more modes of operation defined in ITU-T G.993.2 [1] with fallback capability to one or more modes of operation defined in ANSI T1.413-1998 [3], ITU-T G.992.1 [4], ITU-T G.992.3 [6], and ITU-T G.992.5 [7]. It is assumed that when operating in VDSL2 automode the VTU-O and VTU-R will synchronize in the mode of operation that provides the best overall performance for the given loop and impairment scenario.
Voiceband services	POTS and all data services that use the voiceband or some part of it.
Voiceband* [1]	0 to 4 kHz; expanded from the traditional 0.3 to 3.4 kHz to deal with voiceband data services wider than POTS.

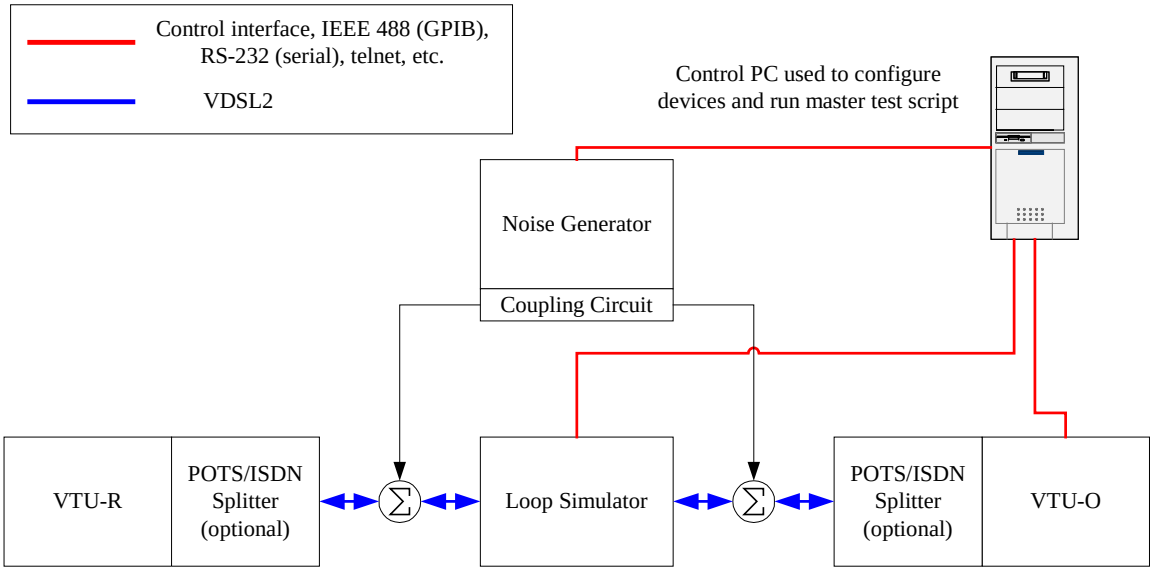
* From ITU-T G.993.2 [1]; repeated here for convenience.

Abbreviations

AWG	American Wire Gauge
AWGN	Additive White Gaussian Noise
Balun	Balance Transformer
CO	Central Office
DMT	Discrete Multi Tone
DSL	Digital Subscriber Line
DSLAM	Digital Subscriber Line Access Multiplexer
DUT	Device Under Test
FEXT	Far End Crosstalk
HDSL	High-bit-rate Digital Subscriber Line
ISDN	Integrated Services Digital Network
Mbps	Megabits per Second
NEXT	Near-End Crosstalk
POTS	Plain Old Telephone Service
VDSL2	Very High Speed Digital Subscriber Line 2
VTU-O	VDSL Transceiver Unit – Optical Network or Central Office End
VTU-R	VDSL Transceiver Unit – Remote End

Test Setups

Test Setup 1: Generic Test Setup



Test Loops

North American Test Loops:

Please refer to VDSL1 test loop, as defined in ANSI T1.424-2005 [2] Section 12. The VDSL1 test loop is a variable length single gauge 24 AWG or 26 AWG straight loop with no bridge taps.

Group 1: Rate vs. Reach Tests for VDSL2 North American Networks

Scope:

The procedures defined in Group 1 are designed to test the interoperability and stability of a VTU-R/VTU-O in a VDSL2 system operating in one or more modes specified in ITU-T G.993.2 [1] on various simulated test loops in the presence of simulated impairments.

Notes:

1. The Group 1 tests are defined for North American test loops only.
2. The DUT may be either the VTU-O or the VTU-R. If the DUT is a VTU-R, the VTU-O may be referred to as the *link partner*, and vice-versa.
3. The tests in Group 1 are broken down by impairment; the same test loops and user specified profiles are used for each test.
4. The tests defined in this document represent only a subset of all possible test cases. Additional test cases can be added upon request.
5. Annexes A, B, and C of ITU-T G.993.2 [1] are all applicable to Group 1.
6. The default maximum train time of 60 seconds, the default stability period of 60 seconds, and the default line reset delay of 10 seconds (the amount of time the VTU-O port is administratively disabled) can be changed to any reasonable value upon request. These values are listed in the test report.
7. The default test conditions for Group 1 are shown in Table 1. For all Group 1 tests the user must specify a single wire gauge for all variable length test loops, either 24 AWG or 26 AWG, as defined in the Test Loops section of this document. Test loops including mixed gauges and bridge taps are for further study.
8. Underlying service, either POTS or ISDN, may not be present during Group 1 tests, even if the DUT is configured for operation in the presence of an underlying service.
9. The Group 1 tests consist of two user specified test profiles, Profile 1 and Profile 2. All specific line and channel configuration parameters for Profiles 1 and 2 listed in Table 2 must be specified by the user prior to implementation of this test suite.
10. ADSL2+ NEXT/FEXT disturbers are specific to the region for which the VDSL2 Annex under test is intended to be deployed.
11. VDSL2 Self-crosstalk disturbers are specific to the Annex under test.
12. Loop simulator and impairment generator compensation should be applied, as defined in Section 4 “Test Tools Requirements and Calibration” of DSL Forum TR-067 [9], whenever possible. The use of loop simulator and impairment generator compensation shall be stated in the test report.

Mode of Operation	Test Loops	Impairments
VDSL2 • Any mode specified in ITU-T G.993.2 [1]; refer to Table 2	• 26 AWG: 300-8500 ft; 300 – 1500 ft in 100 ft increments 1750 – 4000 ft in 250 ft increments 4500 – 5500 ft in 500 ft increments 6500 – 8500 in 1000 ft increments • 24 AWG: for further study • Mixed gauge and bridge tap loops: for further study	• -140 dBm/Hz white noise • 24-disturber ADSL2+ NEXT/FEXT • 24-disturber VDSL2 Self NEXT/FEXT

Table 1 – Group 1 default test conditions.

User Specified Profile Parameters		User Specified Profile 1	User Specified Profile 2
Line Configuration Parameters	Annex	*User Specified*	*User Specified*
	Band Plan	*User Specified*	*User Specified*
	Profile	*User Specified*	*User Specified*
	VTU-R Limit PSD Mask	*User Specified*	*User Specified*
	VTU-O Limit PSD Mask	*User Specified*	*User Specified*
	Max SNRM Up (dB)	*User Specified*	*User Specified*
	Target SNRM Up (dB)	*User Specified*	*User Specified*
	Min SNRM Up (dB)	*User Specified*	*User Specified*
	Max SNRM Down (dB)	*User Specified*	*User Specified*
	Target SNRM Down (dB)	*User Specified*	*User Specified*
	Min SNRM Down (dB)	*User Specified*	*User Specified*
Channel Configuration Parameters	Min Rate Up (kbps)	*User Specified*	*User Specified*
	Max Rate Up (kbps)	*User Specified*	*User Specified*
	Min Rate Down (kbps)	*User Specified*	*User Specified*
	Max Rate Up (kbps)	*User Specified*	*User Specified*
	Max Interleaving Delay Up (ms)	*User Specified*	*User Specified*
	Max Interleaving Delay Down (ms)	*User Specified*	*User Specified*
	Min INP Up (symbols)	*User Specified*	*User Specified*
	Min INP Down (symbols)	*User Specified*	*User Specified*
Legacy Parameters	Legacy Modes of Operation for ITU-T G.993.2 [1] (VDSL2) Automode	*User Specified; Required for Group 2 only*	*User Specified; Required for Group 2 only*

Table 2 – VDSL2 Reach vs. Rate Test Suite user specified profile parameters.

Test V2RR.1.1: VDSL2 Reach vs. Rate Test with –140 dBm/Hz AWGN Impairment

Purpose: The purpose of this test is to determine the maximum net data rate at which a VTU-R/VTU-O initializes on various test loops in the presence of –140 dBm/Hz additive white Gaussian noise (AWGN) impairment.

References:

[1] ITU-T G.993.2 (2006)
[2] ANSI T1.424-2004 (2004)
[5] ANSI T1.417-2001 (2001)
[6] ITU-T G.992.3 (2002)
[8] ITU-T G.996.1 (2001)

Resource requirements:

- VTU-R
- VTU-O
- Line simulator(s) capable of simulating the loop type and lengths defined in Table 1.
- Impairment generator capable of simulating the impairments defined in Table 1 for the desired mode of operation.
- Impairment coupling circuits

Last modification: March 21, 2008

Test setup:

- Test Setup 1

Discussion:

The theoretical maximum attainable data rate for any technology can be achieved only under ideal conditions. The maximum attainable net data rate for VDSL2 devices is primarily limited by factors such as channel attenuation (primarily a function of loop length), channel characteristics (presence of bridge taps, load coils) and the presence of channel impairments (primarily a function of impulsive noise and crosstalk from other pairs operating in the same or nearby binders). This test provides insight into the maximum net data rate attained by a pair of VDSL2 devices for different loop configurations in the presence of –140 dBm/Hz AWGN impairment, and is used as a baseline for the results obtained in Tests V2RR.1.2 through V2RR.1.3.

This test utilizes a line simulator to simulate the loop type and lengths described in Table 1 as defined in ANSI T1.424-2004 [2]. The attenuation characteristics of the test loops simulated using the line simulator(s) should conform to the theoretical attenuation characteristics as defined in ANSI T1.417 [5]. To ensure the robustness of the VDSL connection three iterations of each test case should be performed.

Simulated –140 dBm/Hz AWGN impairment should be injected in both the upstream and downstream directions simultaneously using a high impedance crosstalk injection circuit. The high impedance crosstalk coupling circuit should be designed to meet the requirements defined in ITU-T G.996.1 [8].

A test case refers to a single loop and impairment scenario. For each test case the downstream and upstream net data rates, downstream and upstream noise margins, downstream and upstream impulse noise protections, downstream and upstream interleaving delays, the amount of time required to reach SHOWTIME (train time), and the mode of operation are recorded. This test should be performed according to User Specified Profiles 1 and 2, which are defined entirely by the parameters shown in Table 2. The complete line and channel configuration parameters for User Specified Profiles 1 and 2 will be noted in the test report.

This test can be performed on any VDSL2 system that operates in accordance with ITU-T G.993.2 [1]. POTS or ISDN splitters should be included in this test, however underlying POTS or ISDN service is optional. Annex B provides a graphical representation of the test procedure detailed below.

Procedure:

1. Configure the VTU-O port for User Specified Profile 1.
2. Configure the VTU-R for ITU-T G.993.2 [1] with the line and channel configuration parameters identified in User Specified Profile 1.
3. Connect the VTU-R to the VTU-O as shown in Test Setup 1.
4. Inject -140 dBm/Hz AWGN in both the upstream and downstream directions as shown in Test Setup 1.
5. Configure the line simulator for a straight 26AWG or 24 AWG loop of 300 ft. Note that the user must define a single loop gauge to be used for all Group 1 tests.
6. Administratively enable or activate the VTU-O port.
7. Allow 60 seconds for the link to initialize (this period of time is referred to as "train time").
8. If the VTU-R and VTU-O do not successfully establish (do not reach SHOWTIME) within 60 seconds, record "NC", or *no connect* for the test case and proceed to the next test case, as detailed in step 10.
9. If the link is established and is stable for 60 seconds (does not retrain; this period of time is referred to as "stability time"), record the downstream and upstream net data rates, downstream and upstream noise margins, the actual downstream and upstream impulse noise protections, the actual downstream and upstream interleaving delays, the amount of time required to reach SHOWTIME (train time), and the mode of operation. If the established link is not stable for 60 seconds (link retrained during the 60 second stability period) record "SF" or *stability failure* for the test case and proceed to the next test case.
10. Administratively disable the VTU-O port for 10 seconds (this period is referred to as "line reset delay").
11. Repeat steps 6 to 11 for all loops defined in Table 1.
12. Configure the VTU-O port for User Specified Profile 2 and repeat steps 5 to 11.
13. Repeat steps 5 through 12 two additional times, for a total of three iterations.

Test metrics:

1. For each test case, the VTU-R and VTU-O should reach SHOWTIME within 60 seconds and remain in SHOWTIME for no less than 60 seconds.

Possible Problems:

1. If the VTU-R and VTU-O do not reach SHOWTIME within 60 seconds a no connect, or "NC," shall be recorded for the test case in the test report. If the VTU-R and VTU-O do not remain stable for 60 seconds after the link has been established (if they retrain), stability failure, or "SF," shall be recorded for the test case in the test report.
2. The VTU-O or VTU-R may not support the desired mode of operation as defined in User Specified Profiles 1 and 2. If this is the case, record "NS" or *not supported* in the applicable table(s) in the test report.
3. The user may specify only a single test profile. If this is the case, record "NT" or *not tested* in the User Specified Profile 2 sections of applicable table(s) in the test report.

Test V2RR.1.2: VDSL2 Reach vs. Rate Test with ADSL2+ NEXT/FEXT Impairment

Purpose: The purpose of this test is to determine the maximum net data rate at which a VTU-R/VTU-O initializes on various test loops in the presence of ADSL2+ NEXT and FEXT impairment.

References:

[1] ITU-T G.993.2 (2006)
[2] ANSI T1.424-2004 (2004)
[5] ANSI T1.417-2001 (2001)
[6] ITU-T G.992.3 (2002)
[7] ITU-T G.992.5 (2003)
[8] ITU-T G.996.1 (2001)

Resource requirements:

- VTU-R
- VTU-O
- Line simulator(s) capable of simulating the loop type and lengths defined in Table 1.
- Impairment generator capable of simulating the impairments defined in Table 1 for the desired mode of operation.
- Impairment coupling circuits

Last modification: March 21, 2008

Test setup:

- Test Setup 1

Discussion:

The theoretical maximum attainable data rate for any technology can be achieved only under ideal conditions. The maximum attainable net data rate for VDSL2 devices is primarily limited by factors such as channel attenuation (primarily a function of loop length), channel characteristics (presence of bridge taps, load coils) and the presence of channel impairments (primarily a function of impulsive noise and crosstalk from other pairs operating in the same or nearby binders). This test provides insight into the maximum net data rate attained by a pair of VDSL2 devices for different loop configurations in the presence of ADSL2+ NEXT and FEXT impairment.

This test utilizes a line simulator to simulate the loop type and lengths described in Table 1 as defined in ANSI T1.424-2004 [2]. The attenuation characteristics of the test loops simulated using the line simulator(s) should conform to the theoretical attenuation characteristics as defined in ANSI T1.417 [5]. To ensure the robustness of the VDSL connection three iterations of each test case should be performed.

Simulated ADSL2+ NEXT and FEXT impairment should be injected in both the upstream and downstream directions simultaneously using a high impedance crosstalk injection circuit. The impairments are simulated based on the theoretical maximum power spectral density for the relevant technology as defined in ITU-T G.993.2 [1] for VDSL2 NEXT and FEXT and ITU-T G.992.3 [6] for ADSL2+ NEXT and FEXT. The high impedance crosstalk coupling circuit should be designed to meet the requirements defined in ITU-T G.996.1 [8].

A test case refers to a single loop and impairment scenario. For each test case the downstream and upstream net data rates, downstream and upstream noise margins, the amount of time required to reach SHOWTIME (train time), and the mode of operation are recorded. This test should be performed according to User Specified Profiles 1 and 2, which are defined entirely by the parameters shown in Table 2. The complete line and channel configuration parameters for User Specified Profiles 1 and 2 will be noted in the test report.

This test can be performed on any VDSL2 system that operates in accordance with ITU-T G.993.2 [1]. POTS or ISDN splitters should be included in this test, however underlying POTS or ISDN service is optional. Annex B provides a graphical representation of the test procedure detailed below.

Procedure:

1. Configure the VTU-O port for User Specified Profile 1.
2. Configure the VTU-R for ITU-T G.993.2 [1] with the line and channel configuration parameters identified in User Specified Profile 1.
3. Connect the VTU-R to the VTU-O as shown in Test Setup 1.
4. Inject -140 dBm/Hz AWGN plus ADSL2+ NEXT and FEXT impairment in both the upstream and downstream directions as shown in Test Setup 1.
5. Configure the line simulator for a straight 26AWG or 24 AWG loop of 0 kft. Note that the user must define a single loop gauge to be used for all Group 1 tests.
6. Administratively enable or activate the VTU-O port.
7. Allow 60 seconds for the link to initialize (this period of time is referred to as "train time").
8. If the VTU-R and VTU-O do not successfully establish (do not reach SHOWTIME) within 60 seconds, record "NC", or *no connect* for the test case and proceed to the next test case, as detailed in step 10.
9. If the link is established and is stable for 60 seconds (does not retrain; this period of time is referred to as "stability time"), record the downstream and upstream net data rates, downstream and upstream noise margins, the actual downstream and upstream impulse noise protections, the actual downstream and upstream interleaving delays, the amount of time required to reach SHOWTIME (train time), and the mode of operation. If the established link is not stable for 60 seconds (link retrained during the 60 second stability period) record "SF" or *stability failure* for the test case and proceed to the next test case.
10. Administratively disable the VTU-O port for 10 seconds (this period is referred to as "line reset delay").
11. Repeat steps 6 to 11 for all loops defined in Table 1.
12. Configure the VTU-O port for User Specified Profile 2 and repeat steps 5 to 11.
13. Repeat steps 5 through 12 two additional times, for a total of three iterations.

Test metrics:

1. For each test case, the VTU-R and VTU-O should reach SHOWTIME within 60 seconds and remain in SHOWTIME for no less than 60 seconds.

Possible Problems:

1. If the VTU-R and VTU-O do not reach SHOWTIME within 60 seconds a no connect, or "NC," shall be recorded for the test case in the test report. If the VTU-R and VTU-O do not remain stable for 60 seconds after the link has been established (if they retrain), stability failure, or "SF," shall be recorded for the test case in the test report.
2. The VTU-O or VTU-R may not support the desired mode of operation as defined in User Specified Profiles 1 and 2. If this is the case, record "NS" or *not supported* in the applicable table(s) in the test report.
3. The user may specify only a single test profile. If this is the case, record "NT" or *not tested* in the User Specified Profile 2 sections of applicable table(s) in the test report.

Test V2RR.1.3: VDSL2 Reach vs. Rate Test with VDSL2 NEXT/FEXT Impairment

Purpose: The purpose of this test is to determine the maximum net data rate at which a VTU-R/VTU-O initializes on various test loops in the presence of VDSL2 NEXT and FEXT impairment.

References:

[1] ITU-T G.993.2 (2006)
[2] ANSI T1.424-2004 (2004)
[5] ANSI T1.417-2001 (2001)
[6] ITU-T G.992.3 (2002)
[8] ITU-T G.996.1 (2001)

Resource requirements:

- VTU-R
- VTU-O
- Line simulator(s) capable of simulating the loop type and lengths defined in Table 1.
- Impairment generator capable of simulating the impairments defined in Table 1 for the desired mode of operation.
- Impairment coupling circuits

Last modification: March 21, 2008

Test setup:

- Test Setup 1

Discussion:

The theoretical maximum attainable data rate for any technology can be achieved only under ideal conditions. The maximum attainable net data rate for VDSL2 devices is primarily limited by factors such as channel attenuation (primarily a function of loop length), channel characteristics (presence of bridge taps, load coils) and the presence of channel impairments (primarily a function of impulsive noise and crosstalk from other pairs operating in the same or nearby binders). This test provides insight into the maximum net data rate attained by a pair of VDSL2 devices for different loop configurations in the presence of VDSL2 NEXT and FEXT impairment.

This test utilizes a line simulator to simulate the loop type and lengths described in Table 1 as defined in ANSI T1.424-2004 [2]. The attenuation characteristics of the test loops simulated using the line simulator(s) should conform to the theoretical attenuation characteristics as defined in ANSI T1.417 [5]. To ensure the robustness of the VDSL connection three iterations of each test case should be performed.

Simulated VDSL2 NEXT and FEXT impairment should be injected in both the upstream and downstream directions simultaneously using a high impedance crosstalk injection circuit. The impairments are simulated based on the theoretical maximum power spectral density for the relevant technology as defined in ITU-T G.993.2 [1] for VDSL2 NEXT and FEXT and ITU-T G.992.3 [6] and ADSL2+ NEXT and FEXT. The high impedance crosstalk coupling circuit should be designed to meet the requirements defined in ITU-T G.996.1 [8].

A test case refers to a single loop and impairment scenario. For each test case the downstream and upstream net data rates, downstream and upstream noise margins, the amount of time required to reach SHOWTIME (train time), and the mode of operation are recorded. This test should be performed according to User Specified Profiles 1 and 2, which are defined entirely by the parameters shown in Table 2. The complete line and channel configuration parameters for User Specified Profiles 1 and 2 will be noted in the test report.

This test can be performed on any VDSL2 system that operates in accordance with ITU-T G.993.2 [1]. POTS or ISDN splitters should be included in this test, however underlying POTS or ISDN service is optional. Annex B provides a graphical representation of the test procedure detailed below.

Procedure:

1. Configure the VTU-O port for User Specified Profile 1.
2. Configure the VTU-R for ITU-T G.993.2 [1] with the line and channel configuration parameters identified in User Specified Profile 1.
3. Connect the VTU-R to the VTU-O as shown in Test Setup 1.
4. Inject -140 dBm/Hz AWGN plus VDSL2 NEXT and FEXT impairment in both the upstream and downstream directions as shown in Test Setup 1.
5. Configure the line simulator for a straight 26AWG or 24 AWG loop of 0 kft. Note that the user must define a single loop gauge to be used for all Group 1 tests.
6. Administratively enable or activate the VTU-O port.
7. Allow 60 seconds for the link to initialize (this period of time is referred to as "train time").
8. If the VTU-R and VTU-O do not successfully establish (do not reach SHOWTIME) within 60 seconds, record "NC", or *no connect* for the test case and proceed to the next test case, as detailed in step 10.
9. If the link is established and is stable for 60 seconds (does not retrain; this period of time is referred to as "stability time"), record the downstream and upstream net data rates, downstream and upstream noise margins, the actual downstream and upstream impulse noise protections, the actual downstream and upstream interleaving delays, the amount of time required to reach SHOWTIME (train time), and the mode of operation. If the established link is not stable for 60 seconds (link retrained during the 60 second stability period) record "SF" or *stability failure* for the test case and proceed to the next test case.
10. Administratively disable the VTU-O port for 10 seconds (this period is referred to as "line reset delay").
11. Repeat steps 6 to 11 for all loops defined in Table 1.
12. Configure the VTU-O port for User Specified Profile 2 and repeat steps 5 to 11.
13. Repeat steps 5 through 12 two additional times, for a total of three iterations.

Test metrics:

1. For each test case, the VTU-R and VTU-O should reach SHOWTIME within 60 seconds and remain in SHOWTIME for no less than 60 seconds.

Possible Problems:

1. If the VTU-R and VTU-O do not reach SHOWTIME within 60 seconds a no connect, or "NC," shall be recorded for the test case in the test report. If the VTU-R and VTU-O do not remain stable for 60 seconds after the link has been established (if they retrain), stability failure, or "SF," shall be recorded for the test case in the test report.
2. The VTU-O or VTU-R may not support the desired mode of operation as defined in User Specified Profiles 1 and 2. If this is the case, record "NS" or *not supported* in the applicable table(s) in the test report.
3. The user may specify only a single test profile. If this is the case, record "NT" or not tested in the User Specified Profile 2 sections of applicable table(s) in the test report.

Group 2: Rate vs. Reach Tests for VDSL2 Automode North American Networks

Scope:

The procedures defined in Group 2 are designed to test the interoperability and stability of a VTU-R/VTU-O in a VDSL2 system operating in ITU-T G.993.2 [1] (VDSL2) automode on various simulated test loops in the presence of simulated impairments.

Notes:

1. Refer to notes 1, 2, 4, 5, 6, 8, 9, 10, 11, and 12 of Group 1.
2. For Group 2 the default maximum train time shall be increased to 120 seconds. The default maximum train time of 120 seconds, the default stability period of 60 seconds, and the default line reset delay of 10 seconds (the amount of time the VTU-O port is administratively disabled) can be changed to any reasonable value upon request. These values are listed in the test report.
3. The default test conditions for Group 2 are shown in Table 3. For all Group 2 tests the user must specify a single wire gauge for all variable length test loops, either 24 AWG or 26 AWG, as defined in the Test Loops section of this document. Test loops including mixed gauges and bridge taps are for further study.
4. Testing in ITU-T G.993.2 [1] automode implies that the VTU-O and VTU-R support one or more modes of operation defined in ITU-T G.993.2 [1] with fallback capability to one or more modes of operation defined in ANSI T1.413-1998 [3], ITU-T G.992.1 [4], ITU-T G.992.3 [6], or ITU-T G.992.5 [7]. In ITU-T G.993.2 [1] automode it is assumed that the VTU-O and VTU-R will synchronize in the mode that provides the best performance (the highest possible net data rate) for the given loop and impairment. For shorter loops this may be ITU-T G.993.2 [1] mode, whereas for longer loops the highest net data rate may be achieved in a legacy mode of operation.
5. ITU-T G.993.2 [1] automode requires a loop simulator and impairment generator capable of simulating the loops and impairments defined in Table 3 over the frequency range required for ITU-T G.993.2 [1] when operating in ITU-T G.993.2 [1] mode.

Mode of Operation	Test Loops	Impairments
VDSL2 Automode • Any mode specified in ITU-T G.993.2 [1]; refer to Table 2 • ANSI T1.413-1998 [3] • ITU-T G.992.1 [4] • ITU-T G.992.3 [6] • ITU-T G.992.5 [7]	• 26 AWG: 0 – 21 kft. in 1kft increments • 24 AWG: for further study • Mixed gauge and bridge tap loops: for further study	• -140 dBm/Hz white noise • 24-disturber ADSL2+ NEXT/FEXT • 24-disturber VDSL2 Self NEXT/FEXT

Table 3 – Group 2 default test conditions.

Test V2RR.2.1: VDSL2 Automode Reach vs. Rate Test with –140 dBm/Hz AWGN Impairment

Purpose: The purpose of this test is to determine the maximum net data rate at which a VTU-R/VTU-O operating in ITU-T .993.2 [1] (VDSL2) automode initializes on various test loops in the presence of –140 dBm/Hz additive white Gaussian noise (AWGN) impairment.

References:

[1] ITU-T G.993.2 (2006)
[2] ANSI T1.424-2004 (2004)
[3] ANSI T1.413-1998 (1998)
[4] ITU-T G.992.1 (1999)
[5] ANSI T1.417-2001 (2001)
[6] ITU-T G.992.3 (2002)
[7] ITU-T G.992.5 (2003)
[8] ITU-T G.996.1 (2001)

Resource requirements:

- VTU-R
- VTU-O
- Line simulator(s) capable of simulating the loop type and lengths defined in Table 3.
- Impairment generator capable of simulating the impairments defined in Table 1 for the desired mode of operation.
- Impairment coupling circuits

Last modification: March 21, 2008

Test setup:

- Test Setup 1

Discussion:

The theoretical maximum attainable data rate for any technology can be achieved only under ideal conditions. The maximum attainable net data rate for VDSL2 devices is primarily limited by factors such as channel attenuation (primarily a function of loop length), channel characteristics (presence of bridge taps, load coils) and the presence of channel impairments (primarily a function of impulsive noise and crosstalk from other pairs operating in the same or nearby binders). This test provides insight into the maximum net data rate attained by a pair of VDSL2 devices for different loop configurations in the presence of –140 dBm/Hz AWGN impairment, and is used as a baseline for the results obtained in Tests V2RR.2.2 through V2RR.2.3.

This test utilizes a line simulator to simulate the loop type and lengths described in Table 3 as defined in ANSI T1.424-2004 [2]. The attenuation characteristics of the test loops simulated using the line simulator(s) should conform to the theoretical attenuation characteristics as defined in ANSI T1.417 [5]. To ensure the robustness of the VDSL connection three iterations of each test case should be performed.

Simulated –140 dBm/Hz AWGN impairment should be injected in both the upstream and downstream directions simultaneously using a high impedance crosstalk injection circuit. The high impedance crosstalk coupling circuit should be designed to meet the requirements defined in ITU-T G.996.1 [8].

A test case refers to a single loop and impairment scenario. For each test case the downstream and upstream net data rates, downstream and upstream noise margins, downstream and upstream impulse noise protections, downstream and upstream interleaving delays, the amount of time required to reach SHOWTIME (train time), and the mode of operation are recorded. This test should be performed according to User Specified Profiles 1 and 2, which are defined entirely by the parameters shown in Table 2. The complete line and channel configuration parameters for User Specified Profiles 1 and 2 will be noted in the test report.

This test can be performed on any VDSL2 system that operates in accordance with ITU-T G.993.2 [1]. POTS or ISDN splitters should be included in this test, however underlying POTS or ISDN service is optional. Annex B provides a graphical representation of the test procedure detailed below.

Procedure:

1. Configure the VTU-O port for User Specified Profile 1.
2. Configure the VTU-R for ITU-T G.993.2 [1] automode with the line and channel configuration parameters identified in User Specified Profile 1.
3. Connect the VTU-R to the VTU-O as shown in Test Setup 1.
4. Inject -140 dBm/Hz AWGN in both the upstream and downstream directions as shown in Test Setup 1.
5. Configure the line simulator for a straight 26AWG or 24 AWG loop of 0 kft. Note that the user must define a single loop gauge to be used for all Group 1 tests.
6. Administratively enable or activate the VTU-O port.
7. Allow 120 seconds for the link to initialize (this period of time is referred to as "train time").
8. If the VTU-R and VTU-O do not successfully establish (do not reach SHOWTIME) within 120 seconds, record "NC", or *no connect* for the test case and proceed to the next test case, as detailed in step 10.
9. If the link is established and is stable for 60 seconds (does not retrain; this period of time is referred to as "stability time"), record the downstream and upstream net data rates, downstream and upstream noise margins, the actual downstream and upstream impulse noise protections, the actual downstream and upstream interleaving delays, the amount of time required to reach SHOWTIME (train time), and the mode of operation. If the established link is not stable for 60 seconds (link retrained during the 60 second stability period) record "SF" or *stability failure* for the test case and proceed to the next test case.
10. Administratively disable the VTU-O port for 10 seconds (this period is referred to as "line reset delay").
11. Repeat steps 6 to 11 for all loops defined in Table 2.
12. Configure the VTU-O port for User Specified Profile 2 and repeat steps 5 to 11.
13. Repeat steps 5 through 12 two additional times, for a total of three iterations.

Test metrics:

1. For each test case, the VTU-R and VTU-O should reach SHOWTIME within 120 seconds and remain in SHOWTIME for no less than 60 seconds.

Possible Problems:

1. If the VTU-R and VTU-O do not reach SHOWTIME within 120 seconds a no connect, or "NC," shall be recorded for the test case in the test report. If the VTU-R and VTU-O do not remain stable for 60 seconds after the link has been established (if they retrain), stability failure, or "SF," shall be recorded for the test case in the test report.
2. The VTU-O or VTU-R may not support the desired mode of operation as defined in User Specified Profiles 1 and 2. If this is the case, record "NS" or *not supported* in the applicable table(s) in the test report.
3. The user may specify only a single test profile. If this is the case, record "NT" or *not tested* in the User Specified Profile 2 sections of applicable table(s) in the test report.

Test V2RR.2.2: VDSL2 Automode Reach vs. Rate Test with ADSL2+ NEXT/FEXT Impairment

Purpose: The purpose of this test is to determine the maximum net data rate at which a VTU-R/VTU-O operating in ITU-T .993.2 [1] (VDSL2) automode initializes on various test loops in the presence of ADSL2+ NEXT and FEXT impairment.

References:

[1] ITU-T G.993.2 (2006)
[2] ANSI T1.424-2004 (2004)
[3] ANSI T1.413-1998 (1998)
[4] ITU-T G.992.1 (1999)
[5] ANSI T1.417-2001 (2001)
[6] ITU-T G.992.3 (2002)
[7] ITU-T G.992.5 (2003)
[8] ITU-T G.996.1 (2001)

Resource requirements:

- VTU-R
- VTU-O
- Line simulator(s) capable of simulating the loop type and lengths defined in Table 3.
- Impairment generator capable of simulating the impairments defined in Table 1 for the desired mode of operation.
- Impairment coupling circuits

Last modification: March 21, 2008

Test setup:

- Test Setup 1

Discussion:

The theoretical maximum attainable data rate for any technology can be achieved only under ideal conditions. The maximum attainable net data rate for VDSL2 devices is primarily limited by factors such as channel attenuation (primarily a function of loop length), channel characteristics (presence of bridge taps, load coils) and the presence of channel impairments (primarily a function of impulsive noise and crosstalk from other pairs operating in the same or nearby binders). This test provides insight into the maximum net data rate attained by a pair of VDSL2 devices for different loop configurations in the presence of ADSL2+ NEXT and FEXT impairment.

This test utilizes a line simulator to simulate the loop type and lengths described in Table 3 as defined in ANSI T1.424-2004 [2]. The attenuation characteristics of the test loops simulated using the line simulator(s) should conform to the theoretical attenuation characteristics as defined in ANSI T1.417 [5]. To ensure the robustness of the VDSL connection three iterations of each test case should be performed.

Simulated ADSL2+ NEXT and FEXT impairment should be injected in both the upstream and downstream directions simultaneously using a high impedance crosstalk injection circuit. The impairments are simulated based on the theoretical maximum power spectral density for the relevant technology as defined in ITU-T G.993.2 [1] for VDSL2 NEXT and FEXT and ITU-T G.992.3 [6] and ADSL2+ NEXT and FEXT. The high impedance crosstalk coupling circuit should be designed to meet the requirements defined in ITU-T G.996.1 [8].

A test case refers to a single loop and impairment scenario. For each test case the downstream and upstream net data rates, downstream and upstream noise margins, the amount of time required to reach SHOWTIME (train time), and the mode of operation are recorded. This test should be performed according to User Specified Profiles 1 and 2, which are defined entirely by the parameters shown in Table 2. The complete line and channel configuration parameters for User Specified Profiles 1 and 2 will be noted in the test report.

This test can be performed on any VDSL2 system that operates in accordance with ITU-T G.993.2 [1]. POTS or ISDN splitters should be included in this test, however underlying POTS or ISDN service is optional. Annex B provides a graphical representation of the test procedure detailed below.

Procedure:

1. Configure the VTU-O port for User Specified Profile 1.
2. Configure the VTU-R for ITU-T G.993.2 [1] automode with the line and channel configuration parameters identified in User Specified Profile 1.
3. Connect the VTU-R to the VTU-O as shown in Test Setup 1.
4. Inject -140 dBm/Hz AWGN plus ADSL2+ NEXT and FEXT impairment in both the upstream and downstream directions as shown in Test Setup 1.
5. Configure the line simulator for a straight 26AWG or 24 AWG loop of 0 kft. Note that the user must define a single loop gauge to be used for all Group 1 tests.
6. Administratively enable or activate the VTU-O port.
7. Allow 120 seconds for the link to initialize (this period of time is referred to as "train time").
8. If the VTU-R and VTU-O do not successfully establish (do not reach SHOWTIME) within 120 seconds, record "NC", or *no connect* for the test case and proceed to the next test case, as detailed in step 10.
9. If the link is established and is stable for 60 seconds (does not retrain; this period of time is referred to as "stability time"), record the downstream and upstream net data rates, downstream and upstream noise margins, the actual downstream and upstream impulse noise protections, the actual downstream and upstream interleaving delays, the amount of time required to reach SHOWTIME (train time), and the mode of operation. If the established link is not stable for 60 seconds (link retrained during the 60 second stability period) record "SF" or *stability failure* for the test case and proceed to the next test case.
10. Administratively disable the VTU-O port for 10 seconds (this period is referred to as "line reset delay").
11. Repeat steps 6 to 11 for all loops defined in Table 3.
12. Configure the VTU-O port for User Specified Profile 2 and repeat steps 5 to 11.
13. Repeat steps 5 through 12 two additional times, for a total of three iterations.

Test metrics:

1. For each test case, the VTU-R and VTU-O should reach SHOWTIME within 120 seconds and remain in SHOWTIME for no less than 60 seconds.

Possible Problems:

1. If the VTU-R and VTU-O do not reach SHOWTIME within 120 seconds a no connect, or "NC," shall be recorded for the test case in the test report. If the VTU-R and VTU-O do not remain stable for 60 seconds after the link has been established (if they retrain), stability failure, or "SF," shall be recorded for the test case in the test report.
2. The VTU-O or VTU-R may not support the desired mode of operation as defined in User Specified Profiles 1 and 2. If this is the case, record "NS" or *not supported* in the applicable table(s) in the test report.
3. The user may specify only a single test profile. If this is the case, record "NT" or *not tested* in the User Specified Profile 2 sections of applicable table(s) in the test report.

Test V2RR.2.3: VDSL2 Automode Reach vs. Rate Test with VDSL2 NEXT/FEXT Impairment

Purpose: The purpose of this test is to determine the maximum net data rate at which a VTU-R/VTU-O operating in ITU-T .993.2 [1] (VDSL2) automode initializes on various test loops in the presence of VDSL2 NEXT and FEXT impairment.

References:

[1] ITU-T G.993.2 (2006)
[2] ANSI T1.424-2004 (2004)
[3] ANSI T1.413-1998 (1998)
[4] ITU-T G.992.1 (1999)
[5] ANSI T1.417-2001 (2001)
[6] ITU-T G.992.3 (2002)
[7] ITU-T G.992.5 (2003)
[8] ITU-T G.996.1 (2001)

Resource requirements:

- VTU-R
- VTU-O
- Line simulator(s) capable of simulating the loop type and lengths defined in Table 3.
- Impairment generator capable of simulating the impairments defined in Table 1 for the desired mode of operation.
- Impairment coupling circuits

Last modification: March 21, 2008

Test setup:

- Test Setup 1

Discussion:

The theoretical maximum attainable data rate for any technology can be achieved only under ideal conditions. The maximum attainable net data rate for VDSL2 devices is primarily limited by factors such as channel attenuation (primarily a function of loop length), channel characteristics (presence of bridge taps, load coils) and the presence of channel impairments (primarily a function of impulsive noise and crosstalk from other pairs operating in the same or nearby binders). This test provides insight into the maximum net data rate attained by a pair of VDSL2 devices for different loop configurations in the presence of VDSL2 NEXT and FEXT impairment.

This test utilizes a line simulator to simulate the loop type and lengths described in Table 3 as defined in ANSI T1.424-2004 [2]. The attenuation characteristics of the test loops simulated using the line simulator(s) should conform to the theoretical attenuation characteristics as defined in ANSI T1.417 [5]. To ensure the robustness of the VDSL connection three iterations of each test case should be performed.

Simulated VDSL2 NEXT and FEXT impairment impairment should be injected in both the upstream and downstream directions simultaneously using a high impedance crosstalk injection circuit. The impairments are simulated based on the theoretical maximum power spectral density for the relevant technology as defined in ITU-T G.993.2 [1] for VDSL2 NEXT and FEXT and ITU-T G.992.3 [6] and ADSL2+ NEXT and FEXT. The high impedance crosstalk coupling circuit should be designed to meet the requirements defined in ITU-T G.996.1 [8].

A test case refers to a single loop and impairment scenario. For each test case the downstream and upstream net data rates, downstream and upstream noise margins, the amount of time required to reach SHOWTIME (train time), and the mode of operation are recorded. This test should be performed according to User Specified Profiles 1 and 2, which are defined entirely by the parameters shown in Table 2. The complete line and channel configuration parameters for User Specified Profiles 1 and 2 will be noted in the test report.

This test can be performed on any VDSL2 system that operates in accordance with ITU-T G.993.2 [1]. POTS or ISDN splitters should be included in this test, however underlying POTS or ISDN service is optional. Annex B provides a graphical representation of the test procedure detailed below.

Procedure:

1. Configure the VTU-O port for User Specified Profile 1.
2. Configure the VTU-R for ITU-T G.993.2 [1] automode with the line and channel configuration parameters identified in User Specified Profile 1.
3. Connect the VTU-R to the VTU-O as shown in Test Setup 1.
4. Inject -140 dBm/Hz AWGN plus VDSL2 NEXT and FEXT impairment in both the upstream and downstream directions as shown in Test Setup 1.
5. Configure the line simulator for a straight 26AWG or 24 AWG loop of 0 kft. Note that the user must define a single loop gauge to be used for all Group 1 tests.
6. Administratively enable or activate the VTU-O port.
7. Allow 120 seconds for the link to initialize (this period of time is referred to as "train time").
8. If the VTU-R and VTU-O do not successfully establish (do not reach SHOWTIME) within 120 seconds, record "NC", or *no connect* for the test case and proceed to the next test case, as detailed in step 10.
9. If the link is established and is stable for 60 seconds (does not retrain; this period of time is referred to as "stability time"), record the downstream and upstream net data rates, downstream and upstream noise margins, the actual downstream and upstream impulse noise protections, the actual downstream and upstream interleaving delays, the amount of time required to reach SHOWTIME (train time), and the mode of operation. If the established link is not stable for 60 seconds (link retrained during the 60 second stability period) record "SF" or *stability failure* for the test case and proceed to the next test case.
10. Administratively disable the VTU-O port for 10 seconds (this period is referred to as "line reset delay").
11. Repeat steps 6 to 11 for all loops defined in Table 3.
12. Configure the VTU-O port for User Specified Profile 2 and repeat steps 5 to 11.
13. Repeat steps 5 through 12 two additional times, for a total of three iterations.

Test metrics:

1. For each test case, the VTU-R and VTU-O should reach SHOWTIME within 120 seconds and remain in SHOWTIME for no less than 60 seconds.

Possible Problems:

1. If the VTU-R and VTU-O do not reach SHOWTIME within 120 seconds a no connect, or "NC," shall be recorded for the test case in the test report. If the VTU-R and VTU-O do not remain stable for 60 seconds after the link has been established (if they retrain), stability failure, or "SF," shall be recorded for the test case in the test report.
2. The VTU-O or VTU-R may not support the desired mode of operation as defined in User Specified Profiles 1 and 2. If this is the case, record "NS" or *not supported* in the applicable table(s) in the test report.
3. The user may specify only a single test profile. If this is the case, record "NT" or *not tested* in the User Specified Profile 2 sections of applicable table(s) in the test report.

Annex A: Results Grids

Results Grid Legend

Test V2RR.1.X, Noise Impairment XXXX, User Specified Profile X, Loops 300 – 2000 ft, IOL Test ID: XXXX																
Length (ft)		300	400	500	600	700	800	900	1000	1100	1200	1300	1400	1500	1750	2000
Iteration 1	UNDR															
	DNDR															
	UNM															
	DNM															
	UINP															
	DINP															
	UDLY															
	DDLY															
	Time															
	Mode															

Test V2RR.1.X, Noise Impairment XXXX, User Specified Profile X , Loops 2250 - 8500 ft, IOL Test ID: XXXX															
Length (ft)		2250	2500	2750	3000	3250	3500	3750	4000	4500	5000	5500	6500	7500	8500
Iteration 1	UNDR														
	DNDR														
	UNM														
	DNM														
	UINP														
	DINP														
	UDLY														
	DDLY														
	Time														
	Mode														

Where:

- UNDR = Upstream Net Data Rate in kbps.
- UNM = Upstream Noise Margin in dB.
- UINP = Actual Upstream Impulse Noise Protection in symbols.
- UDLY = Actual Upstream Interleaving Delay in milliseconds.
- DNDR = Downstream Net Data Rate in kbps.
- DNM = Downstream Noise Margin in dB.
- DINP = Actual Downstream Impulse Noise Protection in symbols.
- DDLY = Actual Downstream Interleaving Delay in milliseconds.
- Time = Time in seconds required to reach SHOWTIME.
- Mode = ANSI (ANSI T1.413-1998), DMT (ITU-T G.992.1 Annex A/B), LITE (ITU-T G.992.2), A2 (ITU-T G.992.3 Annex A/B), A2 L (ITU-T G.992.3 Annex L) A2+ (ITU-T G.992.5), or V2 (ITU G.993.2).

Test V2RR.2.X, Noise Impairment XXXX, User Specified Profile X, Loops 0 - 10 kft, IOL Test ID: XXXX																
Length (ft)		300	400	500	600	700	800	900	1000	1100	1200	1300	1400	1500	1750	2000
Iteration 1	UNDR															
	DNDR															
	UNM															
	DNM															
	UINP															
	DINP															
	UDLY															
	DDLY															
	Time															
	Mode															

Test V2RR.2.X, Noise Impairment XXXX, User Specified Profile X, Loops 11 - 21 kft, IOL Test ID: XXXX															
Length (ft)		2250	2500	2750	3000	3250	3500	3750	4000	4500	5000	5500	6500	7500	8500
Iteration 1	UNDR														
	DNDR														
	UNM														
	DNM														
	UINP														
	DINP														
	UDLY														
	DDLY														
	Time														
	Mode														

Where:

- UNDR = Upstream Net Data Rate in kbps.
- UNM = Upstream Noise Margin in dB.
- UINP = Actual Upstream Impulse Noise Protection in symbols.
- UDLY = Actual Upstream Interleaving Delay in milliseconds.
- DNDR = Downstream Net Data Rate in kbps.
- DNM = Downstream Noise Margin in dB.
- DINP = Actual Downstream Impulse Noise Protection in symbols.
- DDLY = Actual Downstream Interleaving Delay in milliseconds.
- Time = Time in seconds required to reach SHOWTIME.
- Mode = ANSI (ANSI T1.413-1998), DMT (ITU-T G.992.1 Annex A/B), LITE (ITU-T G.992.2), A2 (ITU-T G.992.3 Annex A/B), A2 L (ITU-T G.992.3 Annex L) A2+ (ITU-T G.992.5), or V2 (ITU G.993.2).

Group 1: Rate vs. Reach Tests for VDSL2 North American Networks

Test V2RR.1.X, Noise Impairment XXXX, User Specified Profile X, Loops 300 – 2000 ft, IOL Test ID: XXXX																
Length (ft)		300	400	500	600	700	800	900	1000	1100	1200	1300	1400	1500	1750	2000
Iteration 1	UNDR															
	DNDR															
	UNM															
	DNM															
	UINP															
	DINP															
	UDLY															
	DDLY															
	Time															
	Mode															
Iteration 2	UNDR															
	DNDR															
	UNM															
	DNM															
	UINP															
	DINP															
	UDLY															
	DDLY															
	Time															
	Mode															
Iteration 3	UNDR															
	DNDR															
	UNM															
	DNM															
	UINP															
	DINP															
	UDLY															
	DDLY															
	Time															
	Mode															

Test V2RR.1.X, Noise Impairment XXXX, User Specified Profile X , Loops 2250 - 8500 ft, IOL Test ID: XXXX															
Length (ft)		2250	2500	2750	3000	3250	3500	3750	4000	4500	5000	5500	6500	7500	8500
Iteration 1	UNDR														
	DNDR														
	UNM														
	DNM														
	UINP														
	DINP														
	UDLY														
	DDLY														
	Time														
	Mode														
Iteration 2	UNDR														
	DNDR														
	UNM														
	DNM														
	UINP														
	DINP														
	UDLY														
	DDLY														
	Time														
	Mode														
Iteration 3	UNDR														
	DNDR														
	UNM														
	DNM														
	UINP														
	DINP														
	UDLY														
	DDLY														
	Time														
	Mode														

Group 2: Reach Rate Test for VDSL2 Automode North American Networks

Test V2RR.2.X, Noise Impairment XXXX, User Specified Profile X, Loops 0 - 10 kft, IOL Test ID: XXXX												
Length (ft)		0	1000	2000	3000	4000	5000	6000	7000	8000	9000	10000
Iteration 1	UNDR											
	DNDR											
	UNM											
	DNM											
	UINP											
	DINP											
	UDLY											
	DDLY											
	Time											
	Mode											
Iteration 2	UNDR											
	DNDR											
	UNM											
	DNM											
	UINP											
	DINP											
	UDLY											
	DDLY											
	Time											
	Mode											
Iteration 3	UNDR											
	DNDR											
	UNM											
	DNM											
	UINP											
	DINP											
	UDLY											
	DDLY											
	Time											
	Mode											

Test V2RR.2.X, Noise Impairment XXXX, User Specified Profile X, Loops 11 - 21 kft, IOL Test ID: XXXX												
Length (ft)		11000	12000	13000	14000	15000	16000	17000	18000	19000	20000	21000
Iteration 1	UNDR											
	DNDR											
	UNM											
	DNM											
	UINP											
	DINP											
	UDLY											
	DDLY											
	Time											
	Mode											
Iteration 2	UNDR											
	DNDR											
	UNM											
	DNM											
	UINP											
	DINP											
	UDLY											
	DDLY											
	Time											
	Mode											
Iteration 3	UNDR											
	DNDR											
	UNM											
	DNM											
	UINP											
	DINP											
	UDLY											
	DDLY											
	Time											
	Mode											

Annex B: Graphical Representation of the Test Procedure