TECHNICAL REPORT

TR-114

VDSL2 Performance Test Plan

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TR Issue History

Issue Number	Approval Date	Publication Date	Issue Editor	Changes
1	November 2009	November 2009	Arlynn Wilson, ADTRAN	Original
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Comments or questions about this Broadband Forum Technical Report should be directed to help@broadband-forum.org.

Editor	Aleksandra Kozarev	Intel
Physical Layer Transmission Work Area	Les Brown Massimo Sorbara	Huawei Technologies Qualcomm
Project Stream Leaders	Lincoln Lavoie Aleksandra Kozarev	UNH-IOL Intel

TABLE OF CONTENTS

List of Figures

List of Tables

Executive Summary

This Technical Report, TR-114, as part of the Broadband Suite, provides a set of region specific performance requirements and test methods for VDSL2 modems implemented in accordance with ITU-T G.993.2 (Very high speed Digital Subscriber Line transceivers 2). Its key value is in the verification of performance such that network operators may deploy consistent and successful VDSL2 services in their networks.

TR-114 accompanies TR-115 "*VDSL2 Functionality Test Plan*" and TR-138 "*Accuracy Tests for Test Parameters*". TR-115 defines the tests for verification of functional requirements (physical layer and system level) defined in ITU-T G.993.2. TR-138 defines the tests for verification of the accuracy of the reported test (Physical Layer OAM configuration and performance monitoring) parameters defined in ITU-T G.993.2 and G.997.1.

Changes made from Issue 2 to Issue 3:

(a) The following tests were removed:
- (1) *Tests with BA8b_RA_F_150_150*
- (2) *Tests with BA17a band-profile*
- (3) *Tests with BA30a band-profile*
- (4) *Tests with BB30a band-profile*
- (5) *Tests with BA12a band-profile*
- (6) *Tests with BA8c band-profile*

(b) The following tests were updated:
- (1) *Verification of CRC error reporting*
- (2) *Margin verification test*
- (3) *VDSL2oPOTS test cases for error reporting verification test*
- (4) *VDSL2oPOTS test cases for downstream margin verification test*
- (5) *VDSL2oPOTS test cases for upstream margin verification test*

(c) The following tests and/or sections were added:
- (1) *Performance tests with Class 1 Profile-line combination AA17a_UPBO_RA_R-17/2/41_150_096*
- (2) *Performance tests with Class 2 Profile-line combination AA17a_UPBO_RA_R-17/2/41_150_096*
- (3) *Performance tests with Class 1 Profile-line combination BA8b_RA_R-17/2/41_150_150*
- (4) *Performance tests with Class 1 Profile-line combination BA17a0_RA_R-17/2/41_150_150*
- (5) *Performance tests with BA17a0_RA_ I_150_150*
- (6) *Performance tests with Class 1 Profile-line combination BA17a0_D&UPBO_RA_R-17/2/41_150_150*
- (7) *Performance tests with BA17a0_ D&UPBO_RA_ I_150_150*

(8) *Rate adaptive performance tests for BA17ade_D&UPBO, retransmission disabled*
(9) *REIN testing for BA17ade_D&UPBO*
(10) *SHINE testing for BA17ade_D&UPBO*
(11) *Combined Noise Impairment for BA17ade_D&UPBO*
(12) *Long-reach low-noise test for BA17ade_D&UPBO*
(13) *Retransmission testing for profile BA17ade_D&UPBO*
(14) *Appendix VII Crosstalk impairment for Annex B performance tests*

1 Purpose and Scope

1.1 Purpose

TR-114 provides a set of performance requirements for VDSL2 (ITU-T G.993.2) modems. The contents includes the region specific requirements for North American, European and Japanese deployments which have been identified by the Broadband Forum as being of special importance for service operators' deployment.

1.2 Scope

This test plan facilitates VDSL2 over POTS and over ISDN performance testing. This test plan embodies definitions of VDSL2 interoperability between one DSLAM and one CPE at a time and focuses on physical layer testing, as well as validation and verification of selected higher layer functionalities (NOTE1).

NOTE1: There is no requirement for VDSL2 modems to interoperate with G.993.1 (VDSL1) CPE.

VDSL2 provides significant flexibility in transceiver functionality through configuration (e.g., band plans, PSDs, INP, delay) and therefore it is not practical to include tests for all possible combinations. Since network architectures and deployment practices vary greatly amongst service providers, the network conditions (loop models, noise models, loop lengths, etc.) were selected to represent nominal conditions under which dynamic (interoperability) performance is tested. This test plan is focused on ensuring laboratory repeatability such that equipment from different vendors can be easily validated and compared.

It is important to point out that this test plan does not replace operators' pre-deployment testing. Specific operator deployment and service requirements, as well as region specific regulatory requirements, could impose additional tests in addition to those described in this test plan.

The performance requirements defined in this test plan are based on DSLAM equipment, capable of providing the maximum allowable power. DSLAM equipment unable to provide this transmit power is considered to be out of the scope of this interoperability test plan.

This test plan also provides a set of performance requirements for two classes of retransmission enabled profiles:

1. Class 1 (Standard memory operation)
Performance requirements are applicable to systems supporting standard memory per ITU-T G.998.4 Annex C (NOTE2).
NOTE2: ITU-T G.993.5 vectoring functionality shall not be enabled.

2. Class 2 (Extended memory operation)

Performance requirements are applicable to systems supporting extended memory per ITU-T G.998.4 Annex D.

2 References and Terminology

2.1 Conventions

In this Technical Report, several words are used to signify the requirements of the specification. These words are always capitalized. More information can be found be in RFC 2119 [13].

SHALL	This word, or the term "REQUIRED", means that the definition is an absolute requirement of the specification.
SHALL NOT	This phrase means that the definition is an absolute prohibition of the specification.
SHOULD	This word, or the term "RECOMMENDED", means that there could exist valid reasons in particular circumstances to ignore this item, but the full implications need to be understood and carefully weighed before choosing a different course.
SHOULD NOT	This phrase, or the phrase "NOT RECOMMENDED" means that there could exist valid reasons in particular circumstances when the particular behavior is acceptable or even useful, but the full implications need to be understood and the case carefully weighed before implementing any behavior described with this label.
MAY	This word, or the term "OPTIONAL", means that this item is one of an allowed set of alternatives. An implementation that does not include this option SHALL be prepared to inter-operate with another implementation that does include the option.

2.2 References

The following references are of relevance to this Technical Report. At the time of publication, the editions indicated were valid. All references are subject to revision; users of this Technical Report are therefore encouraged to investigate the possibility of applying the most recent edition of the references listed below.
A list of currently valid Broadband Forum Technical Reports is published at www.broadband-forum.org.

	Document	Title	Source	Year
[1]	TR-115 Issue 3	*VDSL2 Functionality Test Plan*	BBF	2016
[2]	G.993.2	*Very high speed subscriber line transceivers 2 (VDSL2), including all in force amendments and corrigenda*	ITU-T	2015
[3]	G.998.4	*Improved impulse noise protection for DSL transceivers, including all in force amendments and corrigenda*	ITU-T	2015

[4]	G.997.1	*Physical Layer Management for Digital Subscriber Line (DSL) Transceivers, including all in force amendments and corrigenda*	ITU-T	2012
[5]	G.996.1	*Test procedures for digital subscriber line (DSL) transceivers*	ITU-T	2001
[6]	G.227	*Conventional Telephone Signal*	ITU-T	1988
[7]	TS 101 271 v1.2.1	*Access Terminals Transmission and Multiplexing (TM); Access transmission system on metallic pairs; Very High Speed digital subscriber line system (VDSL2)*	ETSI	2013
[8]	TS 101 388 v1.4.1	*Access Terminals Transmission and Multiplexing (ATTM); Access transmission systems on metallic access cables; Asymmetric Digital Subscriber Line (ADSL) - European specific requirements*	ETSI	2007
[9]	TS 101 952-2	*Access, Terminals, Transmission and Multiplexing (ATTM); Access network xDSL splitters for European deployment; Part 2: Generic specification of xDSL over ISDN splitters and xDSL universal splitters*	ETSI	2010
[10]	0600417	*Spectrum Management for Loop Transmission Systems*	ATIS	2015
[11]	RFC 1242	*Benchmarking Terminology for Network Interconnection Devices*	IETF	1991
[12]	RFC 2544	*Benchmarking Methodology for Network Interconnection Devices*	IETF	1999
[13]	RFC 2119	*Key words for use in RFCs to Indicate Requirement Levels*	IETF	1997

2.3 Definitions

The following terminology is used throughout this Technical Report.

Class 1	Standard memory operation - Performance requirements are applicable to systems supporting standard memory per ITU-T G.998.4 Annex C [3]. NOTE: ITU-T G.993.5 vectoring functionality shall not be enabled.
Class 2	Extended memory operation - Performance requirements are applicable to systems supporting extended memory per ITU-T G.998.4 Annex D [3].
fdelta	The maximum frequency separation between two consecutive samples of loop attenuation or noise power during calibration
micro-interuption	Disconnection of the loop for a very short time period
Net data rate (NDR)	Sum of net data rates of all bearer channels

Actual net data rate (ACTNDR)	Independent whether retransmission is used or not, this parameter reports the net data rate as defined in [4].
Actual data rate	If retransmission is not used, this parameter reports the actual net data rate (ACTNDR). If retransmission is used, this parameter reports the expected throughput rate (ETR), as defined in [4].
NULL loop	DSLAM/CPE wired "back to back"
Showtime	DSLAM and CPE trained up to the point of passing data
SOS	VDSL2 function defined to avoid retrains by rapid reduction of bandwidth

2.4 Abbreviations

This Technical Report uses the following abbreviations:

ADSL2	Asymmetric digital subscriber line transceivers 2
ADSL2plus	Asymmetric Digital Subscriber Line (ADSL) transceivers – Extended bandwidth ADSL2
ANSI	American National Standards Institute
ATIS	Alliance for Telecommunications Industry Solutions
ATP	Aggregate Transmit Power
AWG	American Wire Gauge
AWGN	Additive White Gaussian Noise
BER	Bit Error Rate
BT	Bridge Tap
CPE	Customer Premises Equipment (modem)
CRC	Cyclic Redundancy Check
CV	Code Violation
CO	Central Office
dB	decibels
dBm	decibels relative to milliwatts
DPBO	Downstream Power Backoff
DS	Downstream
DSLAM	Digital Subscriber Line Access Multiplexer
EDC	Erasure Decoding
EMI	Electromagnetic Interference
E2E	End-to-end

ES	Errored Second
ETSI	European Telecommunications Standards Institute
EU	Extended Upstream
EUT	Equipment Under Test
FEXT	Far-End Crosstalk
FX	Fixed rate mode
FPS	Frames Per Second
HI	High Impulse Noise Protection
High Z	High Impedance
IAT_REIN_RTX	REIN inter-arrival time for retransmission
ID	Identification
INP	Impulse Noise Protection
INPMIN	Minimum impulse noise protection for a system using 4.3125 kHz subcarrier spacing
INPMIN_REIN_RTX	Minimum impulse noise protection against REIN for retransmission for a system using 4.3125 kHz subcarrier spacing
INPMIN_SHINE_RTX	Minimum impulse noise protection against SHINE for retransmission for a system using 4.3125 kHz subcarrier spacing
INPMIN8	Minimum impulse noise protection for a system using 8.625 kHz subcarrier spacing
INPMIN8_REIN_RTX	Minimum impulse noise protection against REIN for retransmission for a system using 8.625 kHz subcarrier spacing
INPMIN8_SHINE_RTX	Minimum impulse noise protection against SHINE for retransmission for a system using 8.625 kHz subcarrier spacing
ISDN	Integrated Service Digital Network
ITU	International Telecommunications Union
L0	Link state zero
L3	Link state three
LEFTR_THRESH	Threshold for declaring a near-end "leftr" defect in retransisSion operation
MAC	Media Access Control
MAE	Mean Absolute Error
MAXNOMATP	Maximum Nominal Aggregate Transmit Power
MAXSNRM	Maximum Signal to Noise ratio Margin

MINSNRM	Minimum Signal to Noise ratio Margin
MD	Medium Density
ME	Mean Error
MIB	Management Information Base
MODEM	End user device or CPE. Concatenation of Modulator-Demodulator
NEXT	Near-End Crosstalk
NOMATP	Nominal Aggregate Transmit Power
OAM	Operations, Administration and Maintenance
OLR	On-line Reconfiguration
PE	Polyethylene
PE04	Test loop for Annex B testing
POTS	Plain Old Telephone Service
PSD	Power Spectral Density
PTM	Packet Transfer Mode
RA	Rate Adaptive mode
RFI	Radio Frequency Ingress
RTX_MODE	Mode of operation of G.998.4 [3] retransmission
RTXUC	Count of the number of uncorrected DTUs
SES	Severely Errored Second
SHINERATIO_RTX	SHINERATIO (loss of rate in a 1 second interval expressed as a fraction of NDR due to a SHINE impulse) in retransmission operation
SRA	Seamless Rate Adaptation
STP	Shielded Twisted Pair
SUT	System Under Test
TARSNRM	Target Signal to Noise ratio Margin
TR	Technical Report
TP100	Test loop for Annex B testing
UPBO	Upstream Power Backoff
US	Upstream
UTP	Unshielded Twisted Pair
VDSL2	Very high speed digital subscriber line transceivers 2
VLOOP-J1	Test loop for Annex C testing

VN	Virtual Noise
VTU	VDSL2 Transceiver Unit

3 Technical Report Impact

3.1 Energy Efficiency

TR-114 has no impact on energy efficiency.

3.2 Security

TR-114 has no impact on security.

3.3 Privacy

Any issues regarding privacy are not affected by TR-114.

4 Common Test Information

4.1 Compliance Requirements

Any DSLAM/CPE combination claiming TR-114 interoperability for a specific profile SHALL comply to the testing requirements for that profile. Any DSLAM/CPE combination claiming interoperability for several distinct profiles SHALL comply with each of the distinct profile test requirements.

A modem SHALL achieve at least the minimum required performance in every mandatory test with each DSLAM for which compliance is claimed, for each VDSL2 profile supported by the DSLAM/CPE pair.

5 Equipment Features

Reports of results obtained as a result of testing performed in accordance with TR-114 SHALL contain, at minimum, the information described in 5.1, 5.2 and 5.3.

5.1 EUT Information

Table 1 and Table 2 are intended to provide test engineers and readers of test reports with sufficient information about the EUT in order to ensure repeatability of results and to allow for accurate comparisons of reported test results. The tables SHALL be populated prior to the start of any testing and SHALL be included as part of any written test report. All fields SHALL be populated; if an item is not applicable to the EUT, the item MAY be marked as "Not Applicable".

Table 1: DSLAM information

DSLAM Manufacturer	
DSLAM Product Name/Model	
DSLAM system software release number	
Line Card Name/Model	
Line Card part number	
Line Card serial number	
Line Card software/firmware release number	
System Vendor ID	
Chipset HW version	
Chipset FW version	
VDSL2 Band-Profiles supported: – AA8d, AA8a, AA12a – BA8b, BA17a0, BA17ade – BB8b, BB12a, BB17a – CG8d, CG12a, CG17a, CG30a	
VDSL2 Band-Profiles tested	
VDSL2 optional features supported: – Virtual Noise	
VDSL2 optional features tested	
TPS-TC encapsulation supported: – PTM	
TPS-TC encapsulation tested	

Table 2: CPE information

CPE Manufacturer	
CPE Product Name/Model	
CPE software release number	
CPE serial number	
System Vendor ID	
Chipset Manufacturer	
Chipset HW version	
Chipset FW version	
VDSL2 Band-Profiles supported: – AA8d, AA8a, AA12a – BA8b, BA17a0, BA17ade – BB8b, BB12a, BB17a – CG8d, CG12a, CG17a, CG30a	
VDSL2 Band-Profiles tested	
VDSL2 optional features supported: – Virtual Noise – Erasure decoding	
VDSL2 optional features tested	
TPS-TC encapsulation supported: – PTM	
TPS-TC encapsulation tested	

Table 3: CO Splitter Information

Manufacturer	
Product Name/Model	
Version number	
Serial number	
Type (ISDN 2B1Q, ISDN 4B3T, etc.)	

Table 4: CPE Splitter Information

Manufacturer	
Product Name/Model	
Version number	
Serial number	

Type (ISDN 2B1Q, ISDN 4B3T, etc.)	

5.2 Temperature and Humidity

The ranges of temperature and humidity of the test facility, over the entire time tests are conducted, SHALL be recorded in a manner similar to that shown in Table 5 and SHALL be included as part of any written test report. The acceptable range of temperatures SHALL be between 15 °C (59 °F) and 35 °C (95 °F). The humidity SHALL be between 5% and 85%.

Table 5: Temperature and Humidity Range of Test Facility

Parameter	High	Low
Temperature		
Humidity		

5.3 Test Equipment Calibration

A TR-114 report SHALL contain test equipment calibration data.

All initial and subsequent ME, MAE values and background noise measurements for all of the loops and noise used during tests conducted in accordance with TR-114, SHALL be included as part of any written test report.

6 Testing Environments

This section contains all the specifications and information required for building the basic testing environment (e.g. test configurations, setup of the simulated network environment, main settings of the equipment under test) for VDSL2 test cases defined in this test plan. Different configurations and settings needed for specific test cases are defined in the related section.

6.1 Test Configurations

Physical layer testing MAY use test setups without data layer present as in Figure 1. Optionally, these tests MAY be performed with data layer (i.e. the router and traffic generator/analyzer) present as in Figure 2. When using the test setup with traffic analyzer present, the modem SHALL be set to a bridged configuration and the router configuration is OPTIONAL.

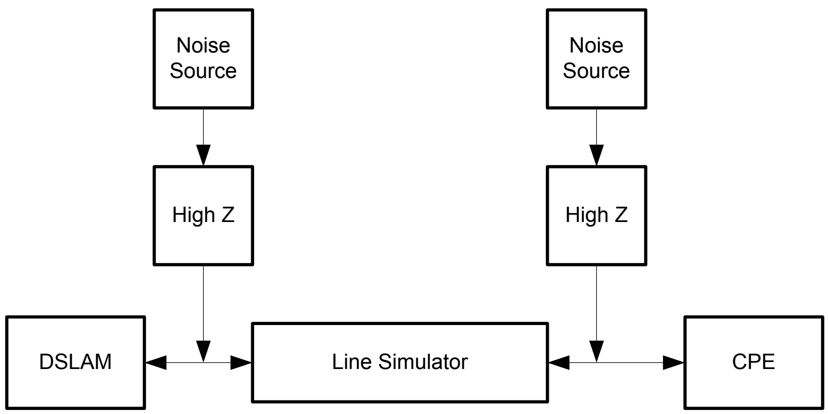

Figure 1: Test configuration for Annex A over POTS and Annex B over POTS testing

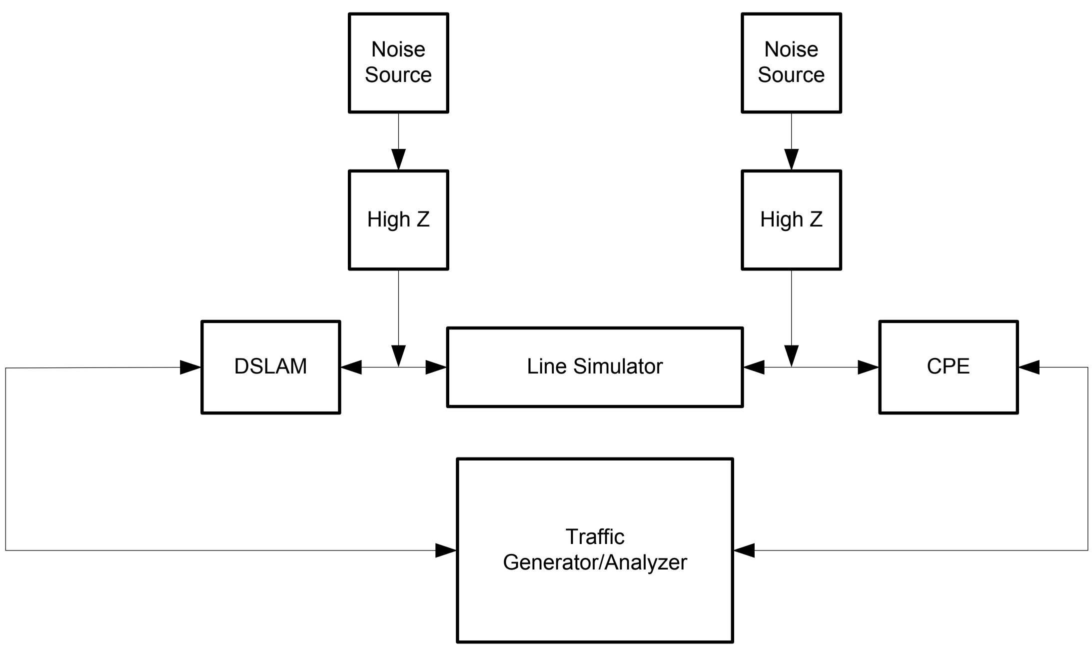

Figure 2: Test setup for configurations using data layer

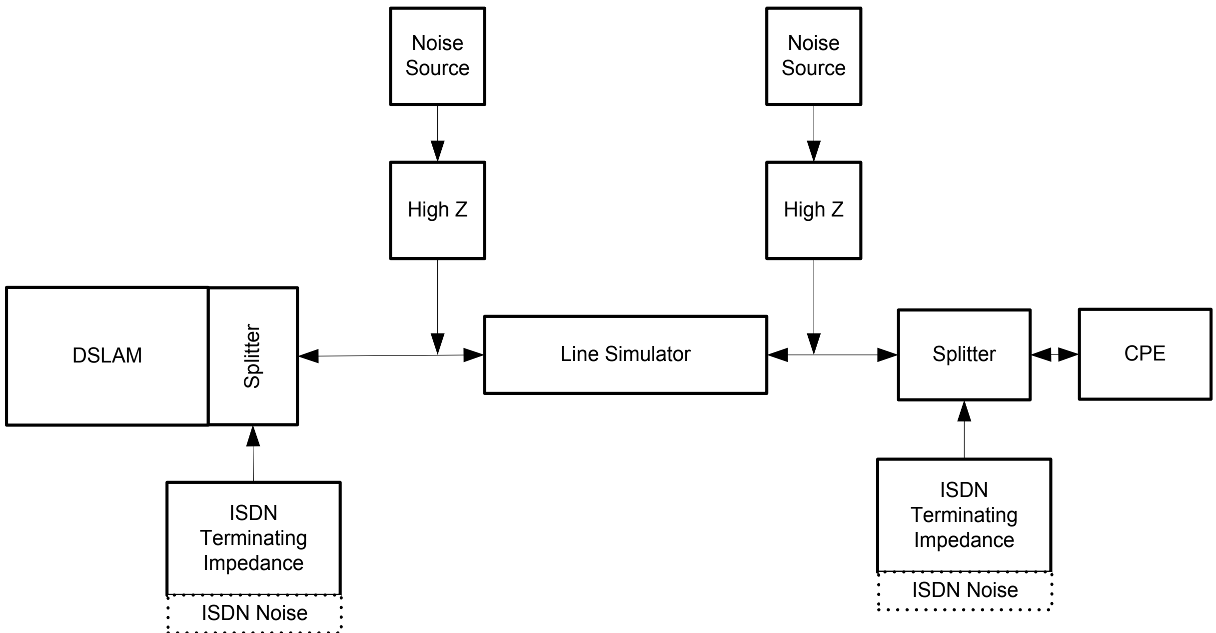

Figure 3: Test configuration for Annex B over ISDN and Annex C over TCM-ISDN testing

6.2 System Under Test Settings

6.2.1 Band Profiles

Band Profiles are used to describe the VDSL2 profile under test. The structure of the abbreviation used throughout the document for Band Profiles is as follows.

The abbreviation begins with a letter designating the G.993.2 [2] Annex to which the profile refers. The next letter refers to the US0 type of the profile, hence indicating profiles for

- AA: G.993.2 Annex A with US0 corresponding to Annex A of G.992.5 (VDSL2 over POTS)
- BA: G.993.2 Annex B with US0 corresponding to Annex A of G.992.5 (VDSL2 over POTS). Note that the same abbreviation is used for profile 17a where US0 is not available
- BB: G.993.2 Annex B with US0 corresponding to Annex B of G.992.5 (VDSL2 over ISDN)
- CG: G.993.2 Annex C (VDSL2 over TCM-ISDN). Note that US0 is not available.

The next symbols are the numeric and letter description of the profile itself (8d, 8b, 8c, 12a, 17a and 30a). Common band profiles are provided in Table 6.

Table 6: Common Band Profiles

Annex A				
VDSL2 Band - profile	AA8d	AA8a	AA12a	AA17a
Profile	8d	8a	12a	17a
Annex	A	A	A	A
Limit PSD Mask	Table A.1/G.993.2	Table A.1/G.993.2	Table A.1/G.993.2	Table A.1/G.993.2
US0 type	EU32 (see Table A.2/G.993.2)	EU32 (see Table A.2/G.993.2)	EU32 (see Table A.2/G.993.2)	EU32 (see Table A.2/G.993.2)
MAXNOMATPds	+14.5 dBm	+17.5 dBm	+14.5 dBm	+14.5 dBm
Annex B				
VDSL2 Band-profile	BA8b	BA17a0	BA17ade	
Profile	8b	17a	17a	
Annex	B	B	B	
Limit PSD Mask (short name)	998-M2x-A (B8-4)	998E17-M2x-A (B8-18)	998ADE17-M2x-A (B8-11)	
US0 type	A	A	A	
MAXNOMATPds	+20.5 dBm	+14.5 dBm	+14.5 dBm	
Annex B				
VDSL2 Band-profile	BB8b	BB12a	BB17a	
Profile	8b	12a	17a	
Annex	B	B	B	
Limit PSD Mask (short name)	998-M2x-B (B8-6)	998-M2x-B (B8-6)	998ADE17-M2x-B (B8-12)	
US0 type	B	B	B	
MAXNOMATPds	+20.5 dBm	+14.5 dBm	+14.5 dBm	
Annex C				
VDSL2 Band-profile	CG8d	CG12a	CG17a	CG30a
Profile	8d	12a	17a	30a
Annex	C	C	C	C

Limit PSD Mask (short name)	Tables C-9 and C-10/ G.993.2 (VDSL2 above TCM_ISDN band)	Tables C-9 and C-10/ G.993.2 (VDSL2 above TCM_ISDN band)	Tables C-9 and C-10/ G.993.2 (VDSL2 above TCM_ISDN band)	Tables C-9 and C-10/ G.993.2 (VDSL2 above TCM_ISDN band)
US0 type	N/A	N/A	N/A	N/A
MAXNOMATPds	+14.5dBm	+14.5dBm	+14.5dBm	+14.5dBm

6.2.2 Line Settings

6.2.2.1 Common Line Settings

This section defines the modem settings of parameters that are common to the configurations of the SUT in this test plan. Common line settings are provided in Table 7.

Table 7: List of common line settings for VDSL2 performance tests

Parameter	Setting	Description
All parameters but those specified below	Default value	
Power management state forced (PMSF)	0	
Power management state enabling (PMMode)	0	
Loop diagnostic mode forced (LDMF)	0	
Automode cold start forced	0	
DPBO	off	
UPBO	off	Activated for Annex A and Annex C tests. For Annex A tests, UPBO settings vary based on the profile under test.
RFI notches	off	
MAXSNRMds	$FFFF_{16}$	
MAXSNRMus	$FFFF_{16}$	
TARSNRMds	6 dB	
TARSNRMus	6 dB	
MINSNRMds	0 dB	
MINSNRMus	0 dB	
MSGMINds	16 kbps	
MSGMINus	16 kpbs	
Preemption option flag, ds	00_{16}	
Preemption option flag, us	00_{16}	
Short packet option flag, ds	00_{16}	
Short packet option flag, us	00_{16}	
FORCEINP	1	

6.2.2.2 General Line Settings

This section defines the profile, latency and INP settings of the SUT. Deviations from these modem settings are indicated in the description of each test or test section. General line settings are provided in Table 8.

Table 8: General line settings

General line-setting	Parameter	Setting	Description
F-1/0	$delay\_max_n$ ds	S1	Special value S1 as defined in Section 7.3.2.2/G.997.1 [4] indicating that S and D in the downstream SHALL be selected such that S ≤ 1 and D=1
	$delay\_max_n$ us	S1	Special value S1 as defined in Section 7.3.2.2/G.997.1 indicating that S and D in the upstream SHALL be selected such that S ≤ 1 and D=1
	INP_min_n ds	0 symbols	
	INP_min_n us	0 symbols	
I-8/2	$delay\_max_n$ ds	8 ms	
	$delay\_max_n$ us	8 ms	
	INP_min_n ds	2 symbols	
	INP_min_n us	2 symbols	
I-1/0	$delay\_max_n$ ds	S2	Special value S2 as defined in Section 7.3.2.2/G.997.1 indicating a delay bound of 1 ms in the downstream.
	$delay\_max_n$ us	S2	Special value S2 as defined in Section 7.3.2.2/G.997.1 indicating a delay bound of 1 ms in the upstream.
	INP_min_n ds	0 symbols	
	INP_min_n us	0 symbols	
I-32/16 *(not applicable for 30MHz profiles)*	$delay\_max_n$ ds	32 ms	
	$delay\_max_n$ us	32 ms	
	INP_min_n ds	16 symbols	
	INP_min_n us	16 symbols	
R-17/2/41 *(applicable for retransmission enabled profiles)*	RTX_MODE	2	RTX_FORCED
	IAT_REIN_RTX	0	REIN at 100Hz
	INPMIN_REIN_RTX	2	DMT symbols protection against REIN
	INPMIN_SHINE_RTX	41	DMT symbols protection

			against PEIN/SHINE
	SHINERATIO_RTX	2	Worst case PEIN retransmission overhead (in %)
	LEFTR_THRESH	0.78	Low rate defect threshold
	DELAYMAX_RTX	17	ms
	DELAYMIN_RTX	0	Outlet shaper off
NOTE 1: For profiles up to 17MHz, INPMIN SHALL be set to INP_min. For 30MHz profiles, INPMIN8 SHALL be set to 2×INP_min.			

6.2.2.3 Specific Line Settings

Nomenclature adopted for the specific line settings is as follows:

- The first two letters describe whether the SUT operates in rate adaptive (RA) or fixed rate (FX) mode
- The next one or two letters describe the profile latency and INP settings according to Table 9 (Fast "_F" or Interleaved "_I" and "_HI") or the retransmission enabled profile settings ("_R") according to Table 10.
- The following two numbers are the upper limits of the downstream and upstream rates rounded and expressed in Mbps.

Table 9: Specific line settings for F and I-FEC tests

Specific line-setting	General line-setting	RA-Mode	DS net data rate (NDR) (kbps) (max-min)	US net data rate (NDR) (kbps) (max-min)
RA_F_150_150	F-1/0	AT_INIT	150000-128	150000-64
RA_I_150_150	I-8/2	AT_INIT	150000-128	150000-64
FX_I_027_002	I-8/2	Manual	27000-27000	2000-2000
FX_I_014_001	I-8/2	Manual	14000-14000	1000-1000
FX_I_040_006	I-8/2	Manual	40400-40400	5700-5700
RA_I_096_056	I-8/2	AT_INIT	96000-256	56000-128
RA_I_105_105	I-1/0	AT_INIT	104960-64	104960-64
RA_HI_150_150	I-32/16	AT_INIT	150000-128	150000-64
RA_I_098_058	I-8/2	AT_INIT	98000-32	58000-32
RA_I_150_096	I-8/2	AT_INIT	150000-256	96000-128
FX_I_050_020	I-8/2	Manual	50000-50000	20000-20000
FX_I_050_015	I-8/2	Manual	50000-50000	15000-15000
FX_I_075_025	I-8/2	Manual	75000-75000	25000-25000
FX_I_080_015	I-8/2	Manual	80000-80000	15000-15000
FX_I_047_019	I-8/2	Manual	47000-47000	19000-19000
FX_I_033_014	I-8/2	Manual	33000-33000	14000-14000
FX_I_018_005	I-8/2	Manual	18000-18000	5000-5000
FX_I_010_002	I-8/2	Manual	10000-10000	2000-2000
FX_HI_011_004	I-32/16	Manual	11000-11000	4000-4000
FX_HI_009_003	I-32/16	Manual	9000-9000	3000-3000

Table 10: Specific line settings for Retransmission enabled tests

Specific line-setting	DS General line-setting	US General line-setting	RA-Mode	DS Expected throughput and net data rate (kbps) (ETR_RTX) (max-min) (NDR)(kbps) (max)	US Expected throughput and net data rate (kbps) (ETR_RTX) (max-min) (NDR)(kbps) (max)
RA_R-17/2/41_150_150	R-17/2/41	R-17/2/41	AT_INIT	MAXETR_RTX=150000 MAXNDR_RTX=150000 MINETR_RTX=518	MAXETR_RTX=150000 MAXNDR_RTX=150000 MINETR_RTX=518
FX_R-17/2/41_050_020	R-17/2/41	R-17/2/41	Manual	MAXETR_RTX=50000 MAXNDR_RTX=50000 MINETR_RTX=50000	MAXETR_RTX=20000 MAXNDR_RTX=20000 MINETR_RTX=20000

6.2.3 Profile Line Combinations

Common band-profiles as described in section 6.2.1 above are combined with line settings described in section 6.2.2 to specify the common settings for a system under test. Without enumerating each combination a new nomenclature is formed using the concatenation of the two common setting nomenclatures. Table 11 provides a few examples of these combinations without a complete listing of all of the expected combinations. Actual combinations to be used in Annex A, Annex B and Annex C testing SHALL be specified in the test setup description as listed in appendix C.

Table 11: Concatenated common settings, testing combination description

Band-profile	Specific line-setting	Profile-line combination
AA8d	RA_I_096_056	AA8d_UPBO_RA_I_096_056
AA12a	RA_I_098_058	AA12a_UPBO_RA_I_098_058
AA17a	RA_I_150_096	AA17a_UPBO_RA_I_150_096
BB17a	RA_F_150_150	BB17a_RA_F_150_150
BA17a0	RA_R-17/2/41_150_150	BA17a0_RA_R-17/2/41_150_150
etc.	etc.	etc.

6.2.4 Test Plan Passing Criteria

For an SUT to pass this Test Plan for one of the VDSL2 band-profiles defined in Table 6, it is required that the SUT pass the set of physical layer performance test cases, common and region specific applicable to that band-profile as well as higher layer test cases if applicable to that band-profile and supported type of the TPS-TC layer.

6.3 Test Setup

6.3.1 Splitter Requirements

6.3.1.1 Splitter Requirements for Annex B Testing

Splitter requirements for Annex B are as defined in TS 101 952-2 [9].

6.3.1.2 Splitter Requirements for Annex C Testing

Splitter requirements for Annex C are as defined in G.993.2 Annex C §C.5 (Service Splitter), [2]. ISDN ports of ISDN splitters SHALL be terminated by 110 ohms.

6.3.2 Loop Models

6.3.2.1 Loop Models for Annex A Testing

The common loop models for Annex A performance testing consist of both straight loops and loops with bridged taps (BT). The 26 AWG loops are defined in Table 12. The 26 AWG bridged tapped loops have the topology shown in Figure 4.

Table 12: 26 AWG straight test loops for Annex A testing

	Initial Length (ft)	Final Length (ft)	Increment (ft)	# of Loops
Very Short	300	900	300	3
Short	1200	4000	400	8
Medium	4500	4500	500	1
Long	5500	8500	1000	4

Figure 4: North American bridged tap topology

6.3.2.2 Loop Models for Annex B testing

For test cases applicable to systems using G.993.2 Annex B (Europe) the loop types are straight homogeneous loops PE04 and TP100 defined in TS 101 271 [7] Annex A. Loop type PE04 SHALL be used for all Annex B band profiles (Table 6), except the BA17ade, for which the loop TP100 SHALL apply.

6.3.2.3 Loop Models for Annex C testing

For test cases applicable to systems using G.993.2 Annex C (Japan), the loop type is VLOOP-J1 (0.4mm PE cables with straight homogeneous loop topologies) as defined in G.993.2 section C.6.1, [2].

6.3.3 Noise Models

This section specifies noise models relevant for the execution of the test cases defined within this test plan. Given the broad set of VDSL2 configuration options and of relevant legacy broadband deployments (ADSL1/2/2plus, SDSL, ISDN, …), the number of possible reference noise scenarios MAY become quite high. The reference noise models specified for this Test Plan have been chosen as a reasonable compromise between covering a challenging set of noise conditions while keeping a manageable overall number of tests.

6.3.3.1 Noise Models for Annex A testing

The noise used for testing of AA8d band-profile is derived using a piece-wise continuous downstream transmit level having total power equal to the maximum nominal power of the SUT. The VDSL2 transmit spectrum used to calculate the crosstalk noise is defined in Table 13. The ADSL2plus transmit spectrum used to calculate the crosstalk noise are defined in Table 17 and Table 18. These transmit spectra are then used with the FEXT and NEXT coupling functions described in ATIS 0600417 [10] Annex A to produce the crosstalk noise for each loop length. Tables with the AA8d crosstalk noise are provided for information only in Appendix D, Table 186 and Table 187.

Table 13: VDSL2 transmit level for noise calculations for AA8d

Loops ≤ 3600ft		Loops ≤ 4000ft		Loops > 3600ft		Loops > 4000ft	
Downstream		Upstream		Downstream		Upstream	
Freq (kHz)	PSD (dBm/Hz)	Freq (kHz)	PSD (dBm/Hz)	Freq (kHz)	PSD (dBm/Hz)	Freq (kHz)	PSD (dBm/Hz)
0	-101	0	-101	0	-101	0	-101
3	-101	3	-101	3	-101	3	-101
4	-93.0	4	-96.0	4	-93.0	4	-96.0
80.0	-76.0	25.875	-37.3	80.0	-76.0	25.875	-36.0
138.0	-53.1	138	-37.3	138.0	-50.4	138	-36.0
1447	-53.1	242.9	-93.2	1622	-50.4	242.9	-93.2
3488	-53.1	686	-103	1840	-50.4	686	-103
3749	-53.5	1200	-110	3749	-53.5	1200	-110
3750	-80.0	2200	-115	3750	-80.0	2200	-115
3925	-100	3450	-110	3925	-100	30000	-115
4500	-112	3575	-103	4500	-112		
5025	-103	3750	-80.0	12000	-112		
5200	-80.0	3751	-53.0	30000	-112		
5201	-55.0	5199	-53.0				
8499	-55.0	5200	-80.0				
8500	-80.0	5375	-100				
8675	-107	5500	-115				
12000	-112	8200	-115				
30000	-112	30000	-115				

The VDSL2 transmit spectrum used to calculate the crosstalk noise for AA8a is defined in Table 14.

Table 14: VDSL2 transmit level for noise calculations for AA8a

Loops ≤ 3600ft Downstream		Loops ≤ 4000ft Upstream		Loops > 3600ft Downstream		Loops > 4000ft Upstream	
Freq (kHz)	**PSD (dBm/Hz)**	**Freq (kHz)**	**PSD (dBm/Hz)**	**Freq (kHz)**	**PSD (dBm/Hz)**	**Freq (kHz)**	**PSD (dBm/Hz)**
0	-101	0	-101	0	-101	0	-101
3	-101	3	-101	3	-101	3	-101
4.1	-93	4	-96	4.1	-93	4	-96
80	-76	25.875	-37.3	80.0	-76	25.875	-36
138	-46.6	138	-37.3	138.0	-45.3	138	-36
1447	-46.6	242.9	-93.2	1375	-45.3	242.9	-93.2
1622	-50	686	-103	1622	-50	686	-103
3749	-53.5	1200	-110	3749	-53.5	1200	-110
3750	-80	2200	-115	3750	-80	2200	-115
3925	-100	3450	-110	3925	-100	5500	-115
4500	-112	3575	-103	4500	-112	8200	-115
5025	-103	3750	-80	12000	-112	30000	-115
5200	-80	3751	-53	30000	-112		
5201	-55	5199	-53				
8499	-55	5200	-80				
8500	-80	5375	-100				
8675	-107	5500	-115				
12000	-112	8200	-115				
30000	-112	30000	-115				

The VDSL2 transmit spectrum used to calculate the crosstalk noise for AA12a is defined in Table 15.

Table 15: VDSL2 transmit level for noise calculations for AA12a

Loops ≤ 2800ft		Loops ≤ 3600ft		2800ft<Loops ≤ 4000ft		Loops > 3600ft		Loops > 4000ft	
Upstream		Downstream		Upstream		Downstream		Upstream	
Freq (kHz)	PSD (dBm/ Hz)	Freq (kHz)	PSD (dBm/ Hz)	Freq (kHz)	PSD (dBm/ Hz)	Freq (kHz)	PSD (dBm/ Hz)	Freq (kHz)	PSD (dBm/ Hz)
0	-101	0	-101	0	-101	0	-101	0	-101
3	-101	3	-101	3	-101	4	-101	3	-101
4	-96	4.1	-93	4	-96	4.1	-93	4	-96
25.875	-37.3	80	-76	25.875	-37.3	80	-76	25.875	-36
138	-37.3	138	-53.1	138	-37.3	138	-50.4	138	-36
242.9	-93.2	3448	-53.1	242.9	-93.2	3488	-50.4	242.9	-93.2
686	-103	3749	-53.5	686	-103	3749	-53.5	686	-103
1200	-110	3750	-80	1200	-110	3750	-80	1200	-110
2200	-115	3925	-100	2200	-115	3925	-103	2200	-115
3450	-110	4500	-112	3450	-110	4500	-112	8501	-115
3575	-103	5025	-103	3575	-103	5025	-112	30000	-115
3750	-80	5200	-80	3750	-80	5200	-112		
3751	-53	5201	-55	3751	-53	5201	-112		
5199	-53	8499	-55	5199	-53	8499	-112		
5200	-80	8500	-80	5200	-80	8500	-112		
5375	-100	8675	-107	5375	-100	8675	-112		
5500	-115	12000	-112	5500	-115	12000	-112		
8200	-115	30000	-112	30000	-115	30000	-112		
8325	-100								
8500	-80								
8501	-54								
11999	-54								
12000	-80								
12175	-107								
12300	-112								
30000	-115								

The VDSL2 transmit spectrum used to calculate the crosstalk noise for AA17a is defined in Table 16.

Table 16: VDSL2 transmit level for noise calculations for AA17a

Loops ≤ 2200ft		Loops ≤ 2800ft		2200ft<Loops ≤ 3600ft		2800ft<Loops ≤ 4000ft	
Downstream		**Upstream**		**Downstream**		**Upstream**	
Freq (kHz)	**PSD (dBm/Hz)**	**Freq (kHz)**	**PSD (dBm/Hz)**	**Freq (kHz)**	**PSD (dBm/Hz)**	**Freq (kHz)**	**PSD (dBm/Hz)**
0	-101	0	-101	0	-101	0	-101
3	-101	3	-101	3	-101	3	-101
4.1	-93.0	4	-96	4.0	-93.0	4	-96
80	-76.0	25.875	-60	80	-76.0	25.875	-54
138	-54.8	138	-60	138	-53.1	138	-54
3488	-54.8	242.9	-93.2	3488	-53.1	242.9	-93.2
3749	-54.5	686	-103	3749	-53.5	686	-103
3750	-80	1200	-110	3750	-80	1200	-110
3925	-100	2200	-115	3925	-103	2200	-115
4500	-112	3450	-110	4500	-112	3450	-110
5025	-103	3575	-103	5025	-112	3575	-103
5200	-80	3750	-80	5200	-80	3750	-80
5201	-55	3751	-53	5201	-55	3751	-53
8499	-55	5199	-53	8499	-55	5199	-53
8500	-80	5200	-80	8500	-80	5200	-80
8675	-107	5375	-100	8675	-107	5375	-100
10500	-115	5500	-115	12000	-112	5500	-115
11825	-115	8200	-115	30000	-112	30000	-115
12000	-80.0	8325	-100				
12001	-60.0	8500	-80				
17664	-60.0	8501	-54				
21000	-80.0	11999	-54				
21450	-107	12000	-80				
30000	-112	12175	-107				
		12300	-112				
		30000	-115				
NOTE: the testing of AA17a band-profile is limited to 1600ft so PSDs described beyond that are for information only.							

Table 17: ADSL2plus downstream transmit level for noise calculations

Frequency Range (kHz)	PSD (dBm/Hz)
0 < freq ≤ 4	-101.0
4 < freq ≤ 80	$-96.0 + 4.63 \times \log_2(freq/4)$
80 < freq ≤ 138	$-76.0 + 36.98 \times \log_2(freq/80)$
138 < freq ≤ 1104	-40.0
1104 < freq ≤ 1622	$-40 - 18.02 \times \log_2(freq/1104)$
1622 < freq ≤ 2208	$-50 - 2.92 \times \log_2(freq/1622)$
2208 < freq ≤ 2500	$-51.3 – 64.74 \times \log_2(freq/2208)$

2500 < freq ≤ 3001.5	$-62.9 – 78.10 \times \log_2(freq/2500)$
3001.5 < freq ≤ 3175	$-83.5 – 246.69 \times \log_2(freq/3001.5)$
3175< freq ≤ 3750	-103.5
3750< freq ≤ 4545	$-103.5 – 36.05 \times \log_2(freq/3750)$
4545 < freq	-113.5

Table 18: ADSL2plus upstream transmit level for noise calculations

Frequency Range (kHz)	PSD (dBm/Hz)
0 < freq ≤ 4	-101.0
4 < freq ≤ 25.875	$-96.0 + 21.5 \times \log_2(freq/4)$
25.875 < freq ≤ 138	-38.0
138 < freq ≤ 243	$-38 - 72.0 \times \log_2(freq/138)$
243< freq ≤ 686	$-97.0 – 15.0 * \log_{10}(freq/243)$
686 < freq ≤ 1411	-110
1411 < freq ≤ 30000	-112

6.3.3.2 Noise Models for Annex B testing

Noise models for Annex B testing of the 8b, 12a and 17a VDSL2 over POTS and VDSL2 over ISDN systems consist of two components, self crosstalk and alien crosstalk. This excludes the noise model n_BA17ade_D&UPBO that is purely self crosstalk. The noise models represent medium density scenarios MD_EX and MD_CAB27 where the SUT is deployed:

- from the local exchange (MD_EX);
- from a street cabinet located at 27 dB attenuation(at 1 MHz) from the local exchange (MD_CAB27);

For each of the noise models the number of self disturbers and a link to the equivalent alien noise PSD profiles is provided together with the associated VDSL2 band-profile in Table 19. Noise models for the band-profiles with the activated DPBO and UPBO are defined in appropriate performance sections. In general, the self-disturber PSD SHALL always be associated to the band-profile.

Table 19: Noise models for Annex B testing

Noise model	Band-profile	ETSI noise scenario	Number of self disturbers	Alien noise disturber frequency profiles
n_BA8b	BA8b	MD_EX	13	see Annex D.1
n_BB8b	BB8b	MD_EX		
n_BB12a	BB12a	MD_CAB27	15	See Annex D.2
n_BA17a0	BA17a0	MD_CAB27		

n_BB17a	BB17a	MD_CAB27		
n_BA17ade	BA17ade	N/A	19	N/A

6.3.3.3 Noise Models for Annex C testing

The noise models for Annex C are defined in Section 6.2/G.993.2. The noise is injected at either the DSLAM or CPE per Figure 3.

- AWGN = -140dBm/Hz AWGN; impairment to VDSL2 downstream and upstream signals.
- XTr = 9 VDSL2 self NEXT and FEXT (99% cumulative case); impairment to the received signal at CPE (VDSL2 downstream signal).
- XTc = 9 VDSL2 self NEXT and FEXT (99% cumulative case); impairment to the received signal at DSLAM (VDSL2 upstream signal).

Where, XTr and XTc are simulated from the disturber PSD of CG30a band-profile, and are applied to all band-profile test cases.

Four kinds of the noise sources are used for testing.

1. AWGNr SHALL be injected at the CPE input port side.
2. AWGNc SHALL be injected at the DSLAM input port side.
3. (XTr+AWGNr) SHALL be injected at the CPE input port side.
4. (XTc+AWGNc) SHALL be injected at the DSLAM input port side.

Where, "+" expresses power sum.

6.3.4 Noise Injection

The Thevenin impedance of all differential noise-coupling circuits connected to the test loop SHALL be greater than 4000 Ohms referred to a 100 Ohm impedance point (Section 5.1.2.1/G.996.1 [5]) for a frequency range from 20kHz to 30 MHz.

7 Test Equipment Requirements and Calibration

The following list of test equipment are used in VDSL2 performance testing:

- Loop simulator
- Traffic generator/analyzer with matching network interfaces
- Noise sources for both ends of the line (loop simulator integral noise sources or arbitrary waveform generators)

All these tools are part of configurations identified in Figure 1 − Figure 3.

7.1 Accuracy of loop simulators and noise sources

7.1.1 Loop Simulators

7.1.1.1 Attenuation

For the loop simulator used in testing, the simulated loop attenuation SHALL be measured over the frequency band (f1, f2) given by Table 20 for the different annexes. At least one measurement SHALL be made per fdelta interval. The Mean Error (ME) and Mean Absolute Error (MAE) of the measured simulated loop attenuation values (in dB), relative to the theoretical loop attenuation values (in dB), SHALL be calculated.

7.1.1.1.1 North American Annex A testing

Loop Attenuation, which corresponds to the insertion loss, is expressed in dB and SHALL be calculated from RLCG parameters using two-port ABCD modeling methodology as specified in Section C.3.1/ATIS 0600417 [10] (for both straight loops and loops with bridge taps).

The RLCG cable parameters SHALL be as specified in Table C.2 "Cable model parameters for 26 AWG twisted pair cable" and Table C.6 "Cable model parameters for 24 AWG twisted pair cable" of ATIS 0600417.

7.1.1.1.2 European Annex B testing

Loop Attenuation, which corresponds to the insertion loss, is expressed in dB and SHALL be calculated from RLCG parameters using two-port ABCD modeling methodology as specified in Section C.3.1/ATIS 0600417 [10]. The line constants for PE04 and TP100 cables are specified in Table 8.1 of TS 101 271 [7].

7.1.1.1.3 Japanese Annex C testing

Loop Attenuation which corresponds to the insertion loss expressed in dB SHALL be calculated from RLCG parameters as specified in Section C.6.1.2 and C.6.1.3 of G.993.2 [2].

7.1.1.1.4 Calibration Related Information

Frequency boundaries used for defining test calibration are provided in Table 20.

Table 20: Loop calibration frequency boundaries for VDSL2

Profile	Band Plan	f1 (kHz) over POTS	f1 (kHz) over ISDN	f1 (kHz) over TCM-ISDN	f2 (MHz)	fdelta (kHz)
8a, b, c, d	998	24	120	640	8.520	12
	997	24	120	N/A	8.844	12
12a	998	20	120	640	12.000	20
	997	20	120	N/A	12.000	20
12b	998	120	120	N/A	12.000	20
	997	120	120	N/A	12.000	20
17a	998	120	120	640	17.670	30
	997	120	120	N/A	17.670	30
30a	998	150	250	640	30.000	50
	997	150	250	N/A	30.000	50

NOTE: Other loop calibration frequency boundaries MAY be required for testing band profiles beyond those specified in this document.

The maximum attenuation A_{max} for use in estimating MAE and ME for the loop simulator SHALL be used from the frequency dependent Table 21.

Table 21: Maximum attenuation for loop simulator calibration

Frequency (MHz)	A_{max} (dB) (NOTE)
0.025	90
1.104	90
1.622	85
3.750	82
5.200	82
7.500	80
15.00	80
15.05	70
30.00	70
NOTE: Values of Amax in between the frequency points SHALL be interpolated using a log frequency scale.	

Mean Absolute Error (MAE) and Mean Error (ME) for loop X are given by:

Formula 7- 1: Determining MAE

$$\mathrm{MAE}_{\mathrm{LoopX}} = \frac{1}{N_i + N_j} \cdot \left[\sum_{i \in \{A_{Ti} \le A_{\max j}\}} \left| A_{Ri} - A_{Ti} \right| + \sum_{j \in \left\{ \substack{A_{Tj} > A_{MAXj} \\ A_{Rj} - A_{MAXj} < -0.5} \right\}} \left| A_{Rj} - A_{MAX_j} \right| \right]$$

Formula 7- 2: Calculating ME

$$\mathrm{ME}_{\mathrm{LoopX}} = \frac{1}{N_i + N_j} \cdot \left[\sum_{i \in \{A_{Ti} \le A_{\max j}\}} \left(A_{Ri} - A_{Ti} \right) + \sum_{j \in \left\{ \substack{A_{Tj} > A_{MAXj} \\ A_{Rj} - A_{MAXj} < -0.5} \right\}} \left(A_{Rj} - A_{MAX_j} \right) \right]$$

[positive error = too much attenuation]

A_{Ri} = Attenuation sample, in dB, of the measured loop X
A_{Ti} = Attenuation sample, in dB, of the theoretical loop X

The index “i” belongs to a set defined by the points necessary to measure the attenuation in steps of fdelta or less and taking into account only those points between f1 and f2 for which $A_T \le A_{Max}$ dB .

N_i is the number of elements in the above set.

The index “j” belongs to a set defined by the points necessary to measure the attenuation in steps of fdelta or less and taking into account only those points between f1 and f2 for which $A_T > A_{Max}$ dB and $A_R - A_{Max} < -0.5$ dB

N_j is the number of elements in the above set.

The loop simulator SHALL be compensated by adjusting the loop length such that the absolute value of ME is minimized while maintaining an MAE less than 0.5 dB. This accuracy requirement SHALL apply for all test loops.

7.1.1.2 Average noise floor

The average noise floor in the wireline simulator SHALL be lower than –150 dBm/Hz within the VDSL2 band.

7.1.1.3 Impedance

7.1.1.3.1 Input impedance for North American Annex A testing

Input Impedance SHALL be calculated from RLCG parameters using two-port ABCD modeling methodology as specified in Section C.3.1/ATIS 0600417 [10] (for both straight loops and loops with bridge taps).

The RLCG cable parameters SHALL be as specified Table C.2 "Cable model parameters for 26 AWG twisted pair cable" and Table C.6 "Cable model parameters for 24 AWG twisted pair cable" of ATIS 0600417.

7.1.1.3.2 Input impedance for European Annex B testing

Input impedances SHALL be calculated from RLCG parameters using two-port ABCD modeling methodology as specified in Section C.3.1/ATIS 0600417 [10]. The line constants for PE04 and TP100 cables are specified in Table 8.1 of TS 101 271 [7].

7.1.1.3.3 Impedance compensation method

The impedance compensation SHALL be based on a difference in injected noise power (for capturing the impact on the data rate).

The difference in injected noise power due to the variance of the input impedance of the wireline simulator SHALL have a mean absolute error (MAE) of less than 0.5 dB from the injected noise power using the theoretical input impedance, measured with the 100 Ohm termination impedance.

The difference in injected noise power is calculated in dB according to Formula 7- 3.

Formula 7- 3: Noise injection power difference calculation

$$\Delta p_i = 10 \cdot \log_{10}(p_{out}^{sim}) - 10 \cdot \log_{10}(p_{out}^{loop})$$

$$= 10 \cdot \log_{10}\left(\left| \frac{Z_{in,sim}^{R}(f_i) \cdot Z_L(f_i)}{Z_{in,sim}^{R}(f_i) + Z_L(f_i)} \right|^2 \right) - 10 \cdot \log_{10}\left(\left| \frac{Z_{in,loop}^{R}(f_i) \cdot Z_L(f_i)}{Z_{in,loop}^{R}(f_i) + Z_L(f_i)} \right|^2 \right) \text{ dB}$$

where:

f_i = frequency at sample i

p_{out}^{sim} = simulated noise power at frequency i

p_{out}^{loop} = measured noise power at frequency i

$Z_{in,sim}^{R}$ = theoretical input impedance

$Z_{in,loop}^{R}$ = actual input impedance

The mean absolute error is defined in Formula 7- 4.

Formula 7- 4: Input impedance MAE

$$MAE(\Delta p) = \frac{1}{N_{bins}} \sum_i |\Delta p_i|$$

where:

$MAE(\Delta p)$ = Mean Absolute Error

N_{bins} = number of noise power samples

$\Delta p_i = i^{\text{th}}$ power difference defined in formula 7 – 3

and the sum is over those bins in the passband where the insertion loss is less than 90 dB.

7.1.1.3.4 Input impedance for Japanese Annex C testing

Input Impedance SHALL be calculated from RLCG parameters as specified in Section C.6.1.2 and C.6.1.3 of G.993.2.

7.1.1.4 Phase

7.1.1.4.1 North American Region

Phase SHALL be calculated from RLCG parameters using two-port ABCD modeling methodology as specified in Section C.3.1/ATIS 0600417 [10] (for both straight loops and loops with bridge taps). The RLCG cable parameters SHALL be as specified in Table C.2 "Cable model parameters for 26 AWG twisted pair cable" and Table C.6 "Cable model parameters for 24 AWG twisted pair cable" of ATIS-0600417.

7.1.1.4.2 European Region

Phase SHALL be calculated from RLCG parameters using two-port ABCD modeling methodology as specified in Section C.3.1/ATIS 0600417 [10]. The line constants for PE04 and TP100 cables are specified in Table 8.1 of TS 101 271 [7].

Mean Average Percentage Error for Phase delay SHALL be defined as in Formula 7- 5.

Formula 7- 5:Mean average percent error

$$\mathrm{MAPE(PD)} = 100 \times \frac{1}{\mathrm{N}} \times \sum_{\mathrm{N}} \left| \frac{\mathrm{PD_{cable}} - \mathrm{PD_{sim}}}{\mathrm{PD_{cable}}} \right|$$

where:

- Phase Delay(f) = unwrapped(phase(f))/ ($2\pi f$)
- f is the frequency
- PD_{cable} is the Phase Delay for a theoretical loop, and
- PD_{sim} is the measured Phase Delay for the simulator,
- N is the number of frequencies used in the averaging.

Mean Average Percentage Error for Group Delay SHALL be defined as in Formula 7- 6.

Formula 7- 6: Group delay mean average percentage error

$$\mathrm{MAPE(GD)} = 100 \times \frac{1}{N} \times \sum_{N} \left| \frac{GD_{cable} - GD_{sim}}{GD_{cable}} \right|$$

w

here:

- GD_{cable} is the Group delay for a theoretical loop
- GD_{sim} is the measured Group delay for the simulator,
- N is the number of frequencies used in the averaging.

Points where $|GD_{cable}|$ is ≤ 0.1 microseconds SHALL NOT be included in the sum and N SHALL be adjusted accordingly.

The maximum MAPE(PD) SHALL be 7%.
The maximum MAPE(GD) SHALL be 7%.

The measurement of PD and GD, as defined above, SHALL be made over the frequency range appropriate to the profile, as defined in Table 20. The lowest frequency measured SHALL be as defined in Table 20, the highest frequency measured SHALL be the lower frequency of EITHER of the following:

1. The lowest frequency where the insertion loss begins to exceed Amax.
2. The highest frequency defined for the profile, as in Table 20.

At least one PD and GD measurement SHALL be made within each fdelta interval, as defined in Table 20.

The Group delay is defined using the Formula 7- 7.

Formula 7- 7: Group delay formula

$$GD_i = \frac{phase_{i-1} - phase_{i+1}}{2\pi \times (f_{i+1} - f_{i-1})}$$

w

here:

- phase is the unwrapped phase in radians
- the difference in frequency between f_{i+1} and f_i SHALL be fdelta as per Table 20

GD is not calculated or used at the two end frequency points.

7.1.2 Noise sources

Each noise SHALL be measured independently at the VTU terminal. This SHALL be done for one noise source at a time, using a NULL loop. For North American cases, both VTUs are replaced by an 100 Ohm (±1%) resistor. For European cases the methodology in Section 7.1.1 of TS 101 271 [7]. SHALL be used, with both VTUs each replaced by an 100 Ohm (±1%) resistor. The measured noise will be impacted by the noise generator tolerance, the coupling circuit tolerance, cabling tolerance and noise pickup.

At least one measurement SHALL be made per 10 kHz interval. The Mean Error (ME) and Mean Absolute Error (MAE) of the measured simulated noise level values (in dBm/Hz), relative to the theoretical noise level values (in dBm/Hz), SHALL be calculated. The noise calibration frequency ranges f1 and f2 for testing of the various VDSL2 profiles SHALL be identical to the frequencies specified for loop calibration for the same tests (see Table 20).

Mean Absolute Error (MAE) and Mean Error (ME) for noise X are given by:

Formula 7- 8: Noise MAE calculation

$$\mathrm{MAE}_{\mathrm{noise\ X}} = \frac{1}{M} \sum_{i \in \left\{ P_{Ti} \geq -140 dBm/Hz \right\}} \left| P_{Ri} - P_{Ti} \right|$$

Formula 7- 9: Noise ME calculation

$$\mathrm{ME}_{\mathrm{noise\ X}} = \frac{1}{M} \sum_{i \in \left\{ P_{Ti} \geq -140 dBm/Hz \right\}} \left(P_{Ri} - P_{Ti} \right)$$

NOTE: Positive error indicates excessive noise power.

where:
P_{Ri} = power sample, in dBm/Hz, of the generated noise X
P_{Ti} = power sample, in dBm/Hz, of the theoretical noise X

The index “i” belongs to a set defined by the points necessary to measure the noise power in steps of fdelta or less and taking into account only those points between f1 and f2 for which $P_{Ti} \geq -140$ dBm/Hz.

N is the number of elements in the above set. Noise measurement resolution bandwidth SHALL be 10 kHz.

The noise generator SHALL be compensated such that the absolute value of ME is minimized while maintaining an MAE less than 0.5 dB.

NOTE: For noise calibration, there is measurement uncertainty that can not be compensated, consisting of the following contributions:

1. absolute amplitude accuracy
2. vertical linearity
3. frequency response of the measurement equipment used
4. tolerance of the calibration impedance.

7.1.2.1 Noise Impairment Cumulative Amplitude Distribution

7.1.2.1.1 North American Region

Noise impairments used in this specification for Annex A (North America) SHALL comply with the following specifications. The theoretical noise level SHALL have a Gaussian amplitude distribution to 5 sigma. For a normalized Gaussian distribution with mean μ and sigma σ we write:

Formula 7- 10

$$p(a_i) = \frac{1}{\sqrt{2\pi}} e^{-\frac{a_i^2}{2}} \qquad a_i = \frac{x_i - \mu}{\sigma}$$

and define the following limits

Formula 7- 11

$$\Delta\sigma = 0.5 \qquad \beta = 10^{\frac{\Delta\sigma}{20}} \qquad \varepsilon = 0.1$$

$$\mathrm{ULimit}_i = (1+\varepsilon)\left\{1 - erf\left(\frac{a_i}{\sqrt{2}}\right)\right\} \qquad a_i \le 4$$

$$\mathrm{ULimit}_i = 10^{(0.802-1.24 a_i)} \qquad 4 \le a_i \le 4.68$$

$$\mathrm{ULimit}_i = \left\{1 - erf\left(\frac{a_i}{\beta\sqrt{2}}\right)\right\} \qquad a_i > 4.68$$

$$\mathrm{LLimit}_i = (1-\varepsilon)\left\{1 - erf\left(\frac{a_i}{\sqrt{2}}\right)\right\} \qquad a_i \le 5$$

$$= 0 \qquad a_i > 5$$

7.1.2.1.2 European Region

Noise impairments used in this specification for Annex B (Europe) SHALL comply with Section 7.3.4.3 of TS 101 271 [7].

7.1.3 Cabling

Cabling, switches and other equipment are needed to connect the DSLAM, the loop simulator, the noise generator and the CPE. Care SHALL be taken in order that the minimum noise is coupled into this cabling, so the wiring SHOULD be kept as short as practically possible. Recommended cables are Cat 5 UTP and STP or better.

For all loops with bridged taps at modem side, the modem interconnect cable SHALL be included in the calculations. Unless required differently in the relevant test setup the modem cable used for these tests SHALL have an attenuation of 6ft 26 AWG.

For straight loops the length of the cable sections sections between the loop simulator and the associated VTU terminals are included in the calibration (NOTE). STP is only required when there is high EMI in the vicinity (typically from engines, air conditioning units) or for longer cables coming from the DSLAM. If the test is performed in a large operational lab (where also other work is done), then consider this lab as a high-noise environment.

NOTE: If noise is injected at the loop simulator end of the connection cable to the appropriate VTU, this cable is included in the noise calibration calculations.

One SHOULD take care that the shielding is connected in an appropriate way. Connect the shield to the loop simulator ground only (one-sided grounding). A badly connected shield can even make the performance worse. In case of doubt, use the unshielded twisted pair.

Computer screens and power supplies radiate in the frequency bands used by VDSL2. It is recommended that these devices be placed at a distance from the setup or even be switched off. This noise MAY be generated by either internal or external power supplies. When the pickup noise levels are greater than -150 dBm/Hz, they will limit the VDSL2 performance and influence the test results. The background noise measurement reported in section 7.1.4 provides the data necessary to evaluate whether this recommendation is satisfied. The background noise is measured at both ends of the loop as per 7.1.2 with the noise generator powered on but with no noise being generated.
The CPE and DSLAM and their wiring SHOULD be physically separated, since when testing on long loops, crosstalk can occur between the cabling. Independent of attenuation conditions special care SHOULD be taken with the wiring to avoid crosstalk. Variations of noise external to the test setup and coupled in will have a greater chance of influencing the test result for tests of long duration (e.g., upstream margin verification tests).   Special attention SHOULD be made to make sure the influence of such variations is minimized. To obtain the maximum accuracy, the cables, switches and any other equipment used in the link between the DSLAM and the CPE SHALL be included in the compensation process described above in section 7.1.1.

7.1.4 Calibration

A test set-up background noise measurement SHALL be taken and recorded at the time ME and MAE measurement tests are conducted. If there is a change in test set-up, the ME and MAE and background noise measurements SHALL be redone.

8 Physical Layer Test Cases

This section provides some information about general procedure for performance testing.

The CO splitter used SHALL be the splitter integral to the DSLAM, if that option exists. Otherwise, an external CO splitter as specified in section 6.3.1 SHALL be used.

Tests will be performed at consecutive loop lengths identified in tables of the region-specific annexes.

The tests are initiated by placing the VDSL2 port of the DSLAM out of service. Then the loop simulator is set with the appropriate noise impairments and loop length, after which the VDSL2 port of the DSLAM is placed in service.

- At each test point, the line SHALL reach Showtime within a total of 90 seconds, starting from the time that the DSLAM port / line was placed in service.
- If the line fails to reach Showtime within this 90-second period, a result of “no connect” SHALL be recorded as the result for that test point.

No retrain is allowed after the expiry of the 90-second timer.

- If the line retrains after the 90-second period, then a result of “no connect” SHALL be recorded as the result for that test point.

When Showtime is reached, a 60 second waiting time SHALL be started, to settle bitswaps, etc. At the end of the 60-second waiting time the data rate and noise margins for the test point SHALL be recorded.

The DSLAM port / line SHALL then be placed out of service, the loop simulator and noise generator are then configured for the next test point. The DSLAM line / port is placed back in service, modem trained, and the 90 second timer is restarted.
This sequence SHALL continue until all loop lengths defined in the table are complete.

The CPE SHALL NOT be power cycled, rebooted or otherwise reinitialized between test points.

Any section containing a result of “no connect” SHALL result in the failure of that section.

To obtain a result for each individual test, each test SHALL be performed once. In rate-adaptive testing, any test point that fails to meet the requirement in downstream direction by 128 kbps or less or in the upstream direction by 64 kbps SHALL be re-tested, but no more than 3 times. If a re-test is performed, then the first passing value achieved, SHALL be recorded. If none of the retests provides a passing value then the highest non-passing value SHALL be recorded.

NOTE: Listed are two known sources of variability that need to be taken into account when verifying the interoperability of a CPE and DSLAM combination.

CPE Variability

For a modem type to be considered compliant, unit(s) submitted for compliance testing SHALL pass the performance requirements in this section. Taking into account the statistical variability in the manufacturing process, it is expected that the large majority of randomlyselected units will pass these requirements.

Bridged Tap Noise Injection Variability
The noise injection method of the present version of the document for loops with bridge tap sections MAY lead to:

- results differing from those on real loops,
- lower repeatability of results (due to, for example, varying noise floor and impedance) from test environment to test environment even if they are compliant to this document.

8.1 Verification of error reporting

8.1.1 Verification of CRC error reporting

The purpose of this test described in Table 22 is to verify that the CPE or the DSLAM correctly reports CRC errors. CRC error counts are the basis of margin verification tests and error seconds count is a key metric to quantify the quality of service experienced by the end user.

Table 22: Test procedure for verification of CRC error reporting

Test Configuration	(1) Configure the SUT according to the settings of the profile-line combination under test defined in Annex A and Annex B. (2) Test configuration (test loops, noise impairment) SHALL be according to Section A.1.5 and Section B.10.
Method of Procedure	(1) Connect CPE and DSLAM to selected loop and noise condition among those applicable to the band-profile under test. (2) Force a new initialization and wait for modems to sync. Wait for 1 minute after initialization for bitswaps to settle. (3) For CPE CRC error reporting test force a "micro-interruption" of the loop at the CPE side with duration of 10 ms. For DSLAM CRC error reporting test force a "micro-interruption" of the loop at the DSLAM side with duration of 10 ms. (4) Record the number of reported CRC errors and Error seconds after 30seconds. (5) Repeat step 3 and 4 every 30 seconds, for a total test time of 240 seconds (i.e. a total of 8 micro-interruptions are issued).
Expected Result	(1) For CPE test: a. If each micro-interruption does not result in at least one reported downstream CRC error, then the CPE has **failed** the CRC error reporting test. b. If each micro-interruption does not result in one or two ES resulting in the different total between 8 and16, then the CPE has failed the CRC error reporting test. (2) For DSLAM test: a. If each micro-interruption does not result in at least one reported upstream CRC error, then the DSLAM has **failed** the CRC error

	reporting test. b. If each micro-interruption does not result in one or two ES resulting in the different total between 8 and16, then the DSLAM has failed the CRC error reporting test.

8.1.2 Verification of uncorrected DTUs reporting

The purpose of this test described in Table 23 is to verify that the CPE or the DSLAM correctly reports number of uncorrected DTUs (RTXUC-CFE in downstream or RTXUC-C in upstream). Uncorrected DTUs counts are the basis of margin verification tests with Retransmission enabled.

Table 23: Test procedure for verification of uncorrected DTUs reporting

Test Configuration	(1) Configure the SUT according to the settings of the profile-line combination under test defined in Annex B. (2) Test configuration (test loops, noise impairment) SHALL be according to Section B.10. (3) The test mode shall be selected with setting RTX_ENABLE = RTX_TESTMODE[1].
Method of Procedure	(1) Connect CPE and DSLAM to selected loop and noise condition among those applicable to the band-profile under test. (2) Force a new initialization and wait for modems to sync. Wait for 1 minute after initialization for bitswaps to settle. (3) For CPE uncorrected DTUs reporting test force a "micro-interruption" of the loop at the CPE side with duration of 10 ms. For DSLAM uncorrected DTUs reporting test force a "micro-interruption" of the loop at the DSLAM side with duration of 10 ms. (4) Record the number of reported uncorrected DTUs and Error seconds after 30seconds. (5) Repeat step 3 and 4 every 30 seconds, for a total test time of 240 seconds (i.e. a total of 8 micro-interruptions are issued).
Expected Result	(1) For CPE test: a. If each micro-interruption does not result in at least one reported RTXUC-CFE, then the CPE has **failed** the test. b. If each micro-interruption does not result in one or two ES resulting in the different total between 8 and16, then the CPE has failed the test. (2) For DSLAM test: a. If each micro-interruption does not result in at least one reported RTXUC-C, then the DSLAM has **failed** the test. b. If each micro-interruption does not result in one or two ES resulting in the different total between 8 and16, then the DSLAM has failed the test.

[1] In this test mode retransmissions are not requested by the receiver nor sent autonomously by the transmitter.

8.2 Margin Verification Test

8.2.1 Margin Verification Test with Retransmission disabled

The measurement time is based on the occurrence of 10 error events and a confidence interval of 0.9. With this confidence interval the required BER limit for a 1e-7 target estimated bit error rate is 1.5e-7. Also due to this confidence interval, one out of 10 margin verification tests can result in a false FAIL. Therefore when the first margin verification test fails, the test SHALL be redone once, so that the confidence interval becomes 0.99.

Because of the significant dependency of achievable data rates on the noise margin, margin verification tests are performed across several loop and noise scenarios of TR-114 to ensure that there is no optimization of margin or modem performance for some specific test loops.

Table 24 shows how the estimated BER SHALL be derived from the CRC count. Table 25 contains the test procedure on margin verification.

Table 24: The equations for estimating BER

Modem configuration	Equations for estimating BER
Fast path	$BER = \frac{\text{Number of bit errors}}{\text{Number of transmitted bits}} \cong \frac{15 * CRC\_error\_count}{data\_rate * 1000 * test\_time * 60}$
Interleaved path, high latency	$BER = \frac{\text{Number of bit errors}}{\text{Number of transmitted bits}} \cong \frac{40 * CRC\_error\_count}{data\_rate * 1000 * test\_time * 60}$

Since CRC error counts are the basis of margin verification tests, it is necessary to verify if the DSLAM or CPE accurately counts and reports CRC errors. A mandatory test procedure to verify CRC error reporting is required and defined in section 8.1.

Table 25: Test procedure for margin verification with Retransmission disabled

Test Configuration	(1)Configure the SUT according to the settings of the profile-line combination under test defined in Annex A and Annex B. (2) Test configuration (test loops, noise conditions) SHALL be according to Section A.1.6, Section B.11 and Section B.12. (3) Noise injection location and performance counter collection (near end / far end) SHALL take place according to the requirements of the section defining test configuration
Method of Procedure	(1)Connect CPE and DSLAM to first test loop option, with the noise injected at the specified reference power level. This power level is considered the 0 dB noise power level for that type of noise. (2)Force a new initialization and wait for modems to sync. (3)Wait for 1 minute for bitswaps to settle. (4)Check reported margin and document as initial_reported_margin. (5)Increase the power by 1 dB only on the side under test (CPE side for

	CPE margin verification tests, DSLAM side for DSLAM margin verification tests). (6)Wait for 1 minute. (7)Repeat steps 5 and 6 until the noise power is increased by min(initial_reported_margin – 1, target margin) dB. At this point the power level of the noise is at the min(initial_reported_margin – 1, target margin) dB level. (8)Execute a BER test for the duration as specified in each testcase. Record the CRC and SES counts at the start and the end of the BER test. Actual number of CRCs and SESs is the difference between these two counts. Document the estimated BER. (9)If the estimated BER > the limit value or the link re-initializes during steps 5-8 then the test for that loop option SHALL be repeated once. (10) Repeat steps 1 to 9 for every test loop.
Expected Result	(1)For every test loop the estimated BER SHALL be less than the limit value in the margin verification table of that loop option. (2)If a second attempt is run, the link SHALL NOT re-initialize during the second attempt. (3)No SES has been reported.

An explanation of the regional margin verification tables (Table 99 −Table 101 and Table 104 - Table 106) is given below.

Column 1 of each table specifies the profile-line combination (e.g. BB8b_RA_F_150_150)

Column 2 specifies the loop length (e.g. 150m).

Column 3 specifies the crosstalk impairment (e.g. n_BB8b).

Column 4 specifies the anticipated data rate (kbps).

In Column 5 it is required that the actual net data rate SHALL be recorded twice: first at the start of the margin verification test and also at the end of the margin verification test. This captures a potential modem retrain and connection at lower DS net data rates due to the increase in injected noise level.
It is expected that the actual net data rate is close to the anticipated net data rate. If the actual net data rate is ≤ 75% of the anticipated rate, the test duration SHALL be increased by the scale value.

$$scale\,value = \frac{anticipated\ rate}{actual\ rate}$$

The actual net data rate is not a pass/fail criteria of this test.

Column 6 specifies the required test time in order to observe approximately 10 CRC error events at a target BER of 1e-7. These test times are calculated based on the data rates in the corresponding performance requirements section. To allow for modem connections with slightly lower than the anticipated data rates, the test durations are rounded up in increments of 5 minutes.

Column 7 asks for the insertion of the measured DS(US) SES count after the injected noise level has been increased by min(initial_reported_margin – 1, target margin) dB. Measurement of initial_reported_margin SHALL be done from the DSLAM.

Column 8 asks for the insertion of the measured DS(US) CRC count after the injected noise level has been increased by min(initial_reported_margin – 1, target margin) dB. Measurement of initial_reported_margin SHALL be done from the DSLAM.

Column 9 asks for the computation of the estimated BER from the number of observed CRC error events according to Table 24. If the estimated BER is smaller than the BER limit in this column, then the test PASSES, else it FAILS.

Column 10 asks for the insertion of "PASS" or "FAIL".

8.2.2 Margin Verification Test with Retransmission enabled

This test case is based on the criteria and accelerated testing methodology defined in chapter 10 of ITU-T G.998.4 [3]. This allows to adopt a measurement time set to 10 minutes, rather than referring to the target MTBE of 4 hours (i.e. 14400 s) specified in G.998.4.

Margin verification tests are performed across several loop and noise scenarios of TR-114 to ensure that there is no optimization of margin or modem performance for some specific test loops.

Since uncorrected DTU counts are the basis of margin verification tests with Retransmission enabled, it is necessary to verify if the CPE or DSLAM accurately counts and reports number of uncorrected DTUs (RTXUC-CFE in downstream or RTXUC-C in upstream). A mandatory test procedure to verify uncorrected DTU reporting is required and defined in Section 8.1.2.

Table 26: Test procedure for margin verification with Retransmission enabled

Test Configuration	(1) Configure the SUT according to the settings of the profile-line combination under test defined in Annex B. (2) Test configuration (test loops, noise conditions) SHALL be according to Section B.11 and Section B.12. (3) The test mode shall be selected with setting RTX_ENABLE = RTX_TESTMODE[2].
Method of Procedure	(1) Connect CPE and DSLAM to first test loop option, with the stationary noise injected at the specified reference power level. (2) Force a new initialization and wait for modems to sync. (3) Wait for 1 minute for bitswaps to settle. (4) Check reported margin and document as initial_reported_margin.

[2] In this test mode retransmissions are not requested by the receiver nor sent autonomously by the transmitter.

	(5) For CPE margin verification tests, if the reported margin is higher than 2 dB increase the noise power level by 1 dB, otherwise increase by 0.5 dB, at CPE side only. (6) For DSLAM margin verification tests, if the reported margin is higher than 2 dB increase the noise power level by 1 dB, otherwise increase by 0.5 dB, at DSLAM side only. (7) Wait for 1 minute. (8) Repeat steps 5 and 6, and adjust the noise power increase until the actual Noise Margin of the direction under test is between 1 dB and 1.5 dB. (9) Execute a test on the "probability of uncorrected DTUs" (P_{DTU}) for the duration specified in each test case. Record the RTXUC counts and SES counts at the start and the end of the P_{DTU} test. Actual number of RTXUCs and SESs is the difference between these two counts. Document the estimated P_{DTU} referring to the following equation: $$P_{DTU} = \left(\frac{Number\_of\_RTXUCs}{Measurement\_Time / T_{DTU}} \right)$$ where: • *Measurement_Time* is expressed in seconds • T_{DTU} is the time duration of a DTU expressed in seconds • *Number_of_RTXUCs* is the number of uncorrected DTUs reported in the G.997.1 counter RTXUC. (10) Repeat steps 1 to 9 for every test loop.
Expected Result	(1) For every test loop the estimated P_{DTU} SHALL fulfill: $$P_{DTU} \le \frac{8.3333 \times 10^{-3}}{\sqrt{f_s}} \times \left(T_{DTU\_in\_DMT}\right)^{1/2}$$ where f_s is the symbol rate in Hz $T_{DTU\_in\_DMT}$ is the duration of a DTU expressed in DMT symbols (NOTE) (2) There SHALL be no SES during the test.
NOTE: $T_{DTU\_in\_DMT}$ is identical to Q × S1, where Q is the number of Reed-Solomon (RS) codewords per DTU and S1 is the number of data symbols per RS codeword. This can be expressed in ITU-T G.997.1 terms as: $T_{DTU\_in\_DMT}$ = RSPERDTU × S1= RSPERDTU × 8 × (NFEC/LSYMB), where NFEC is the framing parameter that represents size of the RS codeword in bytes, LSYMB is the framing parameter that represents number of bits per symbol, and RSPERDTU is the framing parameter that represents the number of Reed-Solomon codewords per DTU.	

An explanation of the regional margin verification tables (Table 102 - Table 107) is given below.

Column 1 of each table specifies the profile-line combination (e.g. BA17a0_RA_R-17/2/41_ 150_150).

Column 2 specifies the loop length (e.g. 150m).

Column 3 specifies the crosstalk impairment (e.g. n_BA17a0).

Column 4 specifies the required test time.

Column 5 has to be filled with the measured SES count after the injected noise level has been increased.Column 6 has to be filled with the measured RTXUC count after the injected noise level has been increased.

Column 7 has to be filled with the estimated P_{DTU} calculated per the equation in Table 26.

Column 8 has to be filled with "PASS" or "FAIL" depending on the criterion in the Expected Result is met or not.

8.3 Erasure decoding tests (optional)

This test applies only to CPE modems that claims support of the erasure decoding. For a CPE that does not claim EDC support, the expected result SHALL be not applicable ("N/A").

FORCEINP is the G.997.1 [4] parameter that:

- when set to ONE, indicates that the CPE receiver SHALL set the impulse noise protection according to the formula specified in Section 9.6/G.993.2. The receiver SHALL ensure that the impulse noise protection is greater than or equal to the minimal impulse noise protection requirement. FORCEINP=1 is sometimes referred to as the "I don't trust you" mode.

- when set to ZERO, indicates that the CPE receiver is not required to set the impulse noise protection according to the formula specified in section 9.6/G.993.2. The receiver SHALL ensure that the impulse noise protection is greater than or equal to the minimal impulse noise protection requirement. FORCEINP=0 is sometimes referred to as the "I do trust you" mode.

8.3.1 Erasure decoding testing in FORCEINP=1 mode

Table 27: Erasure decoding test in FORCEINP=1 mode

Test Configuration	(1)Configure the SUT according to the settings of the interleaved band-profile under test defined in regional annexes (A and B) from Table 185. Additionally, the following parameters configured: • INP_min_ds= 2 and 4 symbols • INP_min_us = 2 × INP_min_ds (4 and 8, respectively) • delay_max = 8ms • FORCEINP=1 (2)Configure the loop simulator according to the band-profiles under test: • 8d profile 1.2 kft 26 AWG loop (Region A) • 17a/17a0 and 12a profiles 450 m PE04 (Region B) • 8b profiles - 1200 m PE04 (Region B) (3)Inject -120dBm/Hz AWGN at both ends of the loop (4)The REIN noise consists of pulses whose differential signal power spectral density is -90 dBm/Hz. Each pulse SHALL be a burst of pseudo random AWGN. The REIN noise is injected at the CPE side with a repetition frequency of 120 Hz (Region A) or 100 Hz (Region B). (5)Additional test conditions: • Ts = 250μs • δ = 15 μs is correction factor for pulse spreading in AFE • The OPTIONAL OLR functionality (SRA, SOS) SHALL NOT be used
Method of Procedure	(1)Inject the background noise at both sides and let the system train (2)Wait for 1 minute after initialization and report the actual INP, delay and data rate (3)At CPE side apply for 3 minutes the REIN noise with a variable pulse width $\{-\delta + [(INP\_min -1)\ldots(2 \times INP\_min -3)] \times T_s\}$ in steps of one T_s. Wait 3 minutes between the two measurements (4)For each pulse width report the actual INP, actual interleaving delay and actual data rate and measure number of code violations in the 3 minute measurement interval (5)Repeat step 1 to 4 for each INP_min setting.
Expected Result	For a CPE claiming support of Erasure Decoding, (1)Reported number of downstream code violations ≤ 1 per minute (2)Actual INP ≥ INP_min and actual delay ≤ delay_max

Table 28: Erasure Decoding Testing FORCEINP=1 mode

Pulse width (in steps of one T_s)	Actual downstream net data rate	Actual INP	Actual delay	Reported CVs	Pass/fail
INP_min = 2					
1					
INP_min = 4					
3					
4					
5					

8.3.2 Erasure decoding test procedure in FORCEINP=0 mode

Table 29: Erasure decoding test in FORCEINP=0 mode

Test Configuration	(1)Configure the SUT according to the settings of the interleaved band-profile under test defined in regional annexes (A and B) from Table 185. Additionally, the following parameters SHALL be configured: • INP_min_ds= 2 and 4 symbols • INP_min_us = 2 × INP_min_ds (4 and 8, respectively) • delay_max = 8ms • FORCEINP=0 (2)Configure the loop simulator according to the band-profiles under test: • 8d profile 1.2 kft 26 AWG loop (Region A) • 17a/17a0 and 12a profiles 450 m PE04 (Region B) • 8b profiles - 1200 m PE04 (Region B) (3)Inject -120dBm/Hz AWGN at both ends of the loop (4)The REIN noise consists of pulses at whose differential signal power spectral density is -90 dBm/Hz. Each pulse SHALL be a burst of pseudo random AWGN. The REIN noise is injected at the CPE side with a repetition frequency of 120 Hz (Region A) or 100 Hz (Region B). (5)Additional test conditions: • Ts = 250μs • δ = 15 μs is correction factor for pulse spreading in AFE • The OPTIONAL OLR functionality (SRA, SOS) SHALL NOT be used
Method of Procedure	(1)Inject the background noise at both sides and let the system train (2)Wait for 1 minute after initialization and report the actual INP, delay and data rate (3)At CPE side apply for 3 minutes the REIN noise with a pulse width (INP_min -1) × Ts - δ (4)Report the actual INP, actual interleaving delay and actual data rate and measure number of code violations in the 3 minute measurement interval (5)Repeat step 1 to 4 for each INP_min setting.
Expected Result	For a CPE claiming support of Erasure Decoding, (1)Reported number of code violations ≤ 1 per minute (2)Actual INP ≥ INP_min and actual delay ≤ delay_max (3)The data rate SHALL be higher than the achieved data rate for the same band-profile condition in FORCEINP=1 mode.

Table 30: Erasure Decoding Testing in FORCEINP=0 mode

Data rate	Actual downstream net data rate	Actual INP	Actual delay	Reported CVs	Pass/fail
INP_min=2					
INP_min=4					

8.4 Virtual Noise test (optional)

The purpose of this test defined in Table 32 is to verify that the virtual noise mechanism in the DSLAM/CPE is implemented correctly according to the directions of Section 11.4.1.1.6.1.2/G.993.2. The way this test is specified makes it applicable to BA17a0_D&UPBO band profile. The noise profile corresponds to a crosstalk from a group of VDSL2 systems operating in BA17a0_D&UPBO band profile.

A transmitter referred virtual noise profile will be programmed in the DSLAM. The modem SHALL be trained on a quiet line and then simulated crosstalk noise SHALL be added to the line at transmitter side, with PSD equal to the transmitter referred virtual noise profile The modem SHALL not lose synchronization and the recorded margin SHALL not drop by more than 2 dB when the external noise injection is enabled. The crosstalk noise SHALL only be injected at one end of the loop at once, in order to avoid noise from both ends of the system combining, causing deviation from the desired noise PSD. The test setup SHALL support the actual noise injection over the entire transmission band.

NOTE: When configuring the Transmitter Referred Virtual Noise PSD's using a G.997.1 interface, the frequency SHOULD be converted into the nearest sub carrier index, and the VN PSD power SHOULD be rounded to the nearest 0.5 dBm/Hz resolutions. The same correction SHALL also be applied to the generated crosstalk noise.

The transmitter referred virtual noise at DSLAM side is defined in Table 31.

Table 31: VN PSD for BA17a0_D&UPBO

Freq (kHz)	VN PSD (dBm/Hz)
0	-140.0
4.3125	-140.0
155.25	-140.0
159.5625	-96.8
276	-92.8
284.625	-103.5
288.9375	-107.8
293.25	-107.7
319.125	-109.7
323.4375	-109.6
327.75	-111.3
340.6875	-111.4
547.6875	-107.3
875.4375	-103.3

1401.563	-99.2
2242.5	-95.1
3588	-91.0
3726	-90.7
3730.313	-140.0
5218.125	-140.0
5222.438	-88.0
8478.375	-85.8
8482.688	-140.0
14019.94	-140.0
14024.25	-83.1
21424.5	-79.3
21428.81	-140.0
24909	-140.0
24913.31	-77.9
25318.69	-78.1
29976.19	-76.6
29980.5	-140.0

Table 32: Transmitter Referred Virtual Noise Test

Test Configuration	(1) The modems SHALL be connected as shown in Figure 1 and configured in one of the following profile-line combination: BA17a0_D&UPBO_RA_R-17/2/41_150_150, defined in Table 85. (2) Downstream transmitter referred virtual noise (TXREFVNds) SHALL be configured according to Table 31. (3) The SNRMODEds SHALL be set to 2, which implies SNRM_MODE (as defined in G.993.2) is set to 2. (4) Line simulator SHALL be set up for the straight homogeneous loop specified for the regional annex in Section 6.3.2. Its length SHALL be varied in 3 steps from the NULL loop to the length at which the loop is the equivalent of 20dB @ 1MHz. (5) Inject –140dBm/Hz AWGN noise at both the DSLAM and CPE.
Method of Procedure	(1) Force initialization and wait for modems to synchronize. (2) Wait 1 minute following synchronization (3) Record the downstream SNR margin. (4) Noise injection SHALL be configured to generate simulated crosstalk noise with PSD equal to the transmitter referred virtual noise for DSLAM. This noise SHALL be injected on the loop at the DSLAM side. (5) After 1 minute, record the downstream SNR margin. (6) Repeat the test steps 1 through 5 for the 3 loop lengths.
Expected Result	(1) Link SHALL not retrain when simulated crosstalk is turned on. (2) For each loop the SNR Margin drop SHALL be ≤ 2 dB when simulated crosstalk noise is turned on.

9 Higher Layer Test Cases

9.1 PTM Throughput Test

This test applies only to VDSL2 modems that support the PTM-TC functionality (Annex K.3/G.993.2 [2]). Table 34 describes the test procedure for the PTM packet throughput test. Test setup is shown in Figure 2.

The throughput tests specified satisfy the terminology criteria of IETF RFC 1242 [11] and the test methodology specified in IETFRFC 2544 [12].

According to RFC 1242, throughput is “the maximum rate at which none of the offered frames are dropped by the device.”

According to RFC 2544, the methodology to measure throughput is to “Send a specific number of frames at a specific rate through the DUT and then count the frames that are transmitted by the DUT.”

If the count of offered frames is equal to the count of received frames, the rate of the offered stream is raised and the test is rerun. If fewer frames are received than were transmitted, the rate of the offered stream is reduced and the test is rerun.

In this test specification, the number of frames transmitted from one end of the VDSL2 link is compared with the number of frames received at the far end of the VDSL2 link.

Table 33: Packet throughput test bitrates

Profile-line combination	DS net data rate (NDR) (Mbps)	US net data rate (NDR) (Mbps)	Loop Length	Crosstalk
AA8d_UPBO_FX_I_040_006	40.4	5.7	600ft	24 AA8d self
AA8d_UPBO_FX_I_027_002	27.0	2.0	2400ft	24 AA8d self
BA17a0_D&UPBO_FX_I_050_020	50.0	20.0	150m	n_BA17a0_D&UPBO
BB17a_D&UPBO_FX_I_050_015	50.0	15.0	150m	n_BB17a_D&UPBO
Profile-line combination	**DS Expected throughput (ETR) (Mbps)**	**US Expected throughput (ETR) (Mbps)**	**Loop Length**	**Crosstalk**
BA17ade_D&UPBO_FX_R-17/2/41_050_020	50.0	20.0	150m	n_BA17ade_D&UPBO

Table 34: Packet Throughput Test

Test Configuration	(1)The configuration SHALL be as shown in Figure 2, depending on the customer interface of the modem. (2)Set up the loop simulators at the specified loop lengths 26 AWG cable, or PE04 cable, with the respective noise as defined in Table 33 injected at the VTU modem under test (DSLAM or CPE). (3)Setup the traffic generator/analyzer to send Ethernet frames in both directions. (4)Configure both modems for PTM transport.
Method of Procedure	(1) Configure the SUT in the profile line configuration forcing maximum and minimum rates to those in Table 33. (2) Let the CPE train. (3) Setup traffic generator/analyzer to perform throughput test for selected Ethernet frame length and connect rate. (4) Set the throughput rate of the upstream direction to 50% of the maximum FPS sustainable by the upstream net data rate. (5) Test for the throughput in the downstream direction. Record the downstream throughput rate as frames per second. The test SHALL be run for 120 seconds. (6) Set the throughput rate of the downstream direction to 50% of the maximum Ethernet frames sustainable by the downstream net data rate. (7) Repeat the test for throughput in the upstream direction. Record the upstream throughput rate as frames per second. The test SHALL be run for 120 seconds. (8) Divide the analyzer frames per second by the maximum FPS for the connect rate and frame size. (9) Record as percentage of maximum connect rate.
Expected Result	Based on the throughput tables: The percentage of FPS achievable for all DSL modems SHALL be ≥ 95%.

Table 35: Throughput Test Results for profile AA8d_ FX_I_040_006

Max FPS			Analyzer Recorded Ethernet FPS		% of Max		Pass/Fail	
Packet Size	**DS**	**US**	**DS**	**US**	**DS**	**US**	**DS**	**US**
64	73122	10316						
256	19124	2698						
1024	4836	682						
1514	3275	462						

Table 36: Throughput Test Results for profile AA8d_ FX_I_027_002

Max FPS			Analyzer Recorded Ethernet FPS		% of Max		Pass/Fail	
Packet Size	DS	US	DS	US	DS	US	DS	US
64	48868	3619						
256	12781	946						
1024	3232	239						
1514	2189	162						

Table 37: Throughput Test Results for profile BA17a0_D&UPBO_FX_I_050_020

Max FPS			Analyzer Recorded Ethernet FPS		% of Max		Pass/Fail	
Packet Size	DS	US	DS	US	DS	US	DS	US
64	90497	36199						
256	23668	9467						
1024	5986	2394						
1514	4053	1621						

Table 38: Throughput Test Results for profile BA17ade_D&UPBO_FX_R-17/2/41_050_020

Max FPS			Analyzer Recorded Ethernet FPS		% of Max		Pass/Fail	
Packet Size	DS	US	DS	US	DS	US	DS	US
64	90497	36199						
256	23668	9467						
1024	5986	2394						
1514	4053	1621						

Table 39: Throughput Test Results for profile BB17a_D&UPBO_FX_I_050_015

Max FPS			Analyzer Recorded Ethernet FPS		% of Max		Pass/Fail	
Packet Size	DS	US	DS	US	DS	US	DS	US
64	90497	27149						

256	23668	7100						
1024	5986	1795						
1514	4053	1216						

A Annex A Physical Layer Test Cases for G.993.2 Region A (North America)

A.1 Annex A-specific Test Setup Information

Test configuration associated with the VDSL2 over POTS (VDSL2oPOTS) deployments with Annex A band-profiles is defined in Table 40.

Table 40: Annex A test configuration

Type of VDSL2 deployment	Band-profile	Test configuration
VDSL2oPOTS	AA8d	Figure 1
VDSL2oPOTS	AA8a	Figure 1
VDSL2oPOTS	AA12a	Figure 1
VDSL2oPOTS	AA17a	Figure 1

Following loops SHALL be used (ATIS 0600417 cable models):

- 26 AWG variable length straight loop (6.3.2.1)
- 26 AWG loop with 26 AWG bridged tap segment and 50 ft 24 AWG segment at the customer end of the loop (Figure 4)

NOTE: Modems passing this test are not necessarily meeting the spectrum compatibility as defined by ATIS 0600417 for North America, or any other similar requirement specification. Users of this document SHOULD carry on additional testing to ensure spectral compatibility before deployment.

A.1.1 VDSL2 self-NEXT and FEXT

The VDSL2 near-end and far-end self-crosstalk (NEXT and FEXT) SHALL be based on the VDSL2 transmit level for noise calculations from section 6.3.3.1 and the loop transfer functions from ATIS 0600417:

- NEXT SHALL be calculated using the "Simplified Next Equation" from Section A.3.2.1.1/ATIS 0600417. and the VDSL2 transmit level for the specified loop configuration, gauge, length and number of disturbers.
- FEXT SHALL be calculated using the "Far end crosstalk" equation from Section A.3.2.2/ATIS 0600417 and the VDSL2 transmit level for the specified loop configuration, gauge, length and number of disturbers.
- Self-crosstalk at DSLAM is defined as NEXT from DS VDSL2 and FEXT from US VDSL2
- Self- crosstalk at CPE is defined as NEXT from US VDSL2 and FEXT from DS VDSL2
- US transmit level (noise PSD) assumes the use of simultaneous U0 and U1 and U2
- US noise PSD in U0 is set to nominal level, i.e., mask – 3.5 dB, and assumes no UPBO
- US noise PSD in U1 and U2 assume UPBO, with the value of kl_0 from Table 42
- NEXT and FEXT component are numerically summed in linear units, not dB.

A.1.2 ADSL2plus NEXT and FEXT

The ADSL2 near-end and far-end self-crosstalk (NEXT and FEXT) SHALL be based on the transmit level for noise calculations from Table 17 and Table 18 in section 6.3.3.1 and the loop transfer functions from ATIS 0600417:

- NEXT SHALL be calculated using the “Simplified Next Equation” from Section A.3.2.1.1/ATIS 0600417 and the ADSL2plus transmit level for the specified loop configuration, gauge, length and number of disturbers.
- FEXT SHALL be calculated using the “Far end crosstalk” equation from Section A.3.2.2/ATIS 0600417 and the ADSL2plus transmit level for the specified loop configuration, gauge, length and number of disturbers.
- ADSL2plus-crosstalk at the DSLAM is defined as NEXT from DS ADSL2plus and FEXT from US ADSL2plus
- ADSL2plus-crosstalk at the CPE is defined as NEXT from US ADSL2plus and FEXT from DS ADSL2plus
- ADSL2plus US and DS PSD is set to nominal level, i.e., mask – 3.5 dB, assume no cutback
- ADSL2plus DS tones are: 33 – 511
- ADSL2plus US tones are: 7 – 31
- NEXT and FEXT component are numerically summed in linear units, not dB.

A.1.3 Annex A Noise

The noise impairment for Annex A is defined as follows:

- 24 AA8d VDSL2-self + -140dBm/Hz AWGN
- 12 AA8d VDSL2-self + 12 ADSL2plus + -140dBm/Hz AWGN
- 24 AA8a VDSL2-self + -140dBm/Hz AWGN
- 12 AA8a VDSL2-self + 12 ADSL2plus + -140dBm/Hz AWGN
- 24 AA12a VDSL2-self + -140dBm/Hz AWGN
- 12 AA12a VDSL2-self + 12 ADSL2plus + -140dBm/Hz AWGN
- 24 AA17a VDSL2-self + -140dBm/Hz AWGN
- 12 AA17a VDSL2-self + 12 ADSL2plus + -140dBm/Hz AWGN
- -140dBm/Hz AWGN

, where “+” expresses power sum.

Single sided noise injection SHALL be used to minimize the noise coupling through the loop simulator causing unrealistic noise conditions.

The noise injected for bridged tap loops SHALL be identical to the noise injected for straight loops with the equivalent main length. For example, the noise injected for the 300ft bridged tap loop in Table 52 is identical to the noise injected for the 300ft straight loop in Table 51.

Upstream PBO settings for band profile AA8d, AA8a, AA12a and AA17a is defined in Table 41. UPBOKL for straight 26 AWG loop testing and for 26 AWG with BT loop testing is defined in Table 42 and Table 43, respectively.

Table 41: Upstream PBO settings for Annex A testing

Parameter	Setting	Description
UPBO setting for upstream performance requirements		
UPBOA US0	40.00	A and B values US band 0 (These values imply no UPBO)
UPBOB US0	0	
AA8d		
UPBOKLF	1	CPE SHALL be forced to use the kl0 of the CO-MIB (UPBOKL) to compute the UPBO
UPBOA US1	53	A value US band 1
UPBOB US1	21.2	B value US band 1
UPBOA US2	54	A value US band 2
UPBOB US2	18.7	B value US band 2
AA8a, AA12a, AA17a		
UPBOKLF	0	CPE SHALL NOT be forced to use the kl0 of the CO-MIB (UPBOKL) to compute the UPBO
UPBOA US1	53	A value US band 1
UPBOB US1	16.2	B value US band 1
UPBOA US2	54	A value US band 2
UPBOB US2	10.2	B value US band 2

Table 42: UPBOKL for straight 26 AWG loop testing

Loop length (ft)	UPBOKL (kl0)
300	2.32
600	4.64
900	6.97
1200	9.29
1600	12.39
2000	15.48
2400	18.58
2800	21.68
3200	24.78
3600	27.88
4000	30.97
4500	34.85

5500	42.59
6500	50.33
7500	58.08
8500	65.82

Table 43: UPBOKL for 26 AWG with BT loop testing

Loop length (ft)	Bridge tap length (ft)	UPBOKL (kl0)
300	20	2.32
600	100	4.64
900	200	6.97
1200	50	9.29
2000	100	15.48
2800	100	21.68
3200	200	24.78
4000	100	30.97
4500	50	34.85
5500	100	42.59
6500	100	50.33
7500	200	58.08

A.1.4 Pass/Fail Criteria for Annex A Testing

In addition to achieving the required rate, both downstream and upstream noise margin values are to be considered in determining the result of an individual section. It is acknowledged that achieving a desired noise margin is primarily the responsibility of the receiver. That is, the DSLAM is primarily responsible for achieving desired upstream noise margins, while the CPE is primarily responsible for achieving desired downstream noise margins. Table 44 outlines the pass/fail criteria on the reported noise margin.

Table 44: Noise margin pass/fail requirements

Reported Noise Margin (dB)	Requirement
< 4	On no test point
≥ 4 and < 5	On at most 10% of the test points
≥ 5	On at least 90% of the test points
≥ 5.8	On at least 75% of the downstream test points

All measurements SHALL be from the DSLAM.

Overall pass/fail criteria for each adaptive rate testing is as follows:

- If any reported noise margin is less than 4dB, then the DSLAM/CPE pair fails the noise margin requirements of that section.
- If more than 10% of the reported noise margins are less than 5dB in a section, then the DSLAM/CPE pair fails the noise margin requirements of that section.
- If more than 25% of the reported downstream noise margins are less than 5.8 dB in a section, then the DSLAM/CPE pair fails the noise margin requirements of that section.
- If more than 10% of the data rates are less than the data rate requirements in a section, then the DSLAM/CPE pair fails the data rate requirements of that section.

Overall pass/fail criteria for the fixed rate testing is as follows:

- If any of the reported noise margin is less than 5.8 dB, then the DSLAM/CPE pair fails the noise margin requirements
- If any of the data rates are less than the data rate requirements, then the DSLAM/CPE pair fails the data rate requirements

If the DSLAM/CPE pair passes both the data rate and noise margin requirements, it passes the section; otherwise, it fails the section.

Table 45 lists the number of test points per section corresponding to the 10% and 25% limits mentioned above.

Table 45: Pass/fail criteria for rate adaptive testing

Section number	**Number of test cases**	**10% limit**	**25% limit (applies to downstream margins only)**
A.2.1	32	3	4
A.2.2	24	2	3

A.1.5 **Test cases for CRC error reporting verification test**

Test loops and noise impairment for CRC error reporting verification test defined in section 8.1 are listed in Table 46 and Table 47.

Table 46: CRC reporting tests for RA_I_096_056

Profile-line combination	Length (ft)	Crosstalk	CRC Count	Pass/Fail
AA8d_UPBO	900	24 AA8d self + -140 dBm/Hz AWGN		
	2000 + 100BT			
	3200			
	5500+100 BT	12 AA8d self + 12 ADSL2plus + -140 dBm/Hz AWGN		

Table 47:CRC reporting tests for FX_I_027_002

Profile-line combination	Length (ft)	Crosstalk	CRC Count	Pass/Fail
AA8d_UPBO	2000	24 AA8d self +-140 dBm/Hz AWGN		
	2400			

A.1.6 **Test cases for downstream margin verification test**

Test loops and noise impairment for downstream margin verification test defined in section 8.2 are listed in Table 48 and Table 49.

Table 48: Margin verification tests for RA_I_096_056

Profile-line combination	Length (ft)	Crosstalk	DS net data rate (kbps)		Test Time (minutes)	SES Count	CRC Count	Estimated BER	Pass/Fail
			Anticipated	Actual (test start) (test end)					
AA8d_UPBO	900	24 AA8d self + -140 dBm/Hz AWGN	≥ 40400		5				
	2000 + 100BT		≥ 27500		5				
	3200		≥ 22300		5				
	5500+ 100 BT	12 AA8d self + 12 ADSL2plus	≥ 4500		15				

		+ -140 dBm/Hz AWGN							

NOTE: Maximum BER is 1.5×10^{-7}.

Table 49 Margin verification tests for FX_I_027_002

Profile-line combination	Length (ft)	Crosstalk	DS net data rate (kbps)		Test Time (minutes)	SES Count	CRC Count	Estimated BER	Pass/Fail
			Anticipated	Actual (test start) (test end)					
AA8d_UPBO	2000	24 AA8d self + -140 dBm/Hz AWGN	≥ 27000		5				
	2400		≥ 27000		5				

NOTE: Maximum BER is 1.5×10^{-7}.

A.1.7 Verification of bits, gains and NOMATP values

Downstream and upstream bits, gains and NOMATPds values SHALL be verified prior to collecting the performance measurements. The procedure and expected results are provided in Table 50.

Table 50: Verification of bits, gains and NOMATP values

Test Configuration	(1)Configure the SUT in the following profile-line combination applicable to the band-profile under test: a. AA8d_UPBO_RA_I_096_056 b.AA8a_UPBO_RA_I_098_058 c. AA12a_UPBO_RA_I_098_058 d. AA17a_UPBO_RA_I_150_096 (2)The DSLAM and CPE are connected in turn through randomly selected test loops (one from each of the sets below): • AA8a: ○set 1 (short loops): 600ft, 1200ft, 2400ft ○set 2 (medium loops): 3600ft, 4500ft, 6500ft ○set 3 (bridge tap loops): 2000ft + 100ft BT, 4000ft + 100ft BT, 7500ft + 200ft BT • AA8d: ○set 1 (short loops): 600ft, 1200ft, 2400ft ○set 2 (medium loops): 3600ft, 4500ft, 6500ft ○set 3 (bridge tap loops): 2000ft + 100ft BT, 4000ft + 100ft BT, 7500ft + 200ft BT • AA12a: ○set 1 (short loops): 300ft, 600ft ○set 2 (medium loops): 1200ft, 1600ft ○set 3 (bridge tap loops): 900ft+200ft BT, 2000ft+100ft BT • AA17a: ○set 1 (short loops): 300ft, 600ft ○set 2 (medium loops): 1200ft, 1600ft ○set 3 (bridge tap loops): 900ft+200ft BT, 1600ft+100ft BT
Method of Procedure	(1)Train the modem in the chosen test loop and band-profile. (2)Not sooner than two minutes after entering steady state operation (a.k.a. Showtime), record the reported downstream bi (bits) and gi (gains) values (BITSpsds and GAINSpsds) and upstream bi (bits) and gi (gains) values (BITSpsus and GAINSpsus).
Expected Result	1. In downstream, the g_i settings (in the bits-and-gains table) SHALL comply with the following requirements: (1)If $b_i > 0$, then g_i SHALL be in the [−14.5 to +2.5] (dB) range. (2)If $b_i > 0$, then the linear average of the g_i^2's in any band (as specified during the initialization procedure, see G.993.2 [2] §12.3.2) SHALL be ≤ 1. (3)If $b_i = 0$, then g_i SHALL be equal to 0 (linear) or in the [−14.5 to 0] (dB) range. (4)The NOMATP value calculated as: $$\text{NOMATP} = 10\log_{10}\Delta f + 10\log_{10}\left(\sum_{i\in\text{MEDLEY set}}\left(10^{\frac{\text{MREFPSD}[i]}{10}} g_i^2\right)\right)$$ SHALL NOT exceed the configured MAXNOMATPds and SHALL NOT exceed the maximum power specified for the VDSL2 profile under

	test. 2. In upstream, the g_i settings (in the bits-and-gains table) SHALL comply with the following requirements: (1) If $b_i > 0$, then g_i SHALL be in the [−14.5 to +2.5] (dB) range. (2) If $b_i > 0$, then the linear average of the g_i^2's in any band (as specified during the initialization procedure, see G.993.2 [2] §12.3.2) SHALL be ≤ 1. (3) If $b_i = 0$, then g_i SHALL be equal to 0 (linear) or in the [−14.5 to 0] (dB) range. (4) The NOMATP value calculated as: $$\text{NOMATP} = 10\log_{10}\Delta f + 10\log_{10}\left(\sum_{i\in\text{MEDLEY set}}\left(10^{\frac{\text{MREFPSD}[i]}{10}} g_i^2\right)\right)$$ SHALL NOT exceed the configured MAXNOMATPus and SHALL NOT exceed the maximum power specified for the VDSL2 profile under test.

A.2 Performance tests for Band-Profile AA8d

A.2.1 Rate adaptive tests with straight loops

32 individual tests – 29 tests SHALL be passed

Table 51: Profile-line combination AA8d_UPBO_RA_I_096_056

Loop Length (ft, 26 AWG loop)	AA8d_UPBO_RA_I_096_056							
	Downstream				Upstream			
	Actual net data rate(kbps)			Noise Margin, Reported (dB)	Actual net data rate (kbps)			Noise Margin, Reported (dB)
	Expected	Measured	Pass/Fail		Expected	Measured	Pass/Fail	
Noise Profile: 24 AA8d self + -140 dBm/Hz AWGN								
300	48000				5500			
600	43400				5800			
900	40400				5700			
1200	38200				5600			
1600	36200				5500			
2000	34100				5400			
2400	31400				5300			
2800	26300				4800			
3200	22300				3200			
3600	20300				1400			
4000	16500				800			
Noise Profile: 12 AA8d self + 12 ADSL2plus + -140 dBm/Hz AWGN								
4500	13000				700			
5500	8000				700			
6500	5500				500			
Noise Profile: -140 dBm/Hz AWGN								
7500	6000				500			
8500	3500				500			

A.2.2 Rate adaptive tests with bridged tap loops

24 individual tests – 22 tests SHALL be passed

Table 52: Profile-line combination AA8d_UPBO_RA_I_096_056

Length of A (ft, 26 AWG loop)	Length of Tap (ft, 26 AWG loop)	AA8d_UPBO_RA_I_096_056							
		Downstream				Upstream			
		Actual net data rate(kbps)			Noise Margin, Reported (dB)	Actual net data rate(kbps)			Noise Margin, Reported (dB)
		Expected	Measured	Pass/Fail		Expected	Measured	Pass/Fail	
Noise profile: 24-self and -140dBm/Hz AWGN									
300	20	41000				4500			
600	100	36500				3500			
900	200	33300				4200			
1200	50	32000				4300			
2000	100	27500				3200			
2800	100	17500				2500			
3200	200	16400				1800			
4000	100	12300				800			
Noise profile: 12-self + 12-ADSL2plus and -140dBm/Hz AWGN									
4500	50	8700				700			
5500	100	4500				600			
6500	100	3500				600			
Noise profile: -140dBm/Hz AWGN									
7500	200	1000				400			

A.2.3 Fixed rate tests with straight loops

Fixed rate testing with noise associated with AA8d transmit power as described in section 6.3.3.1 The noise profiles associated with fixed rate testing SHALL be identical to those used for the same loop lengths in the adaptive rate testing above. The loop length dependent UPBO settings and kl0 method used for the adaptive rate testing SHALL be used for the fixed rate tests described in this section.

4 individual tests – 4 tests SHALL be passed

Table 53: Profile-line combination AA8d_UPBO_FX_I_027_002

Loop Length (ft, 26 AWG loop)	AA8d_UPBO_FX_I_027_002							
	Downstream				Upstream			
	Actual net data rate(Mbps)			Pass/Fail	Actual net data rate(Mbps)			Pass/Fail
	Expected	Measured	Reported Margin (dB)		Expected	Measured	Reported Margin (dB)	
Noise profile: 24-self and -140dBm/Hz AWGN								
2000	27				2			
2400	27				2			

4 individual tests – 4 tests SHALL be passed

Table 54: Profile-line combination AA8d_UPBO_FX_I_014_001

Loop Length (ft, 26 AWG loop)	AA8d_UPBO_FX_I_014_001							
	Downstream				Upstream			
	Actual net data rate (Mbps)			Pass/Fail	Actual net data rate(Mbps)			Pass/Fail
	Expected	Measured	Reported Margin		Expected	Measured	Reported Margin	
Noise profile: 24-self and -140dBm/Hz AWGN								
3600	14				1			
4000	14				1			

A.3 REIN Testing for AA8d

The SUT SHALL be configured as described in section 6.2. The REIN test SHALL use a "burst of pseudo random AWGN" of 100us duration whose differential signal power spectral density is described below (Formula A -1). The REIN noise is injected with a repetition frequency of 120Hz. The test procedure is described in Table 55. Reported data rate and noise margin SHALL NOT be considered in the pass/fail criteria.

Formula A -1: Annex A REIN Impulse PSD

$$Noise_{REI}(f) = \begin{cases} -116\, dBm/Hz\; f < 2.2MHz \\ \max\left(-116 - 40 \times \log_{10}\left(f \big/ 2.2 \times 10^{6}\right), -150\right) dBm/Hz;\, f \geq 2.2MHz \end{cases}$$

$where: f \text{ is in Hz}$

Table 55: REIN testing for AA8d

Test Configuration	(1)Configure the SUT in AA8d_UPBO_RA_I_096_056 profile-line combination, with the UPBO settings from Table 41. (2)The DSLAM and CPE are connected in turn through 26 AWG straight loops: 1200ft and 4000ft. (3)The crosstalk noise impairment as defined for the rate adaptive tests (Table 51) SHALL be applied at both DSLAM and CPE. (4)The REIN noise impairment SHALL be applied at the CPE in addition to the crosstalk noise. (5)Additional test conditions: optional OLR functionality (SRA, SOS) SHALL NOT be used.
Method of Procedure	(1)Inject the crosstalk impairment and let the system train. (2)Wait for 3 minutes for bitswaps to settle. (3)Record the actual net data rate and reported noise margin. (4)Apply the REIN impairment for 2 minutes and record the number of ES. (5)Record the actual net data rate and reported noise margin.
ExpectedResult	For each loop distance the reported number of downstream ES SHALL be ≤ 2 per minute.

A.4 Long Term Stability Testing for AA8d

This test applies only to VDSL2 modems that support the PTM-TC functionality.

A.4.1 Long Term Stability Test

Table 56: Long term stability test procedure

Test Configuration	(1)Configure the SUT for PTM transport in AA8d_UPBO_ FX_I_027_002 profile-line combination as defined in Table 6 and Table 9, with the UPBO settings from Table 41. (2)The following parameters SHALL be indicated as follows: • TARSNMRds = 9 dB • MAXSNRMds = 18 dB • packet size: 1500 bytes (3)The loop simulator SHALL be configured to 2 kft 26 AWG straight loop. (4)Inject -140 dBm/Hz white noise from 26 kHz to 8.5 MHz at both ends of the loop.
Method of Procedure	(1)Train the CPE with the DSLAM (2)Wait for 1 minute after initialization (3)Check the reported margin and document as the initial reported margin. (4)Adjust the noise level at the CPE side until the reported CPE-side margin is approximately 9 dB. (5)Configure the traffic generator/analyzer to provide MAC frames, both upstream and downstream, at 85% of the net data rate. (6)Run for four hours with constant noise level. (7)If there are more than 2 ES, then the measurement SHALL be extended for up to an additional four-hour period (for a maximum of 8 hours).
Expected Result	(1)The customer end modem SHALL NOT loose synchronization at any time during the test. (2)If during any 4 hour sliding window there are fewer than 3 ES and no SES then the CPE passes the test.

A.5 Fluctuating Noise Testing

This test applies only to VDSL2 modems that support the PTM-TC functionality.

Table 57: Fluctuating noise test

Test Configuration	(1)Configure the SUT for PTM transport in AA8d_UPBO_ FX_I_027_002 profile-line combination as defined in Table 6 and Table 9, with the UPBO settings from Table 41. (2)The DSLAM and CPE are connected in turn through 2kft 26 AWG straight loop. (3)The AWGN noise at -140dBm/Hz in frequency range from 26 kHz to 8.5MHz SHALL be applied at both DSLAM and CPE. (4)The following parameters SHALL be indicated as follows: • Ethernet frame size without FCS: 1514 bytes • TARSNRMds = 10dB • MAXSNRMds = 18dB (5)Additional test conditions: optional OLR functionality (SRA, SOS) SHALL NOT be used. .
Method of Procedure	(1)Inject the noise impairment and let the CPE and DSLAM train. (2)Wait for 1 minute for bitswaps to settle and record the reported downstream margin as the initial reported margin. (3)Adjust the AWGN level at the CPE side until the reported margin is approximately 10dB. This noise level is termed NL10. (4)Configure the traffic generator/analyzer to provide MAC frames, both upstream and downstream, at 95% of the net data rate. (5)Run the SUT for two minutes with noise level NL10. (6)Increase the noise level at the CPE side by 4dB (NL6), and without re-training run the SUT for 2 minutes. (7)Set the noise injected at the CPE side to -140dBm/Hz, and without re-training run the SUT for 2 minutes. (8)Set the noise injected at the CPE side to NL10 level, and without re-training run the SUT for 2 minutes. (9)Perform steps 6 through 8 a total of five times (total duration: 2x3x5 minutes = 30 minutes). NOTE: To avoid the unintended generation of noise impulses, the noise levels SHALL be changed rapidly within a period of 250 microseconds or less. The noise generator SHALL maintain approximately flat spectrum throughout the transition in noise level.
Expected Result	(1)The CPE modem SHALL NOT lose synchronization at any time during the test. (2)For the duration of the entire 30 minute test, no more than four packet errors SHALL occur.

A.6 Performance tests for Band-Profile AA8a

A.6.1 Rate adaptive tests with straight loops

32 individual tests – 29 tests SHALL be passed

Table 58: Profile-line combination AA8a_UPBO_RA_I_098_058

Loop Length (ft, 26 AWG loop)	AA8a_UPBO_RA_I_098_058							
	Downstream				Upstream			
	Actual net data rate (kbps)			Noise Margin, Reported (dB)	Actual net data rate(kbps)			Noise Margin, Reported (dB)
	Expected	Measured	Pass/Fail		Expected	Measured	Pass/Fail	
Noise Profile: 24 AA8a self + -140 dBm/Hz AWGN								
300	41000				8400			
600	40500				7500			
900	39000				7300			
1200	37000				7000			
1600	34500				6600			
2000	33000				6000			
2400	24500				4900			
2800	22000				4000			
3200	21200				2500			
3600	19000				1000			
4000	16000				875			
Noise Profile: 12 AA8a self + 12 ADSL2plus + -140 dBm/Hz AWGN								
4500	14500				850			
5500	9800				830			
6500	6100				790			
Noise Profile: -140 dBm/Hz AWGN								
7500	7000				750			
8500	5100				725			

A.6.2 **Rate adaptive tests with bridged tap loops**

32 individual tests – 29 tests SHALL be passed

Table 59: Profile-line combination AA8a_UPBO_RA_I_098_058

Length of A (ft, 26 AWG loop)	Length of Tap (ft, 26 AWG loop)	AA8a_UPBO_RA_I_098_058							
		Downstream				Upstream			
		Actual net data rate(kbps)			Noise Margin, Reported (dB)	Actual net data rate(kbps)			Noise Margin, Reported (dB)
		Expected	Measured	Pass/Fail		Expected	Measured	Pass/Fail	
Noise profile: 24 AA8a self and -140dBm/Hz AWGN									
300	20	37500				7700			
600	100	35000				6200			
900	200	32000				6600			
1200	50	30000				6600			
1600	100	28000				5200			
2000	100	21500				3700			
2400	50	18800				3200			
2800	100	16300				2000			
3200	200	14400				1700			
3600	50	13300				925			
4000	100	11800				875			
Noise Profile: 12 AA8a self + 12 ADSL2plus + -140 dBm/Hz AWGN									
4500	50	9400				850			
5500	100	4800				830			
6500	100	4200				790			
Noise profile: -140dBm/Hz AWGN									
7500	200	2900				725			
8500	100	1500				700			

A.7 Performance tests for Band-Profile AA12a

A.7.1 Rate adaptive tests with straight loops

12 individual tests – 11 tests SHALL be passed

Table 60: Profile-line combination AA12a_UPBO_RA_I_098_058

Loop Length (ft, 26 AWG loop)	AA12a_UPBO_RA_I_098_058							
	Downstream				Upstream			
	Actual net data rate (kbps)			Noise Margin, Reported (dB)	Actual net data rate (kbps)			Noise Margin, Reported (dB)
	Expected	Measured	Pass/Fail		Expected	Measured	Pass/Fail	
Noise Profile: 24 AA12a self + -140 dBm/Hz AWGN								
300	42750				23000			
600	39000				21400			
900	37000				19800			
1200	36000				16300			
1600	34000				12300			
2000	31500				9800			

A.7.2 **Rate adaptive tests with bridged tap loops**

12 individual tests – 11 tests SHALL be passed

Table 61: Profile-line combination AA12a_UPBO_RA_I_098_058

Length of A (ft, 26 AWG loop)	Length of Tap (ft, 26 AWG loop)	AA12a_UPBO_RA_I_098_058							
		Downstream				Upstream			
		Actual net data rate(kbps)			Noise Margin, Reported (dB)	Actual net data rate(kbps)			Noise Margin, Reported (dB)
		Expected	Measured	Pass/Fail		Expected	Measured	Pass/Fail	
Noise profile: 24 AA12a self and -140dBm/Hz AWGN									
300	20	37000				21000			
600	100	33500				18500			
900	200	31100				18400			
1200	50	29600				10500			
1600	100	26900				8700			
2000	100	24000				5000			

A.8 Performance tests for Band-Profile AA17a

The tests with retransmission-enabled profiles are designed to be passed by implementations with a MAXDELAYOCTET-split parameter (MDOSPLIT) set to 80%.

A.8.1 Rate adaptive tests with straight loops

10 individual tests – 9 tests SHALL be passed

Table 62: Profile-line combination AA17a_UPBO_RA_I_150_096

Loop Length (ft, 26 AWG loop)	AA17a_UPBO_RA_I_150_096							
	Downstream				Upstream			
	Actual net data rate(kbps)			Noise Margin, Reported (dB)	Actual net data rate(kbps)			Noise Margin, Reported (dB)
	Expected	Measured	Pass/Fail		Expected	Measured	Pass/Fail	
Noise Profile: 24 AA17a self + -140 dBm/Hz AWGN								
300	60000				25000			
600	53000				21500			
900	49000				20000			
1200	44500				18500			
1600	38500				14000			

10 individual tests – 9 tests SHALL be passed

Table 63: Class 1 Profile-line combination AA17a_UPBO_RA_R-17/2/41_150_096

Loop Length (ft, 26 AWG loop)	AA17a_UPBO_RA_ R-17/2/41_150_096							
	Downstream				Upstream			
	Actual net data rate(kbps)			Noise Margin, Reported (dB)	Actual net data rate(kbps)			Noise Margin, Reported (dB)
	Expected	Measured	Pass/Fail		Expected	Measured	Pass/Fail	
Noise Profile: 24 AA17a self + -140 dBm/Hz AWGN								
300	59500				22100			
600	50100				18600			
900	45100				16800			
1200	41800				15700			
1600	37600				13800			

Table 64: Class 2 Profile-line combination AA17a_UPBO_RA_R-17/2/41_150_096

Loop Length (ft, 26 AWG loop)	AA17a_UPBO_RA_ R-17/2/41_150_096							
	Downstream				Upstream			
	Actual net data rate(kbps)			Noise Margin, Reported (dB)	Actual net data rate(kbps)			Noise Margin, Reported (dB)
	Expected	Measured	Pass/Fail		Expected	Measured	Pass/Fail	
Noise Profile: 24 AA17a self + -140 dBm/Hz AWGN								
300	65200				25600			
600	56900				23100			
900	51200				21400			
1200	46900				19700			
1600	41600				15800			

A.8.2 **Rate adaptive tests with bridged tap loops**

10 individual tests – 9 tests SHALL be passed

Table 65: Profile-line combination AA17a_UPBO_RA_I_150_096

Length of A (ft, 26 AWG loop)	Length of Tap (ft, 26 AWG loop)	AA17a_UPBO_RA_I_150_096							
		Downstream				Upstream			
		Actual net data rate(kbps)			Noise Margin, Reported (dB)	Actual net data rate(kbps)			Noise Margin, Reported (dB)
		Expected	Measured	Pass/Fail		Expected	Measured	Pass/Fail	
Noise profile: 24 AA17a self and -140dBm/Hz AWGN									
300	20	51500				20000			
600	100	42000				19000			
900	200	35500				18000			
1200	50	33000				12000			
1600	100	27500				9000			

Table 66: Class 1 Profile-line combination AA17a_UPBO_RA_R-17/2/41_150_096

Length of A (ft, 26 AWG loop)	Length of Tap (ft, 26 AWG loop)	AA17a_UPBO_RA_R-17/2/41_150_096							
		Downstream				Upstream			
		Actual net data rate(kbps)			Noise Margin, Reported (dB)	Actual net data rate(kbps)			Noise Margin, Reported (dB)
		Expected	Measured	Pass/Fail		Expected	Measured	Pass/Fail	
Noise profile: 24 AA17a self and -140dBm/Hz AWGN									
300	20	50100				17600			
600	100	39600				16500			
900	200	33800				13000			
1200	50	32000				11700			
1600	100	26600				9100			

Table 67: Class 2 Profile-line combination AA17a_UPBO_RA_R-17/2/41_150_096

Length of A (ft, 26 AWG loop)	Length of Tap (ft, 26 AWG loop)	AA17a_UPBO_RA_R-17/2/41_150_096							
		Downstream				Upstream			
		Actual net data rate(kbps)			Noise Margin, Reported (dB)	Actual net data rate(kbps)			Noise Margin, Reported (dB)
		Expected	Measured	Pass/Fail		Expected	Measured	Pass/Fail	
Noise profile: 24 AA17a self and -140dBm/Hz AWGN									
300	20	56100				22600			
600	100	45400				21000			
900	200	39100				19200			
1200	50	36100				15000			
1600	100	31000				10900			

B Annex B Physical Layer Test Cases for G.993.2 Region B (Europe)

B.1 Annex B-specific Test Setup Information

Test configurations associated with the VDSL2 over POTS (VDSL2oPOTS) and VDSL2 over ISDN (VDSL2oISDN) deployments with Annex B band profiles are defined in Table 68**.**

Table 68: Annex B test configurations

Type of VDSL2 deployment	Band-profile	Test configuration
VDSL2oPOTS	BA8b	Figure 1
	BA17ade_D&UPBO	
	BA17a0	
	BA17a0_D&UPBO	
VDSL2oISDN	BB8b	Figure 3
	BB12a	
	BB17a	
	BB17a_D&UPBO	

The specific SUT's settings as defined in 6.2 SHALL be used.

B.1.1 **Pass/fail criteria for Annex B testing**

Tests SHALL be performed according to the general procedure described in section 8. Testing is defaulted to no PBO unless specified in specific test procedure.

- For sections with more than 3 test loops, if more than 10% of the data rates are less than the data rate requirements in a section, then the DSLAM/CPE pair fails the data rate requirements of that section.
- For sections with less than 4 test loops, the data rate requirement is indicated per table.

In addition to achieving the required rate, both downstream and upstream noise margin values are to be considered in determining the result of an individual section. It is acknowledged that achieving a desired noise margin is primarily the responsibility of the receiver. That is, the DSLAM is primarily responsible for achieving desired upstream noise margins, while the CPE is primarily responsible for achieving desired downstream noise margins. Table 69 outlines the pass/fail criteria on the reported noise margin.

Table 69: Noise margin pass/fail requirements

Reported Noise Margin (dB)	Requirement
< 5	On no test point
≥ 5 and < 5.8	On at most 10% of the test points
≥ 5.8	On at least 90% of the test points

All values SHALL be collected at the DSLAM.

Overall pass/fail criteria for each rate adaptive test are as follows:

- If any reported noise margin is less than 5 dB, then the DSLAM/CPE pair fails the noise margin requirements of that section.
- If more than 10% of the reported noise margins are less than 5.8 dB in a section, then the DSLAM/CPE pair fails the noise margin requirements of that section.
- If more than 10% of the data rates are less than the data rate requirements in a section, then the DSLAM/CPE pair fails the data rate requirements of that section.
- If the DSLAM/CPE pair passes both the data rate and noise margin requirements, it passes the section; otherwise, it fails the section.

Table 70 lists the number of test points per section or table corresponding to the 10% limit mentioned above.

Table 70: Data rate pass/fail requirements for rate adaptive testing

Section number	Number of test cases	10% limit
B.3	20	2
B.5	20	2
B.6	16	2
B.7	16	2
B.9	16	2
B.15.1	10	1
Section number	**Number of test cases (per table)**	**10% limit (per table)**
B.4	6	1
B.8	6	1

B.1.2 **Noise impairments**

The noise is specified in TS 101 271 [7] and includes the crosstalk noise and the white noise (NEXT noise generator G1, FEXT noise generator G2 and the white noise generator G4).

Noise generators G1 and G2 are injected on one side at a time.

The white noise generator G4 SHALL be set to –140 dBm/Hz at both ends of the loop.

For performance tests with VDSL2oISDN band profiles the line sharing noise generator G8, specified according to TS 101 388 [8], SHALL be used at both ends of the loop.

If the line sharing noise is implemented in the above mentioned generator G8, through the noise injection circuit, the ISDN port of the splitter has to be terminated with the appropriate ISDN impedance. Otherwise, the G8 noise SHALL be realized according to Annex F of TS 101 388 [8]. In this case the ISDN port of the splitter SHALL be used for injecting the line sharing noise.

B.1.2.1 Crosstalk Impairment G1 and G2

Crosstalk impairment includes the NEXT noise generator G1 and FEXT noise generator G2. It is defined as follows.

The crosstalk coupling functions NEXT and FEXT SHALL be calculated using the transfer function equations from Section 7.3.3 of TS 101 271 [7].

For the generic n_XYZ noise the following applies:

- the alien noise disturber frequency domain profiles are associated with the ETSI noise scenario (MD_EX or MD_CAB27) as described in section 6.3.3.2, in a unique way and SHALL be as defined in Annex D.1 and Annex D.2, respectively; these are given in dBm/Hz.
- the self noise disturber frequency domain profile depends on the number (N) of self disturbers and is associated with the VDSL2 Band-profile (XYZ) which implicitly defines the single self-disturber PSD template for the LT side (US bands) and the NT side (DS bands).

Let $P_{Alien\text{-}XYZ,SS}$ be the alien PSD for the generic n_XYZ noise at the SS side (SS=LT, NT) in W/Hz. Let $P_{Self\text{-}XYZ,SS}$ be the self-disturber PSD for the generic n_XYZ noise at the SS side (SS=LT, NT) in W/Hz.

The PSD of the noise generators G1 and G2 for the generic n_XYZ noise is a weighted sum of the self-crosstalk and alien crosstalk profiles, as specified in Section 7.3.3 of TS 101 271 [7].

At DSLAM side:

- G1 = (XA.LT.n_XYZ ∗ XS.LT.n_XYZ), with NEXT coupling function
- G2 = (XA.NT.n_XYZ ∗ XS.NT.n_XYZ), with FEXT coupling function

At CPE side:

- G1 = (XA.NT.n_XYZ ∗ XS.NT.n_XYZ), with NEXT coupling function
- G2 = (XA.LT.n_XYZ ∗ XS.LT.n_XYZ), with FEXT coupling function

Symbol "∗" refers to the FSAN crosstalk sum $P_{XYZ,SS}$ of two PSDs in W/Hz, the alien $P_{Alien\text{-}XYZ,SS}$ and self-crosstalk $P_{Self\text{-}XYZ,SS}$ PSD:

Formula B- 1

$$P_{XYZ,SS} = \left[P_{Alien\text{-}XYZ,SS}^{1/0.6} + P_{Self\text{-}XYZ,SS}^{1/0.6} \right]^{0.6}$$

The alien crosstalk (XA) profiles (XA.LT.n_XYZ, XA.NT.n_XYZ) are defined in Annex D. Self-crosstalk (XS) profiles (XS.LT.n_XYZ, XS.NT.n_XYZ) are specified in Table 71 and describe the self-crosstalk portion of an equivalent disturber co-located at the LT and NT end of the loop.

Table 71: Power calculation of the XS profiles LT and NT

	MD_EX	MD_CAB27	19self_BA17ade_D&U PBO
XS.LT.n_XYZ	$P_{SingleSelf\text{-}XYZ,LT}$ + 6.68dB	$P_{SingleSelf\text{-}XYZ,LT}$ + 7.06dB	$P_{SingleSelf\text{-}XYZ,LT}$ + 7.67dB
XS.NT.n_XYZ	$P_{SingleSelf\text{-}XYZ,NT}$ + 6.68dB	$P_{SingleSelf\text{-}XYZ,NT}$ + 7.06dB	$P_{SingleSelf\text{-}XYZ,NT}$ + 7.67dB

The values 6.68 dB, 7.06dB and 7.67 dB simulate the power generated by the sum of 13, 15 and 19 disturbers, which is added to the single self-disturber PSD $P_{SingleSelf\text{-}XYZ,SS}$ for the generic n_XYZ noise at the SS side (SS=LT, NT).

The following clause specifies the method of computation that applies for the single self-disturber PSD $P_{SingleSelf\text{-}XYZ,SS}$. The basic PSD template corresponds to the associated VDSL2 Band-profile (XYZ) as per Section B.2.4/G.993.2 and Section B.2.5/G.993.2, and is defined in accordance to Section B.4/G.993.2. This is considered constant regardless of the loop length corresponding to the specific test point. The single self-disturber PSD $P_{SingleSelf\text{-}XYZ,SS}$ is always defined for the complete frequency spectrum as given by the Band-profile configuration. No power reallocation to lower frequencies is taken into account as the loop length increases from one test point to the next.

The following steps SHALL be applied:

- identify the basic PSD template that corresponds to the associated VDSL2 Band-profile (XYZ). Where required, apply to the above basic PSD template the DPBO and UPBO shaping of the associated VDSL2 Band-profile (XYZ) to calculate a shaped PSD template. NOTE: for upstream shaped PSD templates the kl_0 value varies with the test point.
- apply a flattening operation that consists in lowering all the highest levels of the above shaped PSD template to a single flattening level. This flattening level is determined on a PSD grid of 0.01dB such that the power under the resulting template up to a frequency of 30.175MHz (for all band plans up to 30MHz) is less or equal, and as close as possible, to the MAXNOMATP of the associated VDSL2 Band-profile (XYZ) (as per Table 6-1/G.993.2 [2]), both for upstream and downstream. The calculated flattened PSD template corresponds to the $P_{SingleSelf\text{-}XYZ,SS}$.

B.1.3 **Verification of bits, gains and NOMATP values**

Downstream and upstream bits, gains and NOMATPds values SHALL be verified prior to collecting the performance measurements. The procedure and expected results are provided in Table 72.

Table 72: Verification of bits, gains and NOMATP values

Test Configuration	(1)Configure the SUT in the RA_F_150_150 specific line settings for BBx band profiles and RA_R-17/2/41 for BAx band profiles. If for the specific band-profile the profile-line combinations are defined with UPBO and/or DPBO enabled, apply the related PBO configuration parameters defined in the Annex B performance sections. (2)The DSLAM and CPE are connected in turn through the following test loops: • BA8b: 300m, 1200m, 1800m • BB8b: 300m, 1200m, 1800m • BA17ade: 150m, 1050m, 1500m • BB12a: 450m, 1050m, 1500m • BA17a0: 150m, 450m, 900m • BB17a: 450m, 1050m, 1500m
Method of Procedure	(1)Train the modem in the chosen test loop and band-profile. (2)Not sooner than two minutes after entering steady state operation (a.k.a. Showtime), record the reported downstream bi (bits) and gi (gains) values (BITSpsds and GAINSpsds) and upstream bi (bits) and gi (gains) values (BITSpsus and GAINSpsus)..

Expected Result	1. In downstream, the g_i settings (in the bits-and-gains table) SHALL comply with the following requirements: (1)If $b_i > 0$, then g_i SHALL be in the [−14.5 to +2.5] (dB) range. (2)If $b_i > 0$, then the linear average of the g_i^2's in any band (as specified during the initialization procedure, see G.993.2 [2] §12.3.2) SHALL be ≤ 1. (3)If $b_i = 0$, then g_i SHALL be equal to 0 (linear) or in the [−14.5 to 0] (dB) range. (4)The NOMATP value calculated as: $\text{NOMATP} = 10\log_{10}\Delta f + 10\log_{10}\left(\sum_{i\in \text{MEDLEY set}}\left(10^{\frac{\text{MREFPSD}[i]}{10}} g_i^2\right)\right)$ SHALL NOT exceed the configured MAXNOMATPds and SHALL NOT exceed the maximum power specified for the VDSL2 profile under test. 2. In upstream, the g_i settings (in the bits-and-gains table) SHALL comply with the following requirements: (1)If $b_i > 0$, then g_i SHALL be in the [−14.5 to +2.5] (dB) range. (2)If $b_i > 0$, then the linear average of the g_i^2's in any band (as specified during the initialization procedure, see G.993.2 [2] §12.3.2) SHALL be ≤ 1. (3)If $b_i = 0$, then g_i SHALL be equal to 0 (linear) or in the [−14.5 to 0] (dB) range. (4)The NOMATP value calculated as: $\text{NOMATP} = 10\log_{10}\Delta f + 10\log_{10}\left(\sum_{i\in \text{MEDLEY set}}\left(10^{\frac{\text{MREFPSD}[i]}{10}} g_i^2\right)\right)$ SHALL NOT exceed the configured MAXNOMATPus and SHALL NOT exceed the maximum power specified for the VDSL2 profile under test.

B.2 Long Term Stability Testing for Annex B

This test applies only to VDSL2 modems that support the PTM-TC functionality.

B.2.1 Long Term Stability Test

Table 73: Long term stability test procedure

<table>
<tr><td>Test Configuration</td><td>(1)Depending on the band-profile under test, select the appropriate profile-line combination and loop length from the below table:
<table>
<tr><th>Band-profile</th><th>Loop Length (m, PE04 or TP100)</th></tr>
<tr><td>BA17a0_RA_I_150_150</td><td>300</td></tr>
<tr><td>BB17a_RA_I_150_150</td><td>300</td></tr>
<tr><td>BA17a0_D&UPBO_RA_I_150_150</td><td>300</td></tr>
<tr><td>BA17ade_D&UPBO_RA_R-17/2/41_150_150</td><td>300</td></tr>
<tr><td>BB17a_D&UPBO_RA_I_150_150</td><td>300</td></tr>
</table>
(2) Configure the SUT for PTM transport.
(3) The following parameters SHALL be indicated as follows:
• TARSNMRds = 9 dB
• MAXSNRMds = 18 dB
• packet size: 1500 bytes
(4) The loop simulator SHALL be configured to the value chosen above.
(5) Inject -140 dBm/Hz white noise at both ends of the loop.</td></tr>
<tr><td>Method of Procedure</td><td>(1)Train the CPE with the DSLAM.
(2)Wait for 1 minute after initialization.
(3)Check the reported margin and document as the initial reported margin.
(4)Adjust the noise level at the CPE side until the reported CPE-side margin is approximately 9 dB.
(5)Configure the traffic generator/analyzer to provide MAC frames, both upstream and downstream, at 85% of the net data rate.
(6)Run for four hours with constant noise level.
(7)If there are more than 2 ES, then the measurement SHALL be extended for up to an additional four-hour period (for a maximum of 8 hours).</td></tr>
<tr><td>Expected Result</td><td>(1)The customer end modem SHALL NOT lose synchronization at any time during the test.
(2)If during any 4 hour sliding window there are fewer than 3 ES and no SES then the CPE passes the test.</td></tr>
</table>

B.3 Rate adaptive performance tests for BA8b

The tests with retransmission-enabled profiles are designed to be passed by implementations with a MAXDELAYOCTET-split parameter (MDOSPLIT) set to 66%.

Noise n_BA8b settings as defined in section 6.3.3.2.

20 individual tests – 18 tests SHALL be passed

Table 74: Class 1 Performance tests with BA8b_RA_R-17/2/41_150_150

Loop Length (m, PE04 loop)	BA8b_RA_ R-17/2/41_150_150							
	Downstream				Upstream			
	Actual net data rate (kbps)			Noise Margin, Reported (dB)	Actual net data rate (kbps)			Noise Margin, Reported (dB)
	Expected	Measured	Pass/Fail		Expected	Measured	Pass/Fail	
150	44000				8800			
300	39600				7700			
750	30400				5800			
1050	20600				2800			
1500	13100				600			

Table 75: Performance tests with BA8b_RA_I_150_150

Loop Length (m, PE04 loop)	BA8b_RA_I_150_150							
	Downstream				Upstream			
	Actual net data rate(kbps)			Noise Margin, Reported (dB)	Actual net data rate (kbps)			Noise Margin, Reported (dB)
	Expected	Measured	Pass/Fail		Expected	Measured	Pass/Fail	
150	41792				8900			
300	37928				7888			
750	28196				5792			
1200	16828				368			
1800	7792				200			

B.4 Rate adaptive performance tests for BA17a0

The tests with retransmission-enabled profiles are designed to be passed by implementations with a MAXDELAYOCTET-split parameter (MDOSPLIT) set to 66%.

Noise n_BA17a0 settings as defined in section 6.3.3.2.

6 individual tests – 5 tests SHALL be passed

Table 76: Class 1 Performance tests with BA17a0_RA_R-17/2/41_150_150

Loop Length (m, PE04 loop)	BA17a0_RA_R-17/2/41_150_150							
	Downstream				Upstream			
	Actual net data rate (kbps)			Noise Margin, Reported (dB)	Actual net data rate (kbps)			Noise Margin, Reported (dB)
	Expected	Measured	Pass/Fail		Expected	Measured	Pass/Fail	
150	57400				29900			
450	42800				21100			
900	27200				4800			

6 individual tests – 5 tests SHALL be passed

Table 77: Performance tests with BA17a0_RA_I_150_150

Loop Length (m, PE04 loop)	BA17a0_RA_I_150_150							
	Downstream				Upstream			
	Actual net data rate (kbps)			Noise Margin, Reported (dB)	Actual net data rate (kbps)			Noise Margin, Reported (dB)
	Expected	Measured	Pass/Fail		Expected	Measured	Pass/Fail	
150	52500				28000			
450	39800				20400			
900	25300				4800			

B.5 Rate adaptive performance tests for BB8b

Noise n_BB8b settings as defined in section 6.3.3.2

20 individual tests – 18 tests SHALL be passed

Table 78: Performance tests with BB8b_RA_F_150_150

Loop Length (m, PE04 loop)	BB8b_RA_F_150_150							
	Downstream				Upstream			
	Actual net data rate (kbps)			Noise Margin, Reported (dB)	Actual net data rate (kbps)			Noise Margin, Reported (dB)
	Expected	Measured	Pass/Fail		Expected	Measured	Pass/Fail	
150	43360				9928			
300	38368				8616			
750	26608				6208			
1200	13040				616			
1800	4576				368			

Table 79: Performance tests with BB8b_RA_I_150_150

Loop Length (m, PE04 loop)	BB8b_RA_I_150_150							
	Downstream				Upstream			
	Actual net data rate (kbps)			Noise Margin, Reported (dB)	Actual net data rate (kbps)			Noise Margin, Reported (dB)
	Expected	Measured	Pass/Fail		Expected	Measured	Pass/Fail	
150	40528				9304			
300	36812				8284			
750	27736				6128			
1200	13976				600			
1800	5320				420			

B.6 Rate adaptive performance tests for BB12a

Noise n_BB12a settings as defined in section 6.3.3.2.

16 individual tests – 14 tests SHALL be passed

Table 80: Performance tests with BB12a_RA_F_150_150

Loop Length (m, PE04 loop)	BB12a_RA_F_150_150							
	Downstream				Upstream			
	Actual net data rate (kbps)			Noise Margin, Reported (dB)	Actual net data rate (kbps)			Noise Margin, Reported (dB)
	Expected	Measured	Pass/Fail		Expected	Measured	Pass/Fail	
150	43772				22166			
450	33704				15804			
1050	17080				2088			
1500	10008				652			

Table 81: Performance tests with BB12a_RA_I_150_150

Loop Length (m, PE04 loop)	BB12a_RA_I_150_150							
	Downstream				Upstream			
	Actual net data rate (kbps)			Noise Margin, Reported (dB)	Actual net data rate (kbps)			Noise Margin, Reported (dB)
	Expected	Measured	Pass/Fail		Expected	Measured	Pass/Fail	
150	39928				20364			
450	32828				15316			
1050	17184				2600			
1500	10384				680			

B.7 Rate adaptive performance tests for BB17a

Noise n_BB17a settings as defined in section 6.3.3.2.

16 individual tests – 14 tests SHALL be passed

Table 82: Performance tests with BB17a_RA_F_150_150

Loop Length (m, PE04 loop)	BB17a_RA_F_150_150							
	Downstream				Upstream			
	Actual net data rate (kbps)			Noise Margin, Reported (dB)	Actual net data rate (kbps)			Noise Margin, Reported (dB)
	Expected	Measured	Pass/Fail		Expected	Measured	Pass/Fail	
150	55676				20768			
450	35616				14644			
1050	15968				2056			
1500	8544				648			

Table 83: Performance tests with BB17a_RA_I_150_150

Loop Length (m, PE04 loop)	BB17a_RA_I_150_150							
	Downstream				Upstream			
	Actual net data rate (kbps)			Noise Margin, Reported (dB)	Actual net data rate (kbps)			Noise Margin, Reported (dB)
	Expected	Measured	Pass/Fail		Expected	Measured	Pass/Fail	
150	53520				21392			
450	38276				14228			
1050	15628				2536			
1500	9164				684			

B.8 Rate adaptive performance tests for BA17a0 with DPBO and UPBO

The tests with retransmission-enabled profiles are designed to be passed by implementations with a MAXDELAYOCTET-split parameter (MDOSPLIT) set to 66%.

The basic BA17a0 Band Profile SHALL be applied with the following modifications to the "Common Line Settings" specified in Table 7 to define the shaped-PSD Band Profile BA17a0_D&UPBO:

Table 84: Common Line Settings for BA17a0_D&UPBO Band Profile

Parameter	Setting	Description
All parameters but those specified below	Value as specified in Table 7	
DPBOEPSD	ADSL2plus Annex A	PSD mask that is assumed to be permitted at the exchange
DPBOESEL	27dB@1MHz	E-side electrical length
DPBOESCMA	0.1924	Model of the frequency dependent loss of E-side cable: scalars DPBOESCMA (NOTE)
DPBOESCMB	0.5960	Model of the frequency dependent loss of E-side cable: scalars DPBOESCMB (NOTE)
DPBOESCMC	0.2086	Model of the frequency dependent loss of E-side cable: scalars DPBOESCMC (NOTE)
DPBOMUS	-95 dBm/Hz	Minimum usable receive signal PSD mask
DPBOFMIN	138 kHz	Minimum frequency from which on the DPBO SHALL be applied
DPBOFMAX	2208 kHz	Maximum frequency up to which the DPBO SHALL be applied
UPBOKLF	0	Force CO-MIB electrical loop length (means that kl_0 is estimated during training)
UPBOKL	estimated during training	Upstream electrical loop length (kl_0)
UPBOA US0	40.00	A and B values US band 0 (These values imply no UPBO)
UPBOB US0	0	
UPBOA US1	47.30	A value US band 1
UPBOB US1	21.14	B value US band 1
UPBOA US2	54.00	A value US band 2
UPBOB US2	16.29	B value US band 2
UPBOA US3	54.00	A value US band 3
UPBOB US3	16.29	B value US band 3
NOTE: the values of DPBOESCMA, B and C are referred to a PE04 loop. Values that are configured according to G.997.1 SHALL be rounded to the nearest scalar value.		

The following Profile-line combinations SHALL be configured on the equipment under test:

Table 85: Profile-line combinations for BA17a0_D&UPBO

Profile-line combination	Band-profile	Specific line-setting
BA17a0_D&UPBO_RA_R-17/2/41_150_150	BA17a0_D&UPBO	RA_R-17/2/41_150_150
BA17a0_D&UPBO_RA_I_150_150	BA17a0_D&UPBO	RA_I_150_150

The noise model n_BA17a0_D&UPBO defined in Table 86 SHALL be used. It is coherent with the noise models framework specified in section 6.3.3.2.

Table 86: Noise model n_BA17a0_D&UPBO

Noise model	Associated band-profile	Self noise disturbers	Alien noise disturbers
n_BA17a0_D&UPBO	BA17a0_D&UPBO	MD_CAB27	ETSI MD_CAB27 Table 166, Annex D.2

For this Band Profile the value of kl_0 (UPBOKL) is estimated by the SUTs during training. The PSD of a single self-disturber SHALL be deterministically defined by the settings of Table 84. The kl0 values for calculation of the single self-disturber PSD are listed in Table 87.

Table 87: kl_0 for calculation of the single self-disturber PSD for BA17a0_D&UPBO

Loop Length (m, PE04 loop)	kl_0 (UPBOKL) (dB @ 1MHz)
150	3.7
450	11.1
900	22.3

6 individual tests – 5 tests SHALL be passed

Table 88: Class 1 Performance tests with BA17a0_D&UPBO_RA_R-17/2/41_150_150

Loop Length (m, PE04 loop)	BA17a0_D&UPBO_RA_R-17/2/41_150_150							
	Downstream				Upstream			
	Actual net data rate (kbps)			Noise Margin, Reported (dB)	Actual net data rate (kbps)			Noise Margin, Reported (dB)
	Expected	Measured	Pass/Fail		Expected	Measured	Pass/Fail	
150	53200				25300			
450	40400				20000			
900	21900				4800			

6 individual tests – 5 tests SHALL be passed

Table 89: Performance tests with BA17a0_D&UPBO_RA_I_150_150

Loop Length (m, PE04 loop)	BA17a0_D&UPBO_RA_I_150_150							
	Downstream				Upstream			
	Actual net data rate (kbps)			Noise Margin, Reported (dB)	Actual net data rate (kbps)			Noise Margin, Reported (dB)
	Expected	Measured	Pass/Fail		Expected	Measured	Pass/Fail	
150	49300				23500			
450	37600				19400			
900	20600				4800			

B.9 Rate adaptive performance tests for BB17a with DPBO and UPBO

The basic BB17a Band Profile SHALL be applied with the following modifications to the "Common Line Settings" specified in Table 7 to define the shaped-PSD Band Profile BB17a_D&UPBO:

Table 90: Common Line Settings for BB17a_D&UPBO Band Profile

Parameter	Setting	Description
All parameters but those specified below	Value as specified in Table 7	
DPBOEPSD	ADSL2plus Annex B	PSD mask that is assumed to be permitted at the exchange
DPBOESEL	27dB@1MHz	E-side electrical length
DPBOESCMA	0.1924	Model of the frequency dependent loss of E-side cable: scalars DPBOESCMA (NOTE)
DPBOESCMB	0.5960	Model of the frequency dependent loss of E-side cable: scalars DPBOESCMB (NOTE)
DPBOESCMC	0.2086	Model of the frequency dependent loss of E-side cable: scalars DPBOESCMC (NOTE)
DPBOMUS	-95 dBm/Hz	Minimum usable receive signal PSD mask
DPBOFMIN	254 kHz	Minimum frequency from which on the DPBO SHALL be applied
DPBOFMAX	2208 kHz	Maximum frequency up to which the DPBO SHALL be applied
UPBOKLF	0	Force CO-MIB electrical loop length (means that kl_0 is estimated during training)
UPBOKL	estimated during training	Upstream electrical loop length (kl_0)
UPBOA US0	40.00	A and B values US band 0 (these values imply no UPBO)
UPBOB US0	0	
UPBOA US1	47.30	A value US band 1
UPBOB US1	21.14	B value US band 1
UPBOA US2	54.00	A value US band 2
UPBOB US2	16.29	B value US band 2
NOTE: the values of DPBOESCMA, B and C are referred to a PE04 loop. Values that are configured according to G.997.1 SHALL be rounded to the nearest scalar value.		

The following Profile-line combinations SHALL be configured on the equipment under test:

Table 91: Profile-line combinations for BB17a_D&UPBO

Profile-line combination	Band-profile	Specific line-setting
BB17a_D&UPBO_RA_F_150_150	BB17a_D&UPBO	RA_F_150_150
BB17a_D&UPBO_RA_I_150_150	BB17a_D&UPBO	RA_I_150_150

The noise model n_BB17a_D&UPBO defined in Table 92 SHALL be used. It is coherent with the noise models framework specified in section 6.3.3.2.

Table 92: Noise model n_BB17a_D&UPBO

Noise model	Associated band-profile	Self noise disturbers	Alien noise disturbers
n_BB17a_D&UPBO	BB17a_D&UPBO	MD_CAB27	ETSI MD_CAB27 Table 166, Annex D.2

For this Band Profile the value of kl_0 (UPBOKL) is estimated by the SUTs during training. The PSD of a single self-disturber SHALL be deterministically defined by the settings of Table 90. The kl0 values for calculation of the single self-disturber PSD are listed in Table 93.

Table 93: kl_0 for calculation of the single self-disturber PSD for BB17a_D&UPBO

Loop Length (m, PE04 loop)	kl_0 (UPBOKL) (dB @ 1MHz)
150	3.7
450	11.1
1050	26.0
1500	37.1

16 individual tests – 14 tests SHALL be passed

Table 94: Performance tests with BB17a_D&UPBO_RA_F_150_150

Loop Length (m, PE04 loop)	BB17a_D&UPBO_RA_F_150_150							
	Downstream				Upstream			
	Actual net data rate (kbps)			Noise Margin, Reported (dB)	Actual net data rate (kbps)			Noise Margin, Reported (dB)
	Expected	Measured	Pass/Fail		Expected	Measured	Pass/Fail	
150	54716				16668			
450	37212				14852			
1050	11304				2584			
1500	2648				772			

Table 95: Performance tests with BB17a_D&UPBO_RA_I_150_150

Loop Length (m, PE04 loop)	BB17a_D&UPBO_RA_I_150_150							
	Downstream				Upstream			
	Actual net data rate (kbps)			Noise Margin, Reported (dB)	Actual net data rate (kbps)			Noise Margin, Reported (dB)
	Expected	Measured	Pass/Fail		Expected	Measured	Pass/Fail	
150	53036				16152			
450	39724				14424			
1050	10920				3016			
1500	2952				756			

B.10 VDSL2oPOTS and VDSL2oISDN test cases for error reporting verification test

B.10.1 Test cases for CRC error reporting verification test

CRC verification testing for Region B SHALL be performed in rate adaptive mode according to section 8.1.1. Testing consists of two test conditions randomly selected from the 3 described in the tables for any given profile-line combination. Test loops and noise impairment for CRC error reporting verification test defined in section 8.1.1 are listed in Table 96 and Table 97.

Table 96: VDSL2oPOTS test cases for CRC error reporting verification test

Profile-line combination	Loop length and type		Noise impairment	CRC Count	ES Count	Pass/ Fail
BA8b_RA_I_150_150	150 m	PE04	n_BA8b			
	750 m					
	1800 m					
BA17ade_D&UPBO_RA_I_150_150	150 m	TP100	n_BA17ade_D&UPBO			
	1050 m					
	1500 m					
BA17a0_RA_I_150_150	150 m	PE04	n_BA17a0			
	450 m					
	900 m					
BA17a0_D&UPBO_RA_I_150_150	150 m	PE04	n_BA17a0_D&UPBO			
	450 m					
	900 m					

Table 97: VDSL2oISDN test cases for CRC error reporting verification test

Profile-line combination	Loop length and type		Noise impairment	CRC Count	ES Count	Pass/ Fail
BB8b_RA_F_150_150	150 m	PE04	n_BB8b			
	750 m					
	1800 m					
BB8b_RA_I_150_150	150 m	PE04	n_BB8b			
	750 m					
	1800 m					
BB12a_RA_F_150_150	150 m	PE04	n_BB12a			
	1050 m					
	1500 m					
BB12a_RA_I_150_150	150 m	PE04	n_BB12a			
	1050 m					
	1500 m					
BB17a_RA_F_150_150	150 m	PE04	n_BB17a			
	1050 m					
	1500 m					
BB17a_RA_I_150_150	150 m	PE04	n_BB17a			
	1050 m					
	1500 m					
BB17a_D&UPBO_RA_F_150_150	150 m	PE04	n_BB17a_D&UPBO			
	1050 m					
	1500 m					
BB17a_D&UPBO_RA_I_150_150	150 m	PE04	n_BB17a_D&UPBO			
	1050 m					
	1500 m					

B.10.2 Test cases for uncorrected DTUs reporting verification test

Uncorrected DTUs reporting tests for Region B SHALL be performed according to Section 8.1.2. Testing consists of two test conditions randomly selected from the 3 described in the tables for any given profile-line combination. Test loops and noise impairment are listed in Table 98.

Table 98: VDSL2oPOTS test cases for uncorrected DTUs reporting verification test

Profile-line combination	Loop length and type		Noise impairment	RTXUC Count	ES Count	Pass/ Fail
BA8b_RA_R-17/2/41_150_150	150 m	PE04	n_BA8b			
	750 m					
	1800 m					
BA17a0_RA_R-17/2/41_150_150	150 m	PE04	n_BA17a0			
	450 m					

	900 m					
BA17a0_D&UPBO_RA_R-17/2/41_150_150	150 m	PE04	n_BA17a0_D &UPBO			
	450 m					
	900 m					
BA17ade_D&UPBO_RA_R-17/2/41_150_150	150 m	TP100	n_BA17ade_ D&UPBO			
	450 m					
	900 m					

B.11 VDSL2oPOTS and VDSL2oISDN test cases for downstream margin verification test

B.11.1 Test cases for downstream margin verification test with Retransmission disabled

Downstream margin verification testing for Region B SHALL be performed in rate adaptive mode according to Section 8.2.1 and Table 99, Table 100 and Table 101. Testing consists of two test conditions randomly selected from the 3 described in the tables for any given profile-line combination.

Table 99: Downstream margin verification for VDSL2oPOTS (PE04) with Retransmission disabled

Profile-line combination	Length (m)	Crosstalk	DS net data rate (kbps)		Test Time (minutes)	SES Count	CRC Count	Estimated BER	Pass/Fail
			Anticipated	Actual (test start) (test end)					
BA8b_RA_I_150_150	300	n_BA8b	≥ 37928		5				
	1200		≥ 16828		5				
	1800		≥ 7792		10				
BA17a0_RA_I_150_150	150	n_BA17a0	≥ 52500		5				
	450		≥ 39800		5				
	900		≥ 25300		5				
BA17a0_D&UPBO_RA_I_150_150	150	n_BA17a0_D&UPBO	≥ 49300		5				
	450		≥ 37600		5				
	900		≥ 20600		5				

Table 100: Downstream margin verification for VDSL2oPOTS (TP100) with Retransmission disabled

Profile-line combination	Length (m)	Crosstalk	DS net data rate (kbps)		Test Time (minutes)	SES Count	CRC Count	Estimated BER	Pass/Fail
			Anticipated	Actual (test start) (test end)					
BA17ade_D&UPBO_RA_I_150_150	150	n_BA17ade_D&UPBO	≥ 46600		5				
	1050		≥ 25100		5				
	1500		≥ 14500		10				

Table 101: Downstream margin verification for VDSL2oISDN (PE04) with Retransmission disabled

Profile-line combination	Length (m)	Crosstalk	DS net data rate (kbps)		Test Time (minutes)	SES Count	CRC Count	Estimated BER	Pass/Fail
			Anticipated	Actual (test start) (test end)					
BB8b_RA_F_150_150	300	n_BB8b	≥ 38368		5				
	1200		≥ 13040		5				
	1800		≥ 4576		10				
BB8b_RA_I_150_150	300	n_BB8b	≥ 36812		5				
	1200		≥ 13976		5				
	1800		≥ 5320		15				
BB12a_RA_F_150_150	450	n_BB12a	≥ 33704		5				
	1050		≥ 17080		5				
	1500		≥ 10008		5				
BB12a_RA_I_150_150	450	n_BB12a	≥ 32828		5				
	1050		≥ 17184		5				
	1500		≥ 10384		10				
BB17a_RA_F_150_150	450	n_BB17a	≥ 35616		5				
	1050		≥ 15968		5				
	1500		≥ 8544		5				
BB17a_RA_I_150_150	450	n_BB17a	≥ 38276		5				
	1050		≥ 15628		5				
	1500		≥ 9164		10				
BB17a_D&UP	150	n_BB17a	≥ 54716		5				

BO_RA_F_150 _150	1050	_D&UP BO	≥ 11304		5				
	1500		≥ 2648		10				
BB17a_D&UP BO_RA_I_150 _150	150	n_BB17a _D&UP BO	≥ 53036		5				
	1050		≥ 10920		10				
	1500		≥ 2952		25				

B.11.2 **Test cases for downstream margin verification test with Retransmission enabled**

Downstream margin verification testing for Region B SHALL be performed according to Section 8.2.2 and Table 102 and Table 103. Testing consists of two test conditions randomly selected from the 3 described in the tables for any given profile-line combination.

Table 102: **Downstream margin verification for VDSL2oPOTS (PE04) with Retransmission enabled**

Profile-line combination	**Length (m)**	**Crosstalk**	**Test Time (minutes)**	**SES Count**	**RTXUC Count**	**Estimated P_{DTU}**	**Pass/Fail**
BA8b_RA_R-17/2/41_150_150	300	n_BA8b	10				
	1200		10				
	1800		10				
BA17a0_RA_R-17/2/41_150_150	150	n_BA17a0	10				
	450		10				
	900		10				
BA17a0_D&UPBO_RA_R-17/2/41_150_150	150	n_BA17a0 _D&UPBO	10				
	450		10				
	900		10				

Table 103: Downstream margin verification for VDSL2oPOTS (TP100) with Retransmission enabled

Profile-line combination	**Length (m)**	**Crosstalk**	**Test Time (minutes)**	**SES Count**	**RTXUC-C Count**	**Estimated P_{DTU}**	**Pass/Fail**
BA17ade_ D&UPBO_RA_R-17/2/41_150_150	150	n_BA17ade_ D&UPBO	10				
	450		10				
	900		10				

B.12 VDSL2oPOTS and VDSL2oISDN test cases for upstream margin verification test

B.12.1 Test cases for upstream margin verification test with Retransmission disabled

Upstream margin verification testing for Region B SHALL be performed in rate adaptive mode according to Section 8.2.1 with parameters provided in Table 104, Table 105 and Table 106. Testing consists of two test conditions randomly selected from the 3 described in the tables for any given profile-line combination.

Table 104: Upstream margin verification for VDSL2oPOTS (PE04) with Retransmission disabled

Profile-line combination	Length (m)	Crosstalk	US net data rate (kbps)		Test Time (minutes)	SES Count	CRC Count	Estimated BER	Pass/Fail
			Anticipated	Actual (test start) (test end)					
BA8b_RA_I_150_150	300	n_BA8b	≥ 7888		10				
	750		≥ 5792		15				
	1200		≥ 368		55 (NOTE)				
BA17a0_RA_I_150_150	150	n_BA17a0	≥ 28000		5				
	450		≥ 20400		5				
	900		≥ 4800		20				
BA17a0_D&UPBO_RA_I_150_150	150	n_BA17a0_D&UPBO	≥ 23500		5				
	450		≥ 19400		5				
	900		≥ 4800		20				
NOTE: Due to the low data rates under this loop and noise condition, the observation of 10 error events takes a very long time (at BER ~ 1e-7). To accelerate testing, the desired number of observed error events is reduced to 3. To remain consistent with previous confidence levels of estimated BER, the range of allowed estimated BER is increased from 1.5e-7 to 2e-7.									

Table 105: Upstream margin verification for VDSL2oPOTS (TP100) with Retransmission disabled

Profile-line combination	Length (m)	Crosstalk	US net data rate (kbps)		Test Time (minutes)	SES Count	CRC Count	Estimated BER	Pass/Fail
			Anticipated	Actual (test start) (test end)					
BA17ade_D&UPBO_RA_I_150_150	150	n_BA17ade_D&UPBO	≥ 15400		10				
	1050		≥ 3900		15				
	1500		≥ 1500		40				

Table 106: Upstream margin verification for VDSL2oISDN(PE04) with Retransmission disabled

Profile-line combination	Length (m)	Crosstalk	US net data rate (kbps)		Test Time (minutes)	SES Count	CRC Count	Estimated BER	Pass/Fail
			Anticipated	Actual (test start) (test end)					
BB8b_RA_F_150_150	300	n_BB8b	≥ 8616		5				
	750		≥ 6208		5				
	1200		≥ 616		45				
BB8b_RA_I_150_150	300	n_BB8b	≥ 8284		10				
	750		≥ 6128		15				
	1200		≥ 600		60 (NOTE)				
BB12a_RA_F_150_150	450	n_BB12a	≥ 15804		5				
	1050		≥ 2088		15				
	1500		≥ 652		40				
BB12a_RA_I_150_150	450	n_BB12a	≥ 15316		5				
	1050		≥ 2600		30				
	1500		≥ 680		50 (NOTE)				
BB17a_RA_F_150_150	450	n_BB17a	≥ 14644		5				
	1050		≥ 2056		15				
	1500		≥ 648		40				
BB17a_RA_I_150_150	450	n_BB17a	≥ 14228		5				
	1050		≥ 2536		30				
	1500		≥ 684		50 (NOTE)				
BB17a_D&UPBO_RA_F_150_150	150	n_BB17a_D&UPBO	≥ 16668		5				
	1050		≥ 2584		10				
	1500		≥ 772		35				
BB17a_D&UPBO_RA_I_150_150	150	n_BB17a_D&UPBO	≥ 16152		5				
	1050		≥ 3016		25				
	1500		≥ 756		45 (NOTE)				

NOTE: Due to the low data rates under this loop and noise condition, the observation of 10 error events takes a very long time (at BER ~ 1e-7). To accelerate testing, the desired number of observed error events is reduced to 5. To remain consistent with previous confidence levels of estimated BER, the range of allowed estimated BER is increased from 1.5e-7 to 1.75e-7.

B.12.2 Test cases for upstream margin verification test with Retransmission enabled

Upstream margin verification testing for Region B SHALL be performed according to Section 8.2.2 and Table 107 and Table 108. Testing consists of two test conditions randomly selected from the 3 described in the tables for any given profile-line combination.

Table 107: Upstream margin verification for VDSL2oPOTS (PE04) with Retransmission enabled

Profile-line combination	Length (m)	Crosstalk	Test Time (minutes)	SES Count	RTXUC Count	Estimated P_{DTU}	Pass/Fail
BA8b_RA_R-17/2/41_150_150	300	n_BA8b	10				
	1200		10				
	1800		10				
BA17a0_RA_R-17/2/41_150_150	150	n_BA17a0	10				
	450		10				
	900		10				
BA17a0_D&UPBO_RA_R-17/2/41_150_150	150	n_BA17a0_D&UPBO	10				
	450		10				
	900		10				

Table 108: Upstream margin verification for VDSL2oPOTS (TP100) with Retransmission enabled

Profile-line combination	Length (m)	Crosstalk	Test Time (minutes)	SES Count	RTXUC-C Count	Estimated P_{DTU}	Pass/Fail
BA17ade_ D&UPBO_RA_R-17/2/41_150_150	150	n_BA17ade_D&UPBO	10				
	450		10				
	900		10				

B.13 REIN Testing for BA17a0_D&UPBO and BB17a_D&UPBOprofiles

B.13.1 Common Line Setting Variations

The BA17a0_D&UPBO and BB17a_D&UPBO Band Profiles SHALL be as defined in Table 84 and Table 90.

The profile-line combinations BA17a0_D&UPBO_RA_I_150_150 and BB17a_D&UPBO_RA_I_150_150, as defined in Table 85 and Table 91, SHALL be configured on the SUT.

B.13.2 Noise Models

The noise models n_BA17a0_D&UPBO and n_BB17a_D&UPBO defined in Table 86 and Table 92 SHALL be used.

The REIN noise SHALL be as defined for profile BA17ade (see Section B.16.2).

B.13.3 REIN testing in rate adaptive mode

The test procedure is described in Table 109.

Table 109: REIN test procedure – rate adaptive mode

Test Configuration	(1) The test set-up is to be configured according to Section 6.1 as appropriate for the modems under test. The test loop SHALL be PE04 straight homogeneous loop. (2) Configure the SUT in the selected rate adaptive profile-line combination. (3) The DSLAM and CPE are connected in turn through each loop length specified in Table 110 and Table 111. (4) The crosstalk noise impairment n_BA17a0_D&UPBO or n_BB17a _D&UPBO, depending on the profile under test, SHALL be applied at both DSLAM and CPE. (5) Additive Gaussian White noise at -140 dBm/Hz is injected at both DSLAM and CPE. (6) The REIN noise impairment SHALL be applied at both DSLAM and CPE in addition to the crosstalk noise and theAWGN. The REIN sources SHALL be coming from a single source to ensure they are synchronous.
Method of Procedure	(1)Train the link in the presence of the crosstalk noise, AWGN and REIN impairments. (2)Wait for 1 minute after initialization for bitswaps to settle. (3)Record the actual net data rate R (kbps) and the number of SES and ES that occur during the following 2 minutes.
Expected Result	(1)The broadband link SHALL operate in the presence of the REIN. (2)If the link fails to train within 2 minutes or the connection is dropped before the end of the test, the result SHALL be declared a fail. (3)The number of reported ES SHALL be ≤ 1. (4)The number of reported SES SHALL be zero.

The following tables define a set of three tests. In each test, the crosstalk and REIN noise impairment is injected at both sides, DSLAM and CPE, and both downstream and upstream data rate, reported margin, SES and the ES count are recorded during the test. In total there are 6 test points (3 in downstream and 3 in upstream) and the SUT SHALL pass a minimum of five of these test points.

Table 110: REIN testing in rate adaptive mode for BA17a0_D&UPBO

BA17a0_D&UPBO											
Loop Length (m, PE04)	Target Margin DS (dB)	Target Margin US (dB)	Link trained and did not loose sync?	Downstream				Upstream			
				ACTNDR (kbps)	Reported ES	Noise Margin, Reported (dB)	Pass/Fail	ACTNDR (kbps)	Reported ES	Noise Margin, Reported (dB)	Pass/Fail
150	6	6									
450	6	6									
900	6	6									

Table 111: REIN testing in rate adaptive mode for BB17a_D&UPBO

BB17a_D&UPBO											
Loop Length (m, PE04)	Target Margin DS (dB)	Target Margin US (dB)	Link trained and did not loose sync?	Downstream				Upstream			
				ACTNDR (kbps)	Reported ES	Noise Margin, Reported (dB)	Pass/Fail	ACTNDR (kbps)	Reported ES	Noise Margin, Reported (dB)	Pass/Fail
150	6	6									
450	6	6									
900	6	6									

B.14 Single High Impulse Noise (SHINE) Testing for BA17a0_D&UPBO and BB17a_D&UPBO profiles

B.14.1 Common Line Setting Variations

The BA17a0_D&UPBO and BB17a_D&UPBO Band Profiles SHALL be as defined in Table 84 and Table 90.

The profile-line combinations BA17a0_D&UPBO_RA_I_150_150 and BB17a_D&UPBO_RA_I_150_150, as defined in Table 85 and Table 91 SHALL be configured on the SUT.

B.14.2 SHINE Noise Models

The noise model n_BA17a0_D&UPBO and n_BB17a_D&UPBO defined in Table 86 and Table 92, SHALL be used.

For BA17a0_D&UPBO and BB17a_D&UPBO Band Profiles, the SHINE noise SHALL be as defined for profile BA17ade (see Section B.17.2) but from 138 kHz up to 17.664 MHz.

B.14.3 SHINE testing in rate adaptive mode

The test procedure is described in Table 112.

Table 112: SHINE rate adaptive test procedure

Test Configuration	(1) The test set-up is to be configured according to Section 6.1 as appropriate for the modems under test. The test loop SHALL be straight homogeneous PE04 loop. (2) Configure the SUT in the selected rate adaptive profile-line combination. Target noise margin SHALL be set to 6dB. (3) The DSLAM and CPE are connected in turn through each loop specified in Table 113. (4) The crosstalk noise impairment n_BA17a0_D&UPBO or n_BB17a_D&UPBO SHALL be applied at both DSLAM and CPE. (5) Additive Gaussian White noise at -140 dBm/Hz is injected at both DSLAM and CPE. (6) The SHINE noise impairment SHALL be applied at the CPE in addition to the crosstalk noise and theAWGN.
Method of Procedure	(1) The link is trained in the presence of the crosstalk noise and the AWGN impairments. (2) Wait for 60s after initialization for bitswaps to settle. (3) The SHINE is applied at the CPE. The duration of the SHINE is as specified in Table 113. (4) Wait for 10s after the end of the SHINE. (5) Record the SES and ES count that occurs during the following 60s.
Expected Result	(1) The modem SHALL NOT retrain during the application of the SHINE event and for 70s after the end of the SHINE event; (2) The number of reported ES that occur between 10s and 70s after the SHINE event SHALL be ≤ 1 (3) The number of reported SES that occur between 10s and 70s after the SHINE event SHALL be zero.

Table 113 defines a set of two tests for each Band Profile. Each test SHALL be repeated 3 times. The CPE SHALL pass all 3 tests for each burst length.

Table 113: SHINE test loop and burst lengths

Loop Length (m, PE04) for BA17a0_D&UPBO and BB17a_D&UPBO Band Profiles	Burst length[1] (ms)
450	1000
450	100
NOTE1: The burst length SHOULD be controllable with a resolution of 10 ms.	

B.15 Rate adaptive performance tests for BA17ade with DPBO and UPBO

The basic BA17ade Band Profile SHALL be applied with the modifications in Table 114 to the "Common Line Settings" specified in Table 7 to define the shaped-PSD Band Profile BA17ade_D&UPBO:

Table 114: Common Line Settings for BA17ade_D&UPBO Band Profile

Parameter	Setting	Description
All parameters but those specified below	Value as specified in Table 7	
DPBOEPSD	ADSL2plus Annex A	PSD mask that is assumed to be permitted at the exchange
DPBOESCMA	0.1719	Model of the frequency dependent loss of E-side cable: scalars DPBOESCMA (NOTE)
DPBOESCMB	0.644453	Model of the frequency dependent loss of E-side cable: scalars DPBOESCMB (NOTE)
DPBOESCMC	0.18359	Model of the frequency dependent loss of E-side cable: scalars DPBOESCMC (NOTE)
DPBOMUS	-101.5 dBm/Hz	Minimum usable receive signal PSD mask
DPBOFMIN	138 kHz	Minimum frequency from which on the DPBO SHALL be applied
DPBOFMAX	2208 kHz	Maximum frequency up to which the DPBO SHALL be applied
UPBOKLF	0	Force CO-MIB electrical loop length (means that kl_0 is estimated during training)
UPBOKL	estimated during training	Upstream electrical loop length (kl_0)
UPBOA US0	40.00	A and B values US band 0 (these values imply no UPBO)
UPBOB US0	0	
UPBOA US1	60	A value US band 1
UPBOB US1	21	B value US band 1
UPBOA US2	60	A value US band 2
UPBOB US2	8	B value US band 2
NOTE: the values of DPBOESCMA, B and C are referred to a PE04 loop @ 1 MHz. Values that are configured according to G.997.1 SHALL be rounded to the nearest scalar value.		

The E-side electrical length SHALL be set according to Table 115.

Table 115: DPBOESEL value

Parameter	Setting	Description
DPBOESEL	27dB@1MHz	E-side electrical length

The following Profile-line combinations SHALL be configured on the SUT:

Table 116: BA17ade_D&UPBO testing descriptions

Profile-line combination	Band-profile	Specific line-setting
BA17ade_D&UPBO_RA_I_150_150	BA17ade_D&UPBO	RA_I_150_150
BA17ade_ D&UPBO_RA_R-17/2/41_150_150	BA17ade_D&UPBO	RA_R-17/2/41_150_150

The noise model n_BA17ade_D&UPBO defined in the following table SHALL be used:

Table 117: Noise model n_BA17ade_D&UPBO

Noise model	Associated band-profile	Self noise disturbers	Alien noise disturbers
n_BA17ade_D&UPBO	BA17ade_D&UPBO	19self_BA17ade_D&UPBO	none

In the table above the 19self_BA17ade_D&UPBO noise scenario corresponds to 19 self disturbers. The associated self noise disturber frequency domain profiles SHALL be calculated as described in B.1.2.1.

As for this Band Profile the value of kl_0 (UPBOKL) is estimated by the SUTs during training, the PSD of a single self-disturber SHALL be deterministically defined by the settings of Table 114 as kl_0 values for calculation of the single self-disturber PSD are listed in Table 118. The UPBOKLE SHALL be reported.

Table 118: kl_0 for calculation of the single self-disturber PSD for BA17ade_D&UPBO

Loop Length (m, TP-100 loop)	kl_0 (UPBOKL) (dB @ 1MHz)
150	2.7
450	8.1
600	10.8
900	16.2
1050	18.9
1200	21.7
1500	27.0

B.15.1 Rate adaptive performance tests for BA17ade with DPBO and UPBO, retransmission disabled

10 individual tests – 9 SHALL be passed

Table 119: Performance tests with BA17ade_D&UPBO_RA_I_150_150

Loop Length (m, TP100 loop)	BA17ade_D&UPBO_RA_I_150_150								
	Downstream				Upstream				Reported UPBOKLE
	Actual net data rate (kbps)			Noise Margin, Reported (dB)	Actual net data rate (kbps)			Noise Margin, Reported (dB)	
	Expected	Measured	Pass/Fail		Expected	Measured	Pass/Fail		
150	46600				15400				
450	39800				11400				
1050	25100				3900				
1200	21400				3800				
1500	14500				1500				

B.15.2 Rate adaptive performance tests for BA17ade with DPBO and UPBO, retransmission enabled

The tests with retransmission-enabled profiles are designed to be passed by implementations with a MAXDELAYOCTET-split parameter (MDOSPLIT) set to 80%.

Table 120: Class 1 Performance tests with BA17ade_D&UPBO_RA_R-17/2/41_150_150 is for further study.

Table 121: Class 2 Performance tests with BA17ade_D&UPBO_RA_R-17/2/41_150_150 is for further study.

B.16 REIN Testing for BA17ade

B.16.1 Common Line Setting Variations

The test setup is to be configured according to Section 6.1 as appropriate for the modems under test. The test loop SHALL be TP100.

The basic BA17ade Band Profile SHALL be applied with the modifications in Table 114 to the "Common Line Settings" specified in Table 7 to define the shaped-PSD Band Profile BA17ade_D&UPBO.

The E-side electrical length SHALL be set according to Table 115.

The following profile-line combinations SHALL be configures on the SUT.

Table 122: Modified BA17ade D&UPBO Profile-line-combinations for REIN testing

Profile-line combination	Band-profile	Specific line-setting
BA17ade_D&UPBO_RA_I_150_150	BA17ade_D&UPBO	RA_I_150_150
BA17ade_D&UPBO_FX_I_047_019	BA17ade_D&UPBO	FX_I_047_019
BA17ade_D&UPBO_FX_I_033_014	BA17ade_D&UPBO	FX_I_033_014
BA17ade_D&UPBO_FX_I_018_005	BA17ade_D&UPBO	FX_I_018_005
BA17ade_D&UPBO_FX_I_010_002	BA17ade_D&UPBO	FX_I_010_002

B.16.2 Noise Models

The noise model n_BA17ade_D&UPBO defined in Table 123 SHALL be used.

Table 123: Noise model n_BA17ade_D&UPBO for REIN testing

Noise model	Associated band-profile	Self noise disturbers	Alien noise disturbers
n_BA17ade_D&UPBO	BA17ade_D&UPBO	19self_BA17ade_D&UPBO	none

The REIN noise SHALL use a burst of pseudo random noise of 100µs duration whose differential signal power spectral density is described by Formula B- 2.

Formula B- 3 REIN Impulse PSD for BA17ade

$$Noise_{REIN}(f) = \begin{cases} -86\, dBm/Hz : f(Hz) < 0.316\times10^6 \\ \max\left[-86-80\times\log_{10}\left(f/0.316\times10^6\right), -116\right] : 0.316\times10^6 < f(Hz) \le 0.75\times10^6 \\ -116\, dBm/Hz : 0.75\times10^6 < f(Hz) < 2.2\times10^6 \\ \max\left[-116-20\times\log_{10}\left(f/2.2\times10^6\right), -150\right] : f(Hz) \ge 2.2\times10^6 \end{cases}$$

The REIN noise is injected with a repetition frequency of 100Hz.

B.16.3 REIN testing in rate adaptive mode

The test procedure is described in Table 124.

Table 124: REIN test procedure – rate adaptive mode

Test Configuration	(1) The test setup is to be configured according to Section 6.1 as appropriate for the modems under test. The test loop SHALL be straight homogeneous TP100. (2) Configure the SUT in the BA17ade_D&UPBO_RA_I_150_150 profile-line combination. Target noise margin is specified in Table 125. (3) The DSLAM and VTU-R are connected in turn through each loop length specified in Table 125. (4) The crosstalk noise impairment n_BA17ade_D&UPBO SHALL be applied at both DSLAM and CPE. (5) Additive Gaussian White noise at -140 dBm/Hz is injected at both DSLAM and CPE. (6) The REIN noise impairment SHALL be applied at both DSLAM and CPE in addition to the crosstalk noise and the AWGN. The REIN sources SHALL be coming from a single source to ensure they are synchronous.
Method of Procedure	(1)Train the link in the presence of the crosstalk noise, AWGN and REIN impairments. (2)Wait for 3 minutes after initialization for bitswaps to settle. (3)Record the actual net data rate R (kbps) and the number of ES that occur during the following 2 minutes.
Expected Result	(1)The broadband link SHALL operate in the presence of the REIN. (2)If the link fails to train within 2 minutes or the connection is dropped before the end of the test, the result SHALL be declared a fail. (3)The number of reported ES SHALL be ≤ 1. (4)A data rate pass on the test point requires that the expected data rate in Table 125 is achieved.

Table 125 defines a set of four tests. In each test, the crosstalk and REIN noise impairment is injected at both sides, DSLAM and CPE, and both downstream and upstream data rate, reported margin and the ES count are recorded during the test. In total there are 8 test points (4 in downstream and 4 in upstream) and the SUT SHALL pass a minimum of seven of these test points.

If one of these test points fails, the test MAY be repeated. One of the test points MAY be repeated several times, but the total number of test attempts required to pass the seven test points SHALL NOT exceed 16.

Table 125: REIN testing in rate adaptive mode

Profile-line combination BA17ade_D&UPBO_RA_I_150_150													
Loop Length (m, TP100)	Target Margin DS (dB)	Target Margin US (dB)	Link trained and did not loose sync?	Downstream					Upstream				
				Expected NDR (kbps)	ACTNDR (kbps)	Reported ES	Noise Margin, Reported (dB)	Pass/Fail	Expected NDR (kbps)	ACTNDR (kbps)	Reported ES	Noise Margin, Reported (dB)	Pass/Fail
150	6	6		47300					19800				
450	9	9		32500					13400				
600	9	9		29800					11500				
1050	9	9		17900					4400				

B.16.4 **REIN testing in fixed rate mode**

The test procedure is described in Table 126.

Table 126: REIN test procedure – fixed rate mode

Test Configuration	(1)The test setup is to be configured according to Section 6.1 as appropriate for the modems under test. The test loop SHALL be straight homogeneous TP100. (2)Configure the SUT in the required BA17ade Fixed-Rate profile-line combination from Table 122. Target noise margin SHALL be set to 6dB. (3)The DSLAM and CPE are connected in turn through each loop length specified in Table 127. (4)The crosstalk noise impairment n_BA17ade_D&UPBO and SHALL be applied at both DSLAM and CPE. (5)Additive Gaussian White noise at -140 dBm/Hz is injected at both DSLAM and CPE. (6)The REIN noise impairment SHALL be applied at both DSLAM and CPE in addition to the crosstalk noise and theAWGN. The REIN sources SHALL be coming from a single source to ensure they are synchronous.
Method of Procedure	(1)Train the link in the presence of the crosstalk noise, AWGN and REIN impairments. (2)Wait for 3 minutes after initialization for bitswaps to settle. (3)Record the actual net data rate R (kbps) and the number of ES that occur during the following 2 minutes.
Expected Result	(1)The broadband link SHALL operate in the presence of the REIN. (2)If the link fails to train within 2 minutes or the connection is dropped before the end of the test, the result SHALL be declared a fail. (3)The number of reported ES SHALL be ≤ 1.

Table 127 defines a set of four tests. In each test, the crosstalk and REIN noise impairment is injected at both VTU sides and both downstream and upstream data rate, reported margin and the ES count are recorded during the test. In total there are 8 test points (4 in downstream and 4 in upstream) and the SUT SHALL pass a minimum of 7 of these test points.

If one of these separate tests fails, the test MAY be repeated. One of the test points MAY be repeated several times, but the total number of test attempts required to pass the seven test points SHALL NOT exceed 16.

Table 127: REIN Reach impairment, Fixed Rate Profile

Band-profile BA17ade_D&UPBO										
			Downstream				Upstream			
Loop Length (m, TP100)	Specific line setting	Link trained and did not loose sync?	ACTNDR (kbps)	Reported ES	Noise Margin, Reported (dB)	Pass/Fail	ACTNDR (kbps)	Reported ES	Noise Margin, Reported (dB)	Pass/Fail
150	FX_I_047_019									
450	FX_I_033_014									
1050	FX_I_018_005									
1500	FX_I_010_002									

B.17 Single High Impulse Noise (SHINE) Testing for BA17ade

B.17.1 Common Line Setting Variations

The basic BA17ade Band Profile SHALL be applied with the modifications in Table 114 to the "Common Line Settings" specified in Table 7 to define the shaped-PSD Band Profile BA17ade_D&UPBO.

The E-side electrical length SHALL be set according to Table 115.

The SUT profile-line combinations SHALL be configured as in Table 128.

Table 128: BA17ade_D&UPBO profile-line combinations – SHINE testing

Profile-line combination	Band-profile	Specific line-setting
BA17ade_D&UPBO_RA_I_150_150	BA17ade_D&UPBO	RA_I_150_150

B.17.2 SHINE Noise Models

The noise model n_BA17ade_D&UPBO defined in Table 129 SHALL be used.

Table 129: Noise model n_BA17ade_D&UPBO SHINE testing

Noise model	Associated band-profile	Self noise disturbers	Alien noise disturbers
n_BA17ade_D&UPBO	BA17ade_D&UPBO	19self_BA17ade_D&UPBO	none

The SHINE test noise burst SHALL use an AWGN noise burst with amplitude of -86 dBm/Hz from 138 kHz up to 7.0 MHz. The out-of-band noise SHALL NOT be higher than -86 dBm/Hz. The SHINE noise SHALL be applied at the CPE side, in Showtime after the 60 seconds settling time.

At the end under test, the SHINE test noise is coupled to the line using a high-impedance coupler. These test noise levels are as measured into a 100 Ω measuring set with another 100 Ω in parallel.

B.17.3 SHINE testing in rate adaptive mode

The test procedure is described in Table 130.

Table 130: SHINE rate adaptive test procedure

Test Configuration	(1) The test setup is to be configured according to Section 6.1 as appropriate for the modems under test. The test loop SHALL be straight homogeneous TP100. (2) Configure the SUT in the BA17ade_D&UPBO_RA_I_150_150 profile-line combination. Target noise margin SHALL be set to 6dB. (3) The DSLAM and CPE are connected in turn through each loop specified in Table 131. (4) The crosstalk noise impairment n_BA17ade_D&UPBO SHALL be applied at both DSLAM and CPE. (5) Additive Gaussian White noise at -140 dBm/Hz is injected at both DSLAM and CPE. (6) The SHINE noise impairment SHALL be applied at the CPE in addition to the crosstalk noise and theAWGN.
Method of Procedure	(1) The link is trained in the presence of the crosstalk noise and the AWGN impairments. (2) Wait for 60s after initialization for bitswaps to settle. (3) The SHINE is applied at the CPE. The duration of the SHINE is as specified in Table 131. (4) Wait for 10s after the end of the SHINE. (5) Record the ES count that occurs during the following 60s.
Expected Result	(1) The modem SHALL NOT retrain during the application of the SHINE event and for 70s after the end of the SHINE event; (2) The number of reported ES that occur between 10s and 70s after the SHINE event SHALL be ≤ 1.

Table 131 defines a set of two tests. Each test SHALL be repeated 3 times. The CPE SHALL pass all 3 tests for each burst length.

Table 131: SHINE test loop and burst lengths

Loop Length (m, TP100)	Burst length (ms)
1500	1000
1500	100
NOTE 1: The burst length SHOULD be controllable with a resolution of 10 ms.	

B.18 Combined Noise Impairment for BA17ade

The purpose of these tests is to verify that VDSL2 links can be parameterized to be stable and operate essentially error free when victim to several fluctuating noise sources at the same time. These tests are based on combined noise models that are more representative of the real network than a single noise test.

Two tests are defined. Type 1 includes repetitive high level impulse noise (REIN), prolonged electrical impulsive noise (PEIN) and fluctuating crosstalk due to modems being switched on and off over time. Type 2 includes prolonged electrical impulsive noise (PEIN), fluctuating RFI ingress from a large number of radio signals, and fluctuating crosstalk.

NOTE: These tests are defined for VDSL2 without the availability of retransmission functionality. Consequently the longest PEIN pulse represented is 3.6 ms. In future versions of this specification the PEIN test MAY be modified to increase the maximum impulse length to of the order 10 ms.

Annex D.3 includes details of the individual noise models and some help in setting up the tests. Type 1 test procedure is defined in section B.18.1. Type 2 test procedure is defined in section B.18.2.

These tests are designed to be passed by implementations using 65536 aggregate interleaver and de-interleaver delay octets (Table 6-1/G.993.2) and a DS memory split in the range of 50% to 80%.

The following additional configuration and pass/fail conditions apply:

• if MAXDELAYOCTET-split parameter (MDOSPLIT) (Section 7.3.1.14/G.997.1) is available, configure MDOSPLIT to a value inside the range of 50% to 80%. If the performance requirements are not met then the test is declaired a fail.

• if MDOSPLIT is not available, then the test is run without memory split control. If the performance requirements are not met due to data rate limitation, then the used DS memory split in the rate adaptive test SHALL be calculated based on the available G.997.1 parameters (INTLVBLOCK and INTLVDEPTH).

  - o If this split is outside the the range of 50%-80%, then the test is declared conditionally passed with a note that the test was failed due to the memory split being out of range.
  - o If this split is inside the range 50%-80%, then the test is declared a fail.

B.18.1 **Type 1 combined threat noise test including high level REIN**

This combined threat noise test uses a combination of REIN, PEIN and fluctuating crosstalk. The test duration is 4 hours during which the crosstalk cycles twice and there SHOULD be about 76 PEIN pulses. The REIN SHALL be on during training and for 2 minutes afterwards.

The system under test SHALL be tested for the rate adaptive and fixed rate profiles defined in Table 137, with 9dB downstream and upstream Target Margins.

The test procedures are described in Table 132 and Table 133.

Table 132: Combined noise test procedure Type 1 – Rate Adaptive mode

Test Configuration	(1)Configure the SUT in the rate adaptive (RA) profile-line combination as defined in Table 137. The target noise margin SHALL be set to 9dB. (2)The DSLAM and CPE are connected in turn through each loop length specified in Table 138. (3)The fluctuating crosstalk noise impairment SHALL be applied at the CPE and DSLAM. The condition during training SHALL be 1 disturber at the CPE and DSLAM. In Showtime, number of disturbers at the CPE and DSLAM side SHALL fluctuate between 1 and 19, as described in D.3.4. The number of NEXT, and FEXT, disturbers at the DSLAM and CPE SHALL be the same and varied synchronously. (4)The REIN and PEIN noise impairment SHALL be applied at the CPE in addition to the fluctuating crosstalk noise.
Method of Procedure	(1)The link is trained in the presence of REIN impairment. (2)The fluctuating crosstalk noise and PEIN impairment SHALL be applied. (3)Record the actual net data rate, reported noise margin, reported number of ES, SES and retrains over the 4 hours of test duration. NOTE: Reported noise margin and SES SHALL NOT be considered in the pass/fail criteria.
Expected Result	(1)The link SHALL operate in the presence of REIN impairment. (2)If the link fails to train within 2 min or the connection is dropped before the end of the test, the result SHALL be declared a fail. (3) The number of reported downstream ES SHALL be ≤ 5 and upstream ES SHALL be ≤ 5. (4) The expected results in Table 138 SHALL be met.

Table 133: Combined noise test procedure Type 1 – Fixed Rate mode

Test Configuration	(1)Configure the SUT in the fixed rate (FX) profile-line combinations as defined in Table 137. The target noise margin SHALL be set to 9dB. (2)The DSLAM and CPE are connected in turn through each loop length specified in Table 139. (3)The fluctuating crosstalk noise impairment SHALL be applied at the CPE and DSLAM. The condition during training SHALL be 1 disturber at the CPE and DSLAM. In Showtime, number of disturbers at the CPE and DSLAM side SHALL fluctuate between 1 and 19, as described in D.3.4. The number of NEXT, and FEXT, disturbers at the DSLAM and CPE SHALL be the same and varied synchronously. (4)The REIN and PEIN noise impairment SHALL be applied at the CPE in addition to the fluctuating crosstalk noise.
Method of Procedure	(1)The link is trained in the presence of REIN impairment. (2)The fluctuating crosstalk noise and PEIN impairment SHALL be applied. (3)Record the actual net data rate, reported noise margin, reported number of ES, SES and retrains over the 4 hours of test duration. NOTE: Reported noise margin and SES SHALL NOT be considered in the pass/fail criteria.
Expected Result	(1)The link SHALL operate in the presence of REIN impairment. (2)If the link fails to train within 2 min or the connection is dropped before the end of the test, the result SHALL be declared a fail. (3)The number of reported DS ES SHALL be ≤ 5 and upstream ES SHALL be ≤ 5. (4)The expected results in Table 139 SHALL be met.

B.18.2 Type 2 Combined Threat Noise Test including fluctuating RFI

The combined threat noise test uses a combination of fluctuating RFI, PEIN and fluctuating cross talk. The test duration is 4 hours during which the crosstalk cycles twice and there SHOULD be about 76 PEIN pulses.

The system under test SHALL be tested for the rate adaptive and fixed rate profiles defined in Table 137, with 9dB downstream and upstream Target Margins.

The test procedures are described in Table 134 and Table 135.

Table 134: Combined noise test procedure Type 2 – Rate Adaptive mode

Test Configuration	(1)Configure the SUT in the rate adaptive (RA) profile-line combination as defined in Table 137. The target noise margin SHALL be set to 9dB. (2)The DSLAM and CPE are connected in turn through each loop length specified in Table 140. (3)The fluctuating crosstalk noise impairment SHALL be applied at the CPE and DSLAM. The condition during training SHALL be 1 disturber at the CPE and DSLAM. In Showtime, number of disturbers at the CPE and DSLAM side SHALL fluctuate between 1 and 19, as described in D.3.4. The number of NEXT, and FEXT, disturbers at the DSLAM and CPE SHALL be the same and varied synchronously. (4)The fluctuating RFI and PEIN noise impairment SHALL be applied at the CPE in addition to the fluctuating crosstalk noise.
Method of Procedure	(1)The link is trained. (2)The fluctuating crosstalk noise, fluctuating RFI and PEIN impairment SHALL be applied. (3)Record the actual net data rate, reported noise margin, reported number of ES, SES and retrains over the 4 hours of test duration. NOTE: Reported noise margin and SES SHALL NOT be considered in the pass/fail criteria.
Expected Result	(1)If the link fails to train within 2 min or the connection is dropped before the end of the test, the result SHALL be declared a fail. (2)The number of reported downstream ES SHALL be ≤ 5. (3)The expected results in Table 140 SHALL be met.

Table 135: Combined noise test procedure Type 2 – Fixed Rate mode

Test Configuration	(1)Configure the SUT in the fixed rate (FX) profile-line combinations as defined in Table 137. The target noise margin SHALL be set to 9dB. (2)The DSLAM and CPE are connected in turn through each loop specified in Table 141. (3)The fluctuating crosstalk noise impairment SHALL be applied at the CPE and DSLAM. The condition during training SHALL be 1 disturber at the CPE and DSLAM. In Showtime, number of disturbers at the CPE and DSLAM side SHALL fluctuate between 1 and 19, as described in D.3.4. The number of NEXT, and FEXT, disturbers at the DSLAM and CPE SHALL be the same and varied synchronously. (4)The fluctuating RFI and PEIN noise impairment SHALL be applied at the CPE in addition to the fluctuating crosstalk noise.
Method of Procedure	(1)The link is trained. (2)The fluctuating crosstalk noise, fluctuating RFI and PEIN impairment SHALL be applied. (3)Record the actual net data rate, reported noise margin, reported number of ES, SES and retrains over the 4 hours of test duration. NOTE: Reported noise margin and SES SHALL NOT be considered in the pass/fail criteria.
Expected Result	(1)If the link fails to train within 2 min or the connection is dropped before the end of the test, the result SHALL be declared a fail. (2)The number of reported downstream ES SHALL be ≤ 5. (3)The expected results in Table 141 SHALL be met.

B.18.3 Common Settings for Combined Threat Noise Tests

The basic BA17ade Band Profile SHALL be applied with the modifications defined in Table 114 to the "Common Line Settings" specified in Table 7 to define the shaped-PSD Band Profile BA17ade_D&UPBO.

The E-side electrical length SHALL be set according to Table 136.

Table 136: DPBOESEL value

Parameter	Setting	Description
DPBOESEL	42dB@1MHz	E-side electrical length

The following profile-line combinations defined in section 6.2 SHALL be used for testing.

Table 137: BA17ade_D&UPBO testing descriptions

Profile-line combination	Band-profile	Specific line-setting
Type 1 and 2		
BA17ade_D&UPBO_RA_HI_150_150	BA17ade_D&UPBO	RA_HI_150_150
BA17ade_D&UPBO_FX_HI_011_004	BA17ade_D&UPBO	FX_HI_011_004

BA17ade_D&UPBO_FX_HI_009_003	BA17ade_D&UPBO	FX_HI_009_003

The fluctuating crosstalk noise as defined in Annex D.3.4 SHALL be injected at the CPE and at the DSLAM.
In addition to the crosstalk noise at the CPE, the REIN as described in Annex D.3.1 is injected with a repetition frequency of 100Hz, and the PEIN as defined in Annex D.3.3 at the CPE end.

The RFI is injected at the CPE end.

The value of kl0 (UPBOKL) is estimated by the SUTs during training, the PSD of a single self-disturber SHALL be deterministically defined by the settings of above, using kl0 (UPBOKL) values provided in Table 118.

B.18.3.1 Performance Tests with Type 1 Combined Threat Noise

4 individual tests – 4 tests SHALL be passed

If an individual test is failed it MAY be repeated. An individual test MAY be repeated twice, but the total number of test attempts required to pass the 4 individual tests SHALL NOT exceed 6.

Table 138: Combined noise impairment 1 test with BA17ade_D&UPBO_RA_HI_150_150

loop length (m, TP100)					Expected Results							
	Target Margin DS (dB)	Target Margin US (dB)	Expected DS NDR (kbps)	Expected US NDR (kbps)	Modem trained and did not lose sync? (Y/N)	DS ACTNDR (kbps)	Initial DS Noise Margin, (dB)	DS Errored Seconds	US ACTNDR (kbps)	Initial US Noise Margin, (dB)	US Errored Seconds	Pass / Fail
450	9	9	11100	4300								
900	9	9	9800	3700								

Table 139: Combined noise impairment 1 test with fixed rate profiles

Test profile BA17ade_D&UPBO_FX_HI_011_004 and BA17ade_D&UPBO_FX_HI_009_003									
Loop length (m, TP100.)	Test profile, with delay set to 32 ms.	Expected Results							
		Modem Trained and did not lose sync? (Y/N)	DS ACTNDR (kbps)	Initial DS Noise Margin,(dB)	DS Errored Seconds	US ACTNDR(kbps)	Initial US Noise Margin (dB)	US Errored Seconds	Pass / Fail
450	FX_HI_011_004								
900	FX_HI_009_003								

B.18.3.2 Performance Tests with Type 2 Combined Threat Noise

4 individual tests – 4 tests SHALL be passed

If an individual test is failed it MAY be repeated. An individual test MAY be repeated twice, but the total number of test attempts required to pass the 4 individual tests SHALL NOT exceed 6.

Table 140: Combined noise impairment 2 test with BA17ade_D&UPBO_RA_HI_150_150

loop length (m, TP100)					Expected Results						
	Target Margin DS (dB)	Target MarginUS (dB)	Expected DS NDR (kbps)	Expected US sNDR (kbps)	Modem trained and did not lose sync? (Y/N)	DS ACTNDR (kbps)	Initial DS Noise Margin, (dB)	DS Errored Seconds	US ACTNDR (kbps)	Initial US Noise Margin, (dB)	Pass / Fail
450	9	9	11100	4300							
900	9	9	10400	3700							

Table 141: Combined noise impairment 2 test with fixed rate profiles

Test profile BA17ade_D&UPBO_FX_HI_011_004 and BA17ade_D&UPBO_FX_HI_009_003								
Loop length (m, TP100.)	Test profile, with delay set to 32 ms.	Expected Results						
		Modem Trained and did not lose sync? (Y/N)	DS ACTNDR(kbps)	Initial DS Noise Margin, (dB)	DS Errored Seconds	US ACTNDR(kbps)	Initial US Noise Margin, (dB)	Pass / Fail
450	FX_HI_011_004							
900	FX_HI_009_003							

B.19 Long-reach low-noise test for BA17ade

The purpose of these tests is to explore interoperability performance on the full range of loop lengths within the scope of G.993.2 [12/2011].

B.19.1 Long-reach low-noise testing in rate adaptive mode

As per rate adaptive performance testing described in section B.15, the basic BA17ade Band Profile SHALL be applied with the modifications in Table 114 to the “Common Line Settings” specified in Table 7 to define the shaped-PSD Band Profile BA17ade_D&UPBO.

The E-side electrical length SHALL be set according to Table 115 in section B.15 (rate adaptive testing).

The interleaved profile-line combination defined in Table 116 in section B.15 (rate adaptive testing) SHALL be configured on the SUT.

The test procedure is described in Table 142.

Table 142: Long-reach low-noise test in rate adaptive mode

Test Configuration	(1) The test setup is to be configured according to Section 6.1 as appropriate for the modems under test. The test loop SHALL be straight homogeneous TP100. (2) Configure the SUT in the BA17ade_D&UPBO_RA_I_150_150 profile-line combination. Target noise margin SHALL be set to 6dB. (3) The DSLAM and CPE are connected in turn through each loop specified in Table 143 and Table 144. (4) No crosstalk noise impairment SHALL be applied at both DSLAM and CPE. (5) Additive Gaussian White noise at -140 dBm/Hz is injected at both DSLAM and CPE.
Method of Procedure	(1) The link is trained in the presence of the AWGN impairment. (2) Record the time taken for the modem to reach synchronisation. (3) Wait for 60 seconds after initialization for bitswaps to settle. (4) Record the DS and US actual net data rates. (5) Ensure the modem can stay in synchronisation for a further 120s.
Expected Result	(1) The modem SHALL reach synchronisation in less than 90 seconds. (2) The actual net data rates recorded SHALL be at least as great as shown in the table below. (3) The modem SHALL NOT retrain during the test.

Table 143 and Table 144 defines a set of 6 tests. The DSLAM/CPE combination SHALL pass all 6 tests. A maximum of 1 repeat attempt can be allowed if a single test is failed.

Table 143: Long-reach Low-noise Test Loops and Rate Targets – Fast Mode Profile

Loop Length (m, TP100)	CAT A DS (kbps)	CAT A US (kbps)	CAT B DS (kbps)	CAT B US (kbps)
2000	9007	400	6170	400
2500	3465	380	3080	380
3000	1970	360	NA	NA

Table 144: Long-reach Low-noise Test Loops and Rate Targets – Interleaved Mode Profile

Loop Length (m, TP100)	CAT A DS (kbps)	CAT A US (kbps)	CAT B DS (kbps)	CAT B US (kbps)
2000	8396	300	5800	300
2500	3639	300	2900	300
3000	1900	300	NA	NA

In order to achieve a category A result, the DSLAM/CPE combination must achieve category A performance (or better) for all six tests, otherwise in order to achieve a category B result, the DSLAM/CPE combination must achieve category B performance (or better) for all four tests where there is a category B requirement defined, otherwise the combination is considered to have failed the test.

C Annex C Physical Layer Test Cases for G.993.2 Region C (Japan)

C.1 Annex C-specific Test Setup Information

Test configuration associated with the VDSL2-over-TCM-ISDN deployments with Annex C band profiles is defined in Table 145.

Table 145: Annex C Test Configuration

Type of VDSL2 deployment	Band-profile	Test configuration	Line setting	Noise impairment
VDSL2 over TCM-ISDN	CG8d CG12a CG17a CG30a	Figure 3	UPBO active RA_I_105_105 I-1/0	AWGNr AWGNc XTr+AWGNr XTc+AWGNc (Refer to section 6.3.3.3.)
NOTE: UPBO PSD mask SHALL be as defined G.993.2 Section C.4 [2].				

The following profile-line combinations SHALL be configured on the SUT. The specific SUT settings as defined in 6.2 SHALL be used.

Table 146: Profile-line combinations for Annex C testing

Band-profile	Specific line-setting	Profile-line combination
CG8d	RA_I_105_105	CG8d_RA_I_105_105
CG12a	RA_I_105_105	CG12a_RA_I_105_105
CG17a	RA_I_105_105	CG17a_RA_I_105_105
CG30a	RA_I_105_105	CG30a_RA_I_105_105

Pass/fail criteria for Annex C

If the following conditions are met, the DSLAM/CPE pair passes the performance objectives of the test point. All values SHALL be read out at the DSLAM.

- If the measured data rate is greater than or equal to the expected data rate, then the DSLAM/CPE pair passes the data rate requirements of the test point.
- If the CRC error counts in a 2-minute period are less than or equal to 1, then the DSLAM/CPE pair passes the bit-error requirements of the test point.

Table 147 outlines the pass/fail criteria on the reported noise margin.

Table 147: Noise margin chart

Reported Noise Margin (dB)	Requirement
< 5	On no test point
≥ 5 and < 6	On at most 10% of the test points
≥ 6	On at least 90% of the test points

Violation of any of the requirements in the Noise Margin Chart SHALL constitute a test section failure.

Overall pass/fail criteria for each adaptive rate test are then as follows:

- If any reported noise margin is less than 5 dB, then the DSLAM/CPE pair fails the noise margin requirements of that section.
- If more than 10% of the reported noise margins are less than 6dB in a section, then the DSLAM/CPE pair fails the noise margin requirements of that section.

If the DSLAM/CPE pair passes the data rate, CRC error count and noise margin requirements, it passes the section; otherwise, it fails the section.

Table 148 lists the number of test points per section corresponding to the overall pass/fail criteria (10% limit).

Table 148: Overall pass/fail criteria

Section number	Number of test cases	10% limit (applies to noise margin only)
C.2.1	7	1
C.2.2	7	1
C.2.3	7	1
C.2.4	6	1
C.3.1	7	1
C.3.2	7	1
C.3.3	7	1
C.3.4	6	1
C.4.1	6	1
C.4.2	6	1
C.4.3	6	1
C.4.4	5	1
C.5.1	6	1
C.5.2	6	1
C.5.3	6	1
C.5.4	5	1

C.2 Performance tests with AWGNr noise impairment

C.2.1 Performance tests for CG8d – downstream

7 individual tests – 7 tests SHALL be passed

Table 149: Noise AWGNr CG8d impairment, profile-line combination CG8d_RA_I_105_105

Loop Length (m, VLOOP-J1)	CG8d_RA_I_105_105									
	Downstream					Upstream				
	Actual net data rate (kbps)		CRC error count	Pass/Fail	Noise Margin, Reported(dB)	Actual net data rate (kbps)		CRC error count	Pass/Fail	Noise Margin, Reported(dB)
	Expected	Measured				Expected	Measured			
100	65000					N/A	----	----	----	----
200	62000					N/A	----	----	----	----
300	59000					N/A	----	----	----	----
500	41000					N/A	----	----	----	----
700	26000					N/A	----	----	----	----
900	13000					N/A	----	----	----	----
1000	Link up					N/A	----	----	----	----

C.2.2 Performance tests for CG12a - downstream

7 individual tests – 7 tests SHALL be passed

Table 150: Noise AWGNr CG12a impairment, profile-line combination CG12a_RA_I_105_105

Loop Length (m, VLOOP-J1)	CG12a_RA_I_105_105									
	Downstream					Upstream				
	Actual net data rate (kbps)		CRC error count	Pass/Fail	Noise Margin, Reported(dB)	Actual net data rate (kbps)		CRC error count	Pass/Fail	Noise Margin, Reported(dB)
	Expected	Measured				Expected	Measured			
100	65000					N/A	----	----	----	----
200	62000					N/A	----	----	----	----
300	60000					N/A	----	----	----	----
500	41000					N/A	----	----	----	----
700	26000					N/A	----	----	----	----
900	13000					N/A	----	----	----	----
1000	Link up					N/A	----	----	----	----

C.2.3 Performance tests for CG17a - downstream

7 individual tests – 7 tests SHALL be passed

Table 151: Noise AWGNr CG17a impairment, profile-line combination CG17a_RA_I_105_105

Loop Length (m, VLOOP-J1)	CG17a_RA_I_105_105									
	Downstream					Upstream				
	Actual net data rate (kbps)		CRC error count	Pass/Fail	Noise Margin, Reported (dB)	Actual net data rate (kbps)		CRC error count	Pass/Fail	Noise Margin, Reported (dB)
	Expected	Measured				Expected	Measured			
100	100000					N/A	----	----	----	----
200	100000					N/A	----	----	----	----
300	89000					N/A	----	----	----	----
500	46000					N/A	----	----	----	----
700	26000					N/A	----	----	----	----
900	13000					N/A	----	----	----	----
1000	Link up					N/A	----	----	----	----

C.2.4 Performance tests for CG30a – downstream

6 individual tests – 6 tests SHALL be passed

Table 152: Noise AWGNr CG30a impairment, profile-line combination CG30a_RA_I_105_105

Loop Length (m, VLOOP-J1)	CG30a_RA_I_105_105									
	Downstream					Upstream				
	Actual net data rate (kbps)		CRC error count	Pass/Fail	Noise Margin, Reported(dB)	Actual net data rate (kbps)		CRC error count	Pass/Fail	Noise Margin, Reported(dB)
	Expected	Measured				Expected	Measured			
100	100000					N/A	----	----	----	----
200	100000					N/A	----	----	----	----
300	100000					N/A	----	----	----	----
500	45000					N/A	----	----	----	----
700	25000					N/A	----	----	----	----
800	Link up					N/A	----	----	----	----

C.3 Performance tests with AWGNc noise impairment

C.3.1 Performance tests for CG8d – upstream

7 individual tests – 7 tests SHALL be passed

Table 153: Noise AWGNc CG8d impairment, profile-line combination CG8d_RA_I_105_105

Loop Length (m, VLOOP-J1)	CG8d_RA_I_105_105									
	Downstream					Upstream				
	Actual net datarate (kbps)		CRC error count	Pass/Fail	Noise Margin, Reported(dB)	Actual net data rate (kbps)		CRC error count	Pass/Fail	Noise Margin, Reported(dB)
	Expected	Measured				Expected	Measured			
100	N/A	----	----	----	----	11000				
200	N/A	----	----	----	----	11000				
300	N/A	----	----	----	----	11000				
500	N/A	----	----	----	----	10000				
700	N/A	----	----	----	----	6000				
900	N/A	----	----	----	----	2000				
1000	N/A	----	----	----	----	Link up				

C.3.2 Performance tests for CG12a - upstream

7 individual tests – 7 tests SHALL be passed

Table 154: Noise AWGNc CG12a impairment, profile-line combination CG12a_RA_I_105_105

Loop Length (m, VLOOP-J1)	CG12a_RA_I_105_105									
	Downstream					Upstream				
	Actual net data rate (kbps)		CRC error count	Pass/Fail	Noise Margin, Reported(dB)	Actual net data rate (kbps)		CRC error count	Pass/Fail	Noise Margin, Reported(dB)
	Expected	Measured				Expected	Measured			
100	N/A	----	----	----	----	45000				
200	N/A	----	----	----	----	45000				
300	N/A	----	----	----	----	45000				
500	N/A	----	----	----	----	24000				
700	N/A	----	----	----	----	7000				
900	N/A	----	----	----	----	2000				
1000	N/A	----	----	----	----	Link up				

C.3.3 Performance tests for CG17a – upstream

7 individual tests – 7 tests SHALL be passed

Table 155: Noise AWGNc CG17a impairment, profile-line combination CG17a_RA_I_105_105

Loop Length (m, VLOOP-J1)	CG17a_RA_I_105_105									
	Downstream					Upstream				
	Actual net data rate (kbps)		CRC error count	Pass/Fail	Noise Margin, Reported(dB)	Actual net data rate (kbps)		CRC error count	Pass/Fail	Noise Margin, Reported(dB)
	Expected	Measured				Expected	Measured			
100	N/A	----	----	----	----	45000				
200	N/A	----	----	----	----	45000				
300	N/A	----	----	----	----	45000				
500	N/A	----	----	----	----	24000				
700	N/A	----	----	----	----	7000				
900	N/A	----	----	----	----	2000				
1000	N/A	----	----	----	----	Link up				

C.3.4 Performance tests for CG30a – upstream

6 individual tests – 6 tests SHALL be passed

Table 156:Noise AWGNc CG30a impairment, profile-line combination CG30a_RA_I_105_105

Loop Length (m, VLOOP-J1)	CG30a_RA_I_105_105									
	Downstream					Upstream				
	Actual net data rate (kbps)		CRC error count	Pass/Fail	Noise Margin, Reported(dB)	Actual net data rate (kbps)		CRC error count	Pass/Fail	Noise Margin, Reported(dB)
	Expected	Measured				Expected	Measured			
100	N/A	----	----	----	----	100000				
200	N/A	----	----	----	----	100000				
300	N/A	----	----	----	----	90000				
500	N/A	----	----	----	----	20000				
700	N/A	----	----	----	----	2800				
800	N/A	----	----	----	----	Link up				

C.4 Performance tests with (XTr+AWGNr) noise impairment

C.4.1 **Performance tests for CG8d - downstream**

6 individual tests – 6 tests SHALL be passed

Table 157: Noise (XTr+AWGNr) CG8d impairment, profile-line combination CG8d_RA_I_105_105

Loop Length (m, VLOOP-J1)	CG8d_RA_I_105_105									
	Downstream					Upstream				
	Actual net data rate (kbps)		CRC error count	Pass/Fail	Noise Margin, Reported(dB)	Actual net data rate (kbps)		CRC error count	Pass/Fail	Noise Margin, Reported(dB)
	Expected	Measured				Expected	Measured			
100	28000					N/A	----	----	----	----
200	24000					N/A	----	----	----	----
300	21000					N/A	----	----	----	----
500	12000					N/A	----	----	----	----
700	8400					N/A	----	----	----	----
800	Link up					N/A	----	----	----	----

C.4.2 **Performance tests for CG12a - downstream**

6 individual tests – 6 tests SHALL be passed

Table 158: Noise (XTr+AWGNr) CG12a impairment, profile-line combination CG12a_RA_I_105_105

Loop Length (m, VLOOP-J1)	CG12a_RA_I_105_105									
	Downstream					Upstream				
	Actual net data rate (kbps)		CRC error count	Pass/Fail	Noise Margin, Reported(dB)	Actual net data rate (kbps)		CRC error count	Pass/Fail	Noise Margin, Reported(dB)
	Expected	Measured				Expected	Measured			
100	28000					N/A	----	----	----	----
200	24000					N/A	----	----	----	----
300	21000					N/A	----	----	----	----
500	12000					N/A	----	----	----	----
700	8400					N/A	----	----	----	----
800	Link up					N/A	----	----	----	----

C.4.3 Performance tests for CG17a - downstream

6 individual tests – 6 tests SHALL be passed

Table 159: Noise (XTr+AWGNr) CG17a impairment, profile-line combination CG17a_RA_I_105_105

Loop Length (m, VLOOP-J1)	CG17a_RA_I_105_105									
	Downstream					Upstream				
	Actual net data rate (kbps)		CRC error count	Pass/Fail	Noise Margin, Reported(dB)	Actual net data rate (kbps)		CRC error count	Pass/Fail	Noise Margin, Reported(dB)
	Expected	Measured				Expected	Measured			
100	36000					N/A	----	----	----	----
200	26000					N/A	----	----	----	----
300	21000					N/A	----	----	----	----
500	12000					N/A	----	----	----	----
700	8400					N/A	----	----	----	----
800	Link up					N/A	----	----	----	----

C.4.4 **Performance tests for CG30a - downstream**

5 individual tests – 5 tests SHALL be passed

Table 160: Noise (XTr+AWGNr) CG30a impairment, profile-line combination CG30a_RA_I_105_105

Loop Length (m, VLOOP-J1)	CG30a_RA_I_105_105									
	Downstream					Upstream				
	Actual net data rate (kbps)		CRC error count	Pass/Fail	Noise Margin, Reported(dB)	Actual net data rate (kbps)		CRC error count	Pass/Fail	Noise Margin, Reported(dB)
	Expected	Measured				Expected	Measured			
100	50000					N/A	----	----	----	----
200	41000					N/A	----	----	----	----
300	30000					N/A	----	----	----	----
500	17000					N/A	----	----	----	----
700	Link up					N/A	----	----	----	----

C.5 Performance tests with (XTc+AWGNc) noise impairment

C.5.1 Performance tests for CG8d - upstream

6 individual tests – 6 tests SHALL be passed

Table 161: Noise (XTc+AWGNc) CG8d impairment, profile-line combination CG8d_RA_I_105_105

Loop Length (m, VLOOP-J1)	CG8d_RA_I_105_105									
	Downstream					Upstream				
	Actual net data rate (kbps)		CRC error count	Pass/Fail	Noise Margin, Reported (dB)	Actual net data rate (kbps)		CRC error count	Pass/Fail	Noise Margin, Reported (dB)
	Expected	Measured				Expected	Measured			
100	N/A	----	----	----	----	5000				
200	N/A	----	----	----	----	4000				
300	N/A	----	----	----	----	4000				
500	N/A	----	----	----	----	4000				
700	N/A	----	----	----	----	2000				
800	N/A	----	----	----	----	Link up				

C.5.2 Performance tests for CG12a - upstream

6 individual tests – 6 tests SHALL be passed

Table 162: Noise (XTc+AWGNc) CG12a impairment, profile-line combination CG12a_RA_I_105_105

Loop Length (m, VLOOP-J1)	CG12a_RA_I_105_105									
	Downstream					Upstream				
	Actual net data rate (kbps)		CRC error count	Pass/Fail	Noise Margin, Reported(dB)	Actual net data rate (kbps)		CRC error count	Pass/Fail	Noise Margin, Reported(dB)
	Expected	Measured				Expected	Measured			
100	N/A	----	----	----	----	17000				
200	N/A	----	----	----	----	15000				
300	N/A	----	----	----	----	12000				
500	N/A	----	----	----	----	6000				
700	N/A	----	----	----	----	2000				
800	N/A	----	----	----	----	Link up				

C.5.3 Performance tests for CG17a - upstream

6 individual tests – 6 tests SHALL be passed

Table 163: Noise (XTc+AWGNc) CG17a impairment, profile-line combination CG17a_RA_I_105_105

Loop Length (m, VLOOP-J1)	CG17a_RA_I_105_105									
	Downstream					Upstream				
	Actual net data rate (kbps)		CRC error count	Pass/Fail	Noise Margin, Reported (dB)	Actual net data rate (kbps)		CRC error count	Pass/Fail	Noise Margin, Reported (dB)
	Expected	Measured				Expected	Measured			
100	N/A	----	----	----	----	17000				
200	N/A	----	----	----	----	15000				
300	N/A	----	----	----	----	12000				
500	N/A	----	----	----	----	6000				
700	N/A	----	----	----	----	2000				
800	N/A	----	----	----	----	Link up				

C.5.4 Performance tests for CG30a - upstream

5 individual tests – 5 tests SHALL be passed

Table 164: Noise (XTc+AWGNc) CG30a impairment, profile-line combination CG30a_RA_I_105_105

Loop Length (m, VLOOP-J1)	CG30a_RA_I_105_105									
	Downstream					Upstream				
	Actual net data rate (kbps)		CRC error count	Pass/Fail	Noise Margin, Reported (dB)	Actual net data rate (kbps)		CRC error count	Pass/Fail	Noise Margin, Reported (dB)
	Expected	Measured				Expected	Measured			
100	N/A	----	----	----	----	30000				
200	N/A	----	----	----	----	28000				
300	N/A	----	----	----	----	13000				
500	N/A	----	----	----	----	4500				
700	N/A	----	----	----	----	Link up				

D Annex D Alien noise disturbers for Annex A and Annex B testing

Linear interpolation of the PSD in dBm/Hz against log(f) SHALL be used to calculate the values between breakpoints.

D.1 PSD profiles for MD_EX scenario

Table 165: XA.LT and XA.NT component for MD_EX noise scenario

Alien LT component for MD_EX scenario			Alien NT component for MD_EX scenario	
[Hz]	[dBm/Hz]		[Hz]	[dBm/Hz]
0.01	-30.2		0.01	-30.2
1000	-30.2		1000	-30.2
6500	-30.1		6500	-30.1
8500	-30.1		8500	-30.1
15000	-30.3		15000	-30.3
28000	-31.4		22000	-30.7
59000	-35		24000	-30.7
86000	-35.6		25000	-30.6
137000	-36.6		28000	-30.7
138000	-35.5		56000	-32.8
139000	-35.4		66000	-33
140000	-34.8		109000	-33.2
183000	-35.5		119000	-32.6
254000	-35.8		131000	-32.6
255000	-35		136000	-32.5
272000	-35		138000	-32.8
273000	-34.3		139000	-33
370000	-34.6		140000	-33
1104000	-34.6		144000	-33.4
1250000	-38.6		165000	-33.8
1300000	-40.4		274000	-34.2
1622000	-46.4		284000	-38
2208000	-47.7		305000	-41.5
3002000	-79.7		385000	-50
3093000	-85.5		542000	-74
3308000	-90		650000	-93.3
3750000	-95		676000	-93.3
4544000	-105.3		759000	-93.8
7255000	-106.5		913000	-94.4
30000000	-106.5		1030000	-94.6
			1411000	-94.6
			1630000	-104.5

			5274000	-106.5
			30000000	-106.5

D.2 PSD profiles for MD_CAB27 scenario

Table 166: XA.LT and XA.NT component for MD_CAB27 noise scenario

Alien LT component for MD_CAB27 scenario			Alien NT component for MD_CAB27 scenario	
[Hz]	[dBm/Hz]		[Hz]	[dBm/Hz]
0.01	-30.2		0.01	-30.2
6900	-30.3		7000	-30.2
15000	-30.5		15000	-30.5
29000	-32		22000	-31
45000	-35.5		24000	-31
74000	-47.4		25000	-30.9
86000	-48		28000	-30.9
102000	-47.5		55000	-33.3
137000	-49.8		69000	-33.6
138000	-48.2		112000	-33.7
139000	-48		119000	-32.9
140000	-47.2		129000	-33
254000	-50.3		136000	-32.8
255000	-49.3		139000	-33.3
272000	-49.7		140000	-33.3
273000	-49		148000	-33.9
560000	-54.7		168000	-34.1
1104000	-63		274000	-34.3
1250000	-68.9		283000	-38.1
1622000	-81.2		301000	-42.4
2208000	-88.8		362000	-48.8
2696000	-113.1		512000	-71
2830000	-117.2		644000	-93.3
3040000	-118.2		676000	-93.3
30000000	-118.2		759000	-94
			918000	-94.5
			1030000	-94.6
			1411000	-94.6
			1630000	-104.6
			5274000	-106.5
			30000000	-106.5

D.3 Noise Sources for Combined Noise Tests

D.3.1 Repetitive Electrical Impulse Noise (REIN) Model

The REIN model is representative of self-install practice. The REIN test SHALL use a burst of pseudo random noise of 100µs duration whose differential signal power spectral density is described by equation

Formula D- 1: REIN noise for high REIN portion of combined noise

$$Noise_{REIN}(f) = \begin{cases} -90\,dbm/Hz : f\,(Hz) < 2.2\times10^{6} \\ \max\left(-90 - 40\times\log_{10}\left(f/2.2\times10^{6}\right), -150\,dBm/Hz\right) : f\,(Hz) \geq 2.2\times10^{6} \end{cases}$$

The repetition rate is regionally dependent and is 100Hz for Annex B testing.

D.3.2 Prolonged Electrical Impulse Noise (PEIN) Model

The PEIN test SHALL use “Bursts of pseudo random AWGN” of varying duration, 1.2, 2.4 and 3.6ms with probabilities of 0.647, 0.229 and 0.124 respectively.

The PSD/levels of the noise bursts in the differential mode SHALL be drawn from the distribution in Table 167.

Table 167: PEIN PSD levels

PEIN PSD X / dBm/Hz	p(X)
-86	0.0044
-88	0.0133
-90	0.0222
-92	0.0311
-94	0.0400
-96	0.0489
-98	0.0578
-100	0.0667
-102	0.0756
-104	0.0844
-106	0.0933
-108	0.1022
-110	0.1111
-112	0.1200
-114	0.1289

The inter-arrival times are chosen between 4 s and 1094 s, with the discrete probability of choosing an inter-arrival time of x seconds being proportional to 1/x, the median inter-arrival time will be 61 s and the average inter-arrival time will be roughly 190 seconds. This equates to a probability of p(x) = 1/ (x*ln(273.5)).

D.3.3 Repeatable test pattern definition – (PEIN)

The PEIN test pattern contains a list of powers and time for each power. Between the PEIN pulses the background noise level is -140 dBm/Hz. The start of a possible test pattern is shown in Table 168.

The pulse lengths are truncated for implementations that are limited to INP_min=16 symbols and profiles using 4.3125 kHz tone spacing.

Table 168: PEIN test pattern definition

PSD (dBm/Hz)	Length (s)
-114	0.0012
-140	239.6863
-102	0.0036
-140	356.9171
-108	0.0012
-140	563.6294
-106	0.0024
-140	65.7596
-108	0.0012
-140	338.3679
-106	0.0012
-140	6.7483
-112	0.0024
-140	430.9218
-90	0.0012
-140	4.0486
-110	0.0012
-140	55.2019

The PEIN test sequence in Appendix V MAY be used optionally. It is defined in terms of a series of PSD levels and associated durations. The test begins with the first PSD level being applied for the first duration value. At the end of each duration, the PSD level switches to the next listed value and remains at that level for the associated duration. The defined test sequence requires 4 hours to complete. The PSD level of -140dBm/Hz is the background noise level.

D.3.4 **Fluctuating Crosstalk Model**

The Fluctuating Crosstalk Noise Model simulates a two day cycle, and starts from a quiet condition when all disturbers are assumed to be turned off. The number of active disturbers in a 20 pair cable ranges from zero to 19 twice during the test. The simulated crosstalk noise is made up of between 0 and 19 self-NEXT and FEXT noise sources.

The condition during training SHALL be 1 active disturber at the CPE and at the DSLAM. The DSLAM and CPE noise fluctuates between 1 and 19 disturbers. With all 19 disturbers active the crosstalk level SHALL be at the 99% worst case level for 19 disturbers. The number of NEXT, and FEXT, disturbers at the DSLAM and CPE SHALL be the same and varied synchronously.

The fluctuating noise model is based on a hypothetical 20 pair cable. In this model the pairs are ordered according to reducing crosstalk coupling factor with respect to a wire pair that is subject to the test. The coupling factors are such that if the cable is progressively filled with active systems in this order, from the highest coupling factor to the lowest coupling factor, then the crosstalk noise will vary according to the classical 0.6 x log(n) multi-pair crosstalk model. The maximum fill of 19 disturbers leads to a crosstalk power that is 7.67 dB greater than the largest single disturber model. A key feature of the model is that the crosstalk noise when there are n disturbers is variable depending on which pairs are active. So we define noise generator PSDs as follows:

Crosstalk coupling functions are defined in section 5.3.2 table 5 of TS 101 388 [8],

Formula D- 2

$$XS.NT.n\_BA8c\_FLX() = \sum_{1}^{19} a_n \cdot P_{SingleSelfBA8c\_FLX,\ NT}(n)$$

$$XS.LT.n\_BA8c\_FLX() = \sum_{1}^{19} a_n \cdot P_{SingleSelfBA8c\_FLX,\ LT}(n)$$

Pair number $n \in 1..19$

Activation $a_n \in True, False$

Per - line crosstalk contribution $P_{SingleSelfBA8c\_D\&UPBO\_FLX,\ NT}(n) = P_{SingleSelfBA8c\_D\&UPBO,\ NT}(n) \cdot 10^{CCFV(n)/10}$

$CCFV(n)$ = The crosstalk coupling factor variation for pair n in dB referenced to pair 1

Table 169: Crosstalk coupling factor for the nth pair in the set

Pair-number	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19
CCF dB Referred to the section 5.3.2 table 5 of TS 101 388 [8]	0	-2.88	-3.79	-4.39	-4.83	-5.18	-5.47	-5.72	-5.93	-6.13	-6.3	-6.46	-6.61	-6.74	-6.86	-6.98	-7.09	-7.19	-7.29

At the start of the test, no other disturbers SHALL be active. One-by-one, additional disturbers SHALL be enabled at a pseudo-random time (random order is implied) , in the first simulated ½ day, until at the time corresponding to noon, all disturbers are active. During the second half of the first simulated day, each disturber SHALL be disabled at a pseudo random time, until at the end of the first day all the disturbers are disabled. The second simulated day follows the same model as the first but with different times and order of disturbers.

D.3.5 **Repeatable test pattern definition – (Fluctuating Crosstalk)**

The lists the start of a possible test pattern for fluctuating crosstalk. The power rises much more rapidly than would be expected in an actual test.

Table 170: Fluctuating crosstalk power test pattern

Time (s)	Power
0	-93.5
1	-93.5
2	-37.5
3	-37.5
4	-28.0

The fluctuating crosstalk test sequence in Appendix VI MAY be used optionally. It is defined for the 19 self crosstalk disturber scenario in terms of a series of relative power (i.e. relative to the 19 disturber power level) and times. The test begins at t=0 s with the relative power of -67.80 dB being applied. At t = 72 s, the relative power level switches to -13.61 dB and so on. At t = 14239 s, the relative power level switches to -67.80 s and remains at this level until t = 14400s, at which point the test ends. Hence the defined test sequence also requires 4 hours to complete.

D.3.6 **Fluctuating Broadband RFI Model**

This model includes 100 AM broadcast and 10 radio amateur signals of interferers at different levels, each carrier modulated with noise fluctuating at the syllabic rate and subject to independent fading at a rate and with a time profile representative of night time reception conditions.

This could be achieved using two AWGs, clocked at slightly different frequencies or two deep memory AWGs with a small difference in pattern length. Whichever method is chosen, it is important that the sequences loaded into memory SHALL be different, in order to ensure that the fading occurs independently between carriers. This could be done by ensuring that the phase of each carrier and associated side band group is given an arbitrary phase offset with respect to the waveform in the other generator and the other carriers.

If the dual AWG method is used, in order to achieve a fade of approximately 1000 seconds duration for carriers in the region of 1 MHz, one of the generators SHALL produce a carrier at 1.000000001 MHz. This can be achieved using reference clocks of 10 MHz and 10.00000001

MHz for the two AWGs as shown in Figure 5. The absolute accuracy of the reference clock is not significant, 50 parts per million accuracy is sufficient for repeatability. It is important that the resolution of frequency setting of the synthesizers is better than 1 part in 10^9.

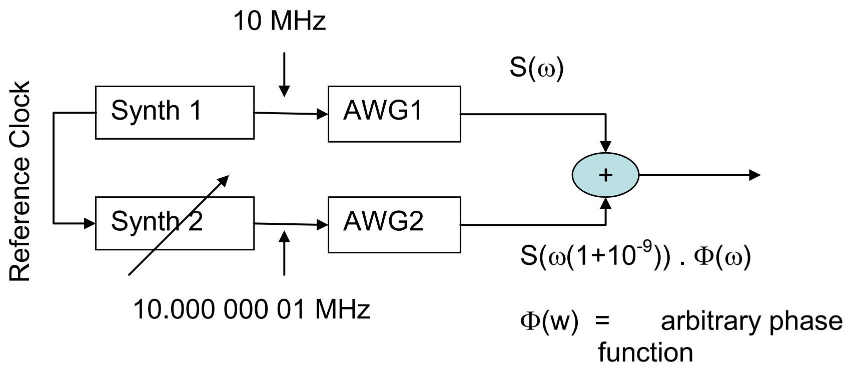

Figure 5: Example of creation of fluctuating noise

Table 171 below defines the carrier amplitudes and phases for one of the two AWGs. It also indicates those frequencies which have been carried forwards from the RF interferer list defined in TS 101 388 [8] and those frequencies which lie in the radio amateur bands. The frequencies have been chosen to allow testing of VDSL2 systems using frequencies up to 30 MHz.

The 100 radio broadcast carriers are amplitude modulated with double side bands and the 10 radio amateur signals with single side band suppressed carrier modulation (SSB). Each carrier SHOULD be independently modulated with speech weighted noise, each noise source being independently modulated at the syllabic rate.

Speech weighted noise SHALL be as defined in G.227 [6] and is limited to 4.2 kHz. The target modulation index for each carrier is 50% and the fade depth 100%.

Syllabic modulation SHALL be performed by periodically interrupting a continuous speech weighted noise source for a period of 150ms every 200ms. In the case of amateur band SSB signals the carrier power column data SHOULD be interpreted as the power of the SSB signal during the on period of the syllabic rate modulation.

Table 171: AM radio channel model

RF	From ADSL plan	Band	Frequency (kHz)	Diff (Carrier) Power dBm	Phase Offset (rad)	Amateur Band
1	Yes		99	-58	3.463	
2	Yes	LW	207	-43	2.906	
3		LW	270	-93	4.292	
4		LW	279	-87	5.538	
5	Yes		333	-50	2.098	
6	Yes		387	-54	5.083	
7	Yes	MW	531	-59	2.522	
8	Yes	MW	603	-60	0.709	
9		MW	630	-82	2.914	
10		MW	693	-53	4.61	
11	Yes	MW	711	-57	4.239	
12		MW	792	-84	1.167	
13	Yes	MW	801	-62	5.793	
14		MW	855	-80	3.738	
15	Yes	MW	909	-52	2.317	
16	Yes	MW	981	-63	0.63	
17		MW	999	-63	6.102	
18		MW	1080	-76	1.94	
19		MW	1269	-83	0.56	
20		SW	3235	-83	1.156	
21		SW	3250	-56	5.164	
22		SW	3300	-61	5.097	
23		SW	3330	-71	3.493	
24		SW	3355	-74	6.011	
25		SW	3365	-59	1.922	
26		SW	3390	-70	4.95	
27			3695	-75	3.353	Y
28			3720	-56	5.75	Y
29			3730	-56	3.738	Y
30			3770	-90	0.393	Y
31		SW	4810	-55	4.996	
32		SW	4845	-80	5.656	
33		SW	5015	-55	5.013	
34		SW	5035	-93	4.841	
35		SW	5970	-54	5.68	

RF	From ADSL plan	Band	Frequency (kHz)	Diff (Carrier) Power dBm	Phase Offset (rad)	Amateur Band
36		SW	5980	-56	3.055	
37		SW	5995	-87	2.994	
38		SW	6005	-85	5.659	
39		SW	6015	-89	3.182	
40		SW	6050	-85	2.031	
41		SW	6060	-93	2.705	
42		SW	6095	-78	2.901	
43		SW	6105	-76	2.951	
44		SW	6160	-89	5.613	
45		SW	6170	-93	0.768	
46		SW	6180	-63	3.319	
47		SW	7130	-71	3.421	Y
48		SW	7145	-90	0.42	Y
49		SW	7175	-92	4.876	Y
50		SW	7185	-63	0.818	Y
51		SW	7350	-92	0.439	
52		SW	9415	-93	4.054	
53		SW	9495	-58	3.044	
54		SW	9515	-77	4.125	
55		SW	9620	-74	5.978	
56		SW	9650	-81	6.176	
57		SW	9685	-91	4.461	
58		SW	9695	-91	4.635	
59		SW	9705	-93	5.387	
60		SW	9800	-91	5.477	
61		SW	9820	-82	3.992	
62		SW	11600	-76	4.049	
63		SW	11610	-92	0.078	
64		SW	11655	-91	5.044	
65		SW	11720	-85	3.833	
66		SW	11730	-72	1.829	
67		SW	11810	-82	3.467	
68		SW	11890	-93	2.351	
69		SW	11915	-90	0.313	
70		SW	11965	-72	0.649	

RF	From ADSL plan	Band	Frequency (kHz)	Diff (Carrier) Power dBm	Phase Offset (rad)	Amateur Band
71		SW	12050	-90	6.006	
72		SW	12060	-70	2.648	
73		SW	12185	-59	0.385	
74		SW	13620	-86	3.852	
75		SW	13675	-84	4.685	
76		SW	13710	-74	0.995	
77		SW	13790	-70	3.553	
78		SW	13830	-79	1.205	
79			14115	-60	3.316	Y
80		SW	15130	-93	0.34	
81		SW	15140	-87	6.108	
82		SW	15150	-77	0.79	
83		SW	15385	-87	3.954	
84		SW	15490	-91	4.853	
85		SW	15535	-93	5.685	
86		SW	15735	-68	4.193	
87		SW	15760	-77	5.347	
88		SW	17500	-91	3.477	
89		SW	17560	-93	1.664	
90		SW	17585	-65	0.468	
91		SW	17595	-59	3.72	
92		SW	17625	-77	4.62	
93		SW	17685	-93	2.864	
94		SW	17780	-78	0.826	
95		SW	18905	-60	3.551	
96		SW	18915	-91	2.09	
97		SW	18995	-93	0.823	
98			21040	-93	1.601	Y
99		SW	21485	-89	4.111	
100		SW	21550	-91	4.507	
101		SW	21660	-93	2.196	
102		SW	21670	-68	2.135	
103		SW	21680	-74	0.743	
104		SW	21690	-92	0.092	
105		SW	21705	-85	0.138	

RF	From ADSL plan	Band	Frequency (kHz)	Diff (Carrier) Power dBm	Phase Offset (rad)	Amateur Band
106		SW	21710	-93	2.839	
107		SW	21745	-93	5.946	
108		SW	21755	-75	0.846	
109		SW	23945	-90	4.689	
110		SW	23960	-86	4.349	

NOTE: Although the above table includes suggested carrier powers, with a bias towards lower powered signals, this item remains the subject of further study.

D.3.7 **Synchronization of the multiple noise models**

REIN is not synchronized with any other source. PEIN and fluctuating crosstalk noise sources SHOULD start simultaneously, but SHALL be aligned to start within 1 second.

The same PEIN and fluctuating crosstalk test patterns SHOULD be used for each of the four tests described.

E Annex E *G.998.4* Retransmission Performance Tests

E.1 Retransmission testing for profile BA17ade_D&UPBO

Three groups of tests are defined for profile BA17ade_D&UPBO, to set requirements for VDSL2 in combination with G.998.4 [3].

These are:

- REIN immunity
- PEIN immunity
- Immunity to combined REIN and PEIN noise ingress

In general, the acronym SHINE (Singular High Impulse Noise Environment) refers to single impulses with duration in the range milliseconds to seconds that MAY or MAY NOT be correctable, as related to G.998.4 control parameters.

The acronym PEIN (Prolonged Electrical Impulse Noise) refers to a sequence of relatively short SHINE impulses spread over a prolonged time period.

The PEIN testing in this annex refers to tests with impulse noise having duration up to the upper limit of error correction capability for the method under test.

The SHINE testing in TR-114 refers to tests with high level impulse noises that are generally longer then the correction capability and lead to un-correctable error bursts.

Table 172: Basic test setup parameters

Test Parameter	Value
Test Loop	TP100 loop, length: 150 m, 450 m, 1050 m, 1200 m, 1500 m
Band-profile	BA17ade_D&UPBO
Common Line Settings	Common Line Settings for BA17ade_D&UPBO band profile as defined in Table 114
Crosstalk Noise model	n_BA17ade_D&UPBO_RTX which is identical to n_BA17ade_D&UPBO as defined in Table 117, except calculated for 1 Self NEXT+FEXT noise disturber (1self_BA17ade_D&UPBO) + -140dBm/Hz AWGN
REIN repetition rate	100Hz
REIN pulse amplitude	Nominal 0dB relative to the REIN noise impairment defined in D.3.1
REIN duration (REIN_T)	{0 | 100µs}
PEIN test pattern	As defined in Table 183.
PEIN duration (PEIN_T)	{0 | 4.3ms | 9.7ms}
PEIN repetition rate	1 per second
Initialization	Rate adaptive start-up without PEIN and without REIN
Ethernet frame size for Down-	300 bytes

and Upstream (FS)	
Ethernet frames per second DS (FpSds) (test group 0)	FLOOR(NDRds*1000*0.95/(8*(300+4)*65/64))
Ethernet frames per second DS (FpSds) (test group 1, 2 and 3)	FLOOR(MIN(ETRds,MINEFTRds)*1000*0.95/(8*(300+4)*65/64))
Ethernet frames per second upstream (FpSus)	53

E.1.1 **Downstream retransmission performance test**

Test Configuration

Table 173: RTX Common Line Settings

Parameter	Setting	Description
MAXSNRM	15 dB	
RTX_MODE	2	RTX_FORCED
IAT_REIN_RTX	0	REIN at 100Hz
NOTE: Other Common Line Settings parameters are defined in Table 7 and Table 114.		

Table 174: RTX General Line Settings

General line setting	Parameter	Setting	Description
"R-10/2/0" (REIN only noise)	INPMIN_REIN_RTX	2	DMT symbols protection against REIN
	INPMIN_SHINE_RTX	0	No guaranteed protection against PEIN/SHINE
	SHINERATIO_RTX	0	No protection against SHINE
	LEFTR_THRESH	0.80	Low rate defect threshold
	DELAYMAX_RTX	10	ms
	DELAYMIN_RTX	0	Outlet shaper off
"R-15/0/41" (PEIN only noise)	INPMIN_REIN_RTX	0	No guaranteed protection against REIN
	INPMIN_SHINE_RTX	41	DMT symbols protection against PEIN/SHINE
	SHINERATIO_RTX	2	Worst case PEIN retransmission overhead (in %)
	LEFTR_THRESH	0.98	Low rate defect threshold
	DELAYMAX_RTX	15	ms
	DELAYMIN_RTX	0	Outlet shaper off
"R-17/2/41" (this setting is intended for use	INPMIN_REIN_RTX	2	DMT symbols protection against REIN
	INPMIN_SHINE_RTX	41	DMT symbols protection against PEIN/SHINE

with the REIN+ PEIN noise impairment)	SHINERATIO_RTX	2	Worst case PEIN retransmission overhead (in %)
	LEFTR_THRESH	0.78	Low rate defect threshold
	DELAYMAX_RTX	17	ms
	DELAYMIN_RTX	0	Outlet shaper off

Table 175: RTX Specific Line Settings

RTX Specific line setting	DS RTX General line settings	US RTX General line settings	RA-Mode	DS Expected throughput (ETR_RTX) or Net data rate (NDR, NDR_RTX) (kbps)	US Net data rate (NDR) (kbps)
RA_D_F*_150_150	F-1/0	I-8/2	AT_INIT	MAXNDR = 150000 MINNDR = 128	MAXNDR = 150000 MINNDR = 64
RA_D_R10/2/0_150_150	R-10/2/0	I-8/2	AT_INIT	MAXETR_RTX = 150000 MAXNDR_RTX = 150000 MINETR_RTX = 518	MAXNDR = 150000 MINNDR = 160
RA_D_R15/0/41_150_150	R-15/0/41	I-8/2	AT_INIT	MAXETR_RTX = 150000 MAXNDR_RTX = 150000 MINETR_RTX = 518	MAXNDR = 150000 MINNDR = 160
RA_D_R17/2/41_150_150	R-17/2/41	I-8/2	AT_INIT	MAXETR_RTX = 150000 MAXNDR_RTX = 150000 MINETR_RTX = 518	MAXNDR = 150000 MINNDR = 160
NOTE: Latency and INP settings for RA_D_F*_150_150 specific line setting SHALL be F-1/0 in downstream and I-8/2 in upstream. F-1/0 and I-8/2 are defined in Table 8.					

Test Profiles

The Common band-profile BA17ade as described in Section B.15 is combined with the line settings described in Table 175 to specify the complete settings for a system under test.

Table 176: Test profiles for retransmission

Band-profile	Specific line-setting	Profile-line combination
BA17ade_D&UPBO	RA_D_F*_150_150	BA17ade_D&UPBO_RA_D_F*_150_150
BA17ade_D&UPBO	RA_D_R10/2/0_150_150	BA17ade_D&UPBO_RA_D_R10/2/0_150_150
BA17ade_D&UPBO	RA_D_R15/0/41_150_150	BA17ade_D&UPBO_RA_D_R15/0/41_150_150
BA17ade_D&UPBO	RA_D_R17/2/41_150_150	BA17ade_D&UPBO_RA_D_R17/2/41_150_150

DPBO and UPBO SHALL be configured as per band profile BA17ade_D&UPBO.

Test Description

Test matrix showing mandatory (M) and optional (O) tests is described in Table 177.

Table 177: Test matrix showing mandatory and optional tests

Test Loop TP100 (m)	Test Group			
	0	1	2	3
150	M	M	M	M
450	O	O	O	O
1050	M	M	M	M
1200	O	O	O	O
1500	M	M	M	M

Table 178: Summary of parameters for each Test Group

Test Profile and Impulse Noise Configuration	Test Group			
	0	1	2	3
BA17ade_D&UPBO _RA_D_F*_150_150	Y			
BA17ade_D&UPBO _RA_D_R10/2/0_150_150		Y		
BA17ade_D&UPBO _RA_D_R15/0/41_150_150			Y	
BA17ade_D&UPBO _RA_D_R17/2/41_150_150				Y
REIN_T (µs)	0	100	0	100
PEIN_T(ms)	0	0	9.7	4.3

Table 179 describes the test procedure for the Downstream retransmission test. All MINEFTR values for each test group SHALL be read within the same monitoring period.

Table 179: Downstream retransmission test

Test Configuration	(1) Test profiles SHALL be configured according to Table 176. (2) Line simulator SHALL be set up for the TP100 straight homogeneous loop. Its length SHALL be as defined in Table 177. (3) The crosstalk noise SHALL be injected at CO and CPE. (4) REIN & PEIN SHALL be injected at the CPE only.
Method of Procedure	(1) Configure the SUT in the test profile for test group 0 as defined in Table 178. (2) Set the first loop for test group 0 as specified in Table 177. (3) Enable crosstalk for this loop length and disable REIN and PEIN.

	(4) Allow modem to train. (5) Allow 1 minute after training for link to stabilize. (6) Enable Ethernet traffic generation with a frame rate FpSds in the downstream direction and FpSus in the upstream direction as defined in Table 172. (7) Allow traffic to run for 2 minutes. (8) Record the highest downstream packet delay as PDfds. (9) Repeat steps 3 to 8 for the next loop lengths from Table 177. (10)Configure the SUT in the test profile for test group 1 as defined in Table 178. Configure the REIN and PEIN parameters for test group 1 as defined in Table 178. (11)Set the first loop for test group 1 as specified in Table 177. (12)Enable crosstalk for this loop length and disable REIN and PEIN. (13)Allow modem to train. (14)Allow 1 minute after training for link to stabilize. (15)Enable REIN and/or PEIN. (16)Wait 2 minutes. (17)Record NDRds, MINEFTRds and ETRds. (18)Enable Ethernet traffic generator with a frame rate FpSds in the downstream direction and FpSus in the upstream direction as defined in Table 172. (19)Record the downstream ES, SES and CV counters. (20)Allow traffic to run for 2 minutes. (21)Record the downstream ES, SES and CV counters. Record the number of dropped packets and the highest downstream packet delay. (22)Disable REIN and/or PEIN. (23)Allow traffic to run for 2 minutes and record the highest downstream packet delay. (24)Record the difference between the E2E packet delay without and with impulse noise impairment as Delay_diff. (25)Repeat steps 12 to 24 for the next loop lengths from Table 177. (26)Repeat steps 10 to 25 for the next test group from Table 178.
Expected Result	For test group 1 to 3 and each loop length: (1) MINEFTRds >= ETRds – ETRds*0.02 (2) Packet Delay without impulse noise - PDfds <= 3.5ms (NOTE1). (3) Delay_diff <= DELAYMAX_RTX (4) ETRds >= 80% NDRds (5) Within the 2 minutes traffic test periods there SHALL be (NOTE2): a.no dropped packets b.no increase in downstream CV, ES and SES counters
NOTE1: if the result is > 3.5ms then repeat the Packet Delay measurement without impulse noise once. NOTE2: If the CV count is increased by 1, the test for this test group and loop length SHALL be repeated once.	

E.1.2 Upstream retransmission performance test (optional)

Basic test setup parameters

See Table 172, with the changes indicated in Table 180.

Table 180: Ethernet Throughput Frames per second

Ethernet frames per second US (FpSus) (test group 0)	FLOOR(NDRus*1000*0.95/(8*(300+4)*65/64))
Ethernet frames per second US (FpSus) (test group 1, 2 and 3)	FLOOR(MIN(ETRus,MINEFTRus*1000*0.95 /(8*(300+4)*65/64))
Ethernet frames per second downstream (FpSds)	53

Test Configuration

See Table 173: RTX Common Line Settings, Table 174: RTX General Line Settings and Table 181.

Table 181: RTX Specific Line Settings

RTX Specific line setting	DS RTX General line settings	US RTX General line settings	RA-Mode	DS Expected throughput (ETR_RTX) or Net data rate (NDR, NDR_RTX) (kbps)	US Expected throughput (ETR_RTX) or Net data rate (NDR, NDR_RTX) (kbps)
RA_F*_150_150	I-8/2	F-1/0	AT_INIT	MAXNDR = 150000 MINNDR = 128	MAXNDR = 150000 MINNDR = 64
RA_R10/2/0_150_150	R-10/2/0	R-10/2/0	AT_INIT	MAXETR_RTX = 150000 MAXNDR_RTX = 150000 MINETR_RTX = 518	MAXETR_RTX = 150000 MAXNDR_RTX = 150000 MINETR_RTX = 518
RA_R15/0/41_150_150	R-15/0/41	R-15/0/41	AT_INIT	MAXETR_RTX = 150000 MAXNDR_RTX = 150000 MINETR_RTX = 518	MAXETR_RTX = 150000 MAXNDR_RTX = 150000 MINETR_RTX = 518
RA_R17/2/41_150_150	R-17/2/41	R-17/2/41	AT_INIT	MAXETR_RTX = 150000 MAXNDR_RTX = 150000 MINETR_RTX = 518	MAXETR_RTX = 150000 MAXNDR_RTX = 150000 MINETR_RTX = 518

RTX Specific line setting	DS RTX General line settings	US RTX General line settings	RA-Mode	DS Expected throughput (ETR_RTX) or Net data rate (NDR, NDR_RTX) (kbps)	US Expected throughput (ETR_RTX) or Net data rate (NDR, NDR_RTX) (kbps)
RA_F*_150_150	I-8/2	F-1/0	AT_INIT	MAXNDR = 150000 MINNDR = 128	MAXNDR = 150000 MINNDR = 64
NOTE: Latency and INP settings for RA_F*_150_150 specific line setting SHALL be I-8/2 in downstream and F-1/0 in upstream. F-1/0 and I-8/2 are defined in Table 8.					

Test Profiles

See Table 176, with the RTX specific line settings of Table 181.

Test Description

Test matrix showing mandatory (M) and optional (O) tests is described in Table 177. The parameters for each test group are summarized in Table 178, with the RTX specific line settings of Table 181.

Table 182 describes the test procedure for the Upstream retransmission test. All MINEFTR values for each test group SHALL be read within the same monitoring period.

Table 182: Upstream retransmission test

Test Configuration	(1) Test profiles SHALL be configured according to Table 176 with the RTX specific line settings of Table 181. (2) Line simulator SHALL be set up for the TP100 straight homogeneous loop. Its length SHALL be as defined in Table 177. (3) The crosstalk noise SHALL be injected at CO and CPE. (4) REIN & PEIN SHALL be injected at the CO only.
Method of Procedure	(1) Configure the SUT in the test profile for test group 0 as defined in Table 178. (2) Set the first loop for test group 0 as specified in Table 177. (3) Enable crosstalk for this loop length and disable REIN and PEIN. (4) Allow modem to train. (5) Allow 1 minute after training for link to stabilize. (6) Enable Ethernet traffic generation with a frame rate FpSds in the downstream direction and FpSus in the upstream direction as defined in Table 180. (7) Allow traffic to run for 2 minutes. (8) Record the highest upstream packet delay as PDfus. (9) Repeat steps 3 to 8 for the next loop lengths from Table 177. (10) Configure the SUT in the test profile for test group 1 as defined in Table 178. Configure the REIN and PEIN parameters for test group 1 as defined in Table 178. (11) Set the first loop for test group 1 as specified in Table 177.

	(12)Enable crosstalk for this loop length and disable REIN and PEIN. (13)Allow modem to train. (14)Allow 1 minute after training for link to stabilize. (15)Enable REIN and/or PEIN. (16)Wait 2 minutes. (17)Record NDRus, MINEFTRus and ETRus. (18)Enable Ethernet traffic generator with a frame rate FpSds in the downstream direction and FpSus in the upstream direction as defined in Table 180. (19)Record the upstream ES, SES and CV counters. (20)Allow traffic to run for 2 minutes. (21)Record the upstream ES, SES and CV counters. Record the number of dropped packets and the highest upstream packet delay. (22)Disable REIN and/or PEIN. (23)Allow traffic to run for 2 minutes and record the highest upstream packet delay. (24)Record the difference between the E2E packet delay without and with impulse noise impairment as Delay_diff. (25)Repeat steps 12 to 24 for the next loop lengths from Table 177. (26)Repeat steps 10 to 25 for the next test group from Table 177.
Expected Result	For test group 1 to 3 and each loop length: (1) MINEFTRus >= ETRus – ETRus*0.02 (2) Packet Delay without impulse noise - PDfus <= 3.5ms (NOTE1). (3) Delay_diff <= DELAYMAX_RTX (4) ETRus >= 80% NDRus. (5) Within the 2 minutes traffic test periods there SHALL be (NOTE2): a.no dropped packets b.no increase in upstream CV, ES and SES counters
NOTE1: if the result is > 3.5ms then repeat the Packet Delay measurement without impulse noise once. NOTE2: If the CV count is increased by 1, the test for this test group and loop length SHALL be repeated once.	

E.1.3 PEIN Test Pattern Definition

Table 183: PEIN Test Pattern Definition

PEIN test pattern fixed pulse length PEIN_T Part 1		PEIN test pattern fixed pulse length PEIN_T Part 2		PEIN test pattern fixed pulse length PEIN_T Part 3		PEIN test pattern fixed pulse length PEIN_T Part 4	
PSD (dBm/Hz)	Pulse Duration	PSD (dBm/Hz)	Pulse Duration	PSD (dBm/Hz)	Pulse Duration	PSD (dBm/Hz)	Pulse Duration
-114	T	-114	T	-108	T	-110	T
-140	1-T	-140	1-T	-140	1-T	-140	1-T
-102	T	-94	T	-114	T	-98	T
-140	1-T	-140	1-T	-140	1-T	-140	1-T
-108	T	-112	T	-98	T	-112	T

-140	1-T
-106	T
-140	1-T
-108	T
-140	1-T
-106	T
-140	1-T
-112	T
-140	1-T
-90	T
-140	1-T
-110	T
-140	1-T
-102	T
-140	1-T
-98	T
-140	1-T
-104	T
-140	1-T
-100	T
-140	1-T
-114	T
-140	1-T
-104	T
-140	1-T
-100	T
-140	1-T
-112	T
-140	1-T
-94	T
-140	1-T
-98	T
-140	1-T
-112	T
-140	1-T

-140	1-T
-104	T
-140	1-T
-106	T
-140	1-T
-112	T
-140	1-T
-112	T
-140	1-T
-92	T
-140	1-T
-108	T
-140	1-T
-114	T
-140	1-T
-114	T
-140	1-T
-108	T
-140	1-T
-98	T
-140	1-T
-114	T
-140	1-T
-100	T
-140	1-T
-102	T
-140	1-T
-96	T
-140	1-T
-104	T
-140	1-T
-96	T
-140	1-T
-108	T
-140	1-T

-140	1-T
-90	T
-140	1-T
-112	T
-140	1-T
-94	T
-140	1-T
-108	T
-140	1-T
-106	T
-140	1-T
-106	T
-140	1-T
-106	T
-140	1-T
-92	T
-140	1-T
-110	T
-140	1-T
-100	T
-140	1-T
-114	T
-140	1-T
-114	T
-140	1-T
-114	T
-140	1-T
-114	T
-140	1-T
-108	T
-140	1-T
-106	T
-140	1-T
-102	T
-140	1-T

-140	1-T
-112	T
-140	1-T
-90	T
-140	1-T
-110	T
-140	1-T
-98	T
-140	1-T
-88	T
-140	1-T
-110	T
-140	1-T
-112	T
-140	1-T
-114	T
-140	1-T
-114	T
-140	1-T
-104	T
-140	1-T
-96	T
-140	1-T
-108	T
-140	1-T
-112	T
-140	1-T
-110	T
-140	1-T
-106	T
-140	1-T
-110	T
-140	1-T
Restart from the beginning	

Appendix I. Amateur Radio Bands (informative)

Amateur radio bands MAY interfere with some regions of the VDSL2 spectrum. Table 184 below provides the frequency ranges of these amateur radio bands as related to frequencies relevant to VDSL2.

Table 184:Amateur Radio Band Frequency Ranges (MHz)

<table>
<tr><th>ITU-R
Region 1
(Europe)</th><th>ITU-R
Region 2
(Americas)</th><th>ITU-R
Region 3
(Asia-Pacific)</th></tr>
<tr><td>1.81-1.85</td><td>1.80-2.00</td><td>1.80-2.00</td></tr>
<tr><td>3.50-3.80</td><td>3.50-4.00</td><td>3.50-3.90</td></tr>
<tr><td>7.00-7.20</td><td>7.00-7.30</td><td>7.00-7.20</td></tr>
<tr><td colspan="3">10.1-10.15</td></tr>
<tr><td colspan="3">14-14.35</td></tr>
<tr><td colspan="3">18.068-18.168</td></tr>
<tr><td colspan="3">21-21.45</td></tr>
<tr><td colspan="3">24.89-24.99</td></tr>
<tr><td colspan="3">28-29.7</td></tr>
</table>

Appendix II. Inside Wiring Topologies (informative)

Testing with inside wiring topologies are for further study.

The splitter is normally located at the NID (network interface device). While the VDSL2 testing specification MAY make reference to the applicable industry requirement for splitters, it is recommended that the specific make and model of the splitter, balun, splitter/balun, and diplexer be chosen by the testing laboratory. An integrated splitter and balun is preferred, but alternatively a separate splitter and balun could be used.

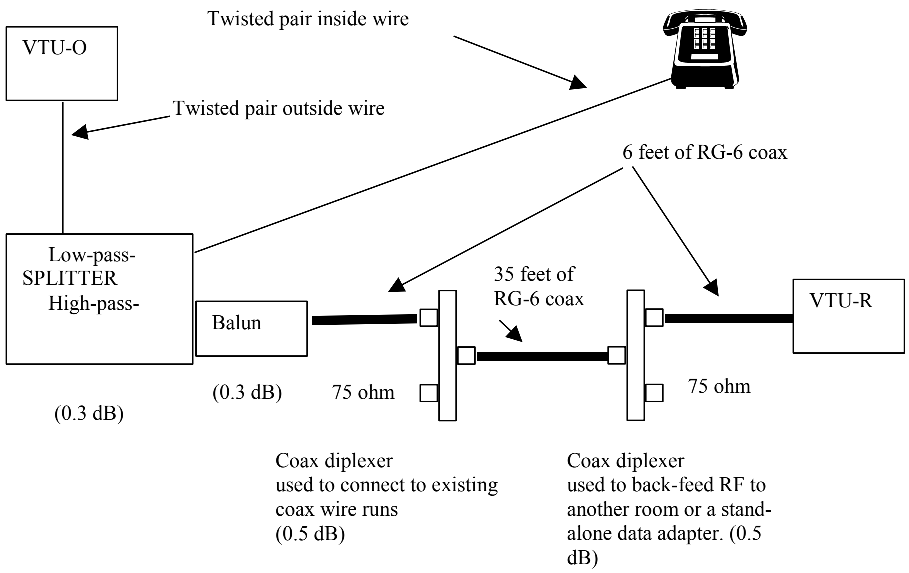

Figure 6: VDSL2 inside wire configuration 1

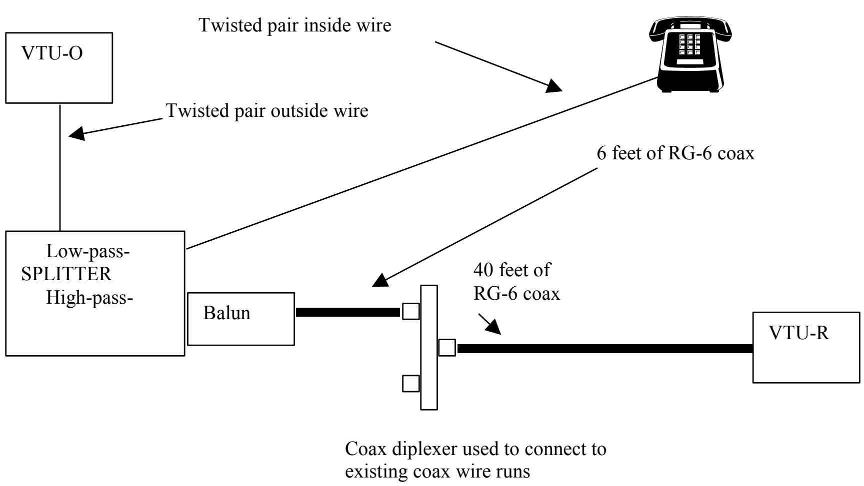

Figure 7: VDSL2 inside wire configuration 2

NOTE: Diplexer function and home data networking functions MAY be integrated within CPE.

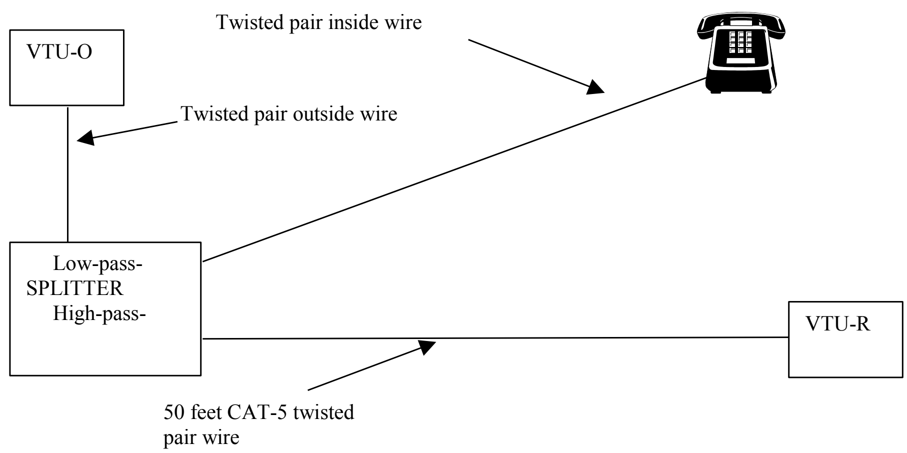

Figure 8: VDSL2 inside wire configuration 3

NOTE: Typical home without coax.

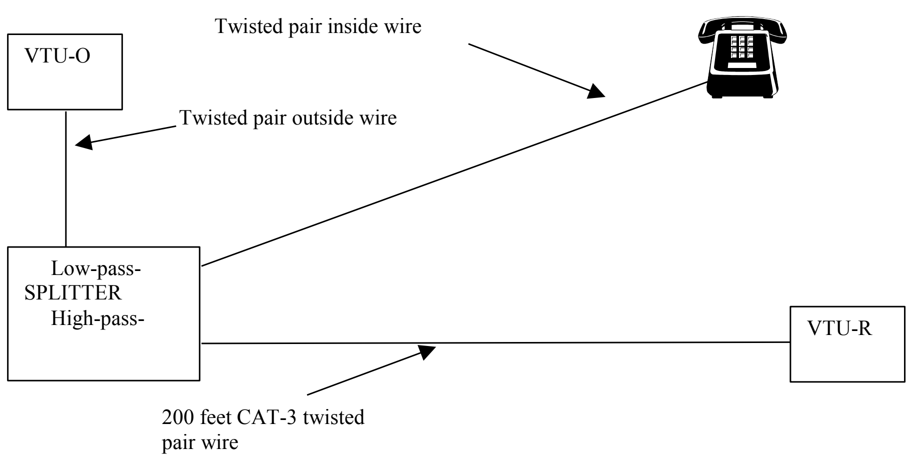

Figure 9: VDSL2 inside wire configuration 4

NOTE: Typical MDU without coax.

Appendix III. Summary of Profile and Line Combinations (informative)

Table 185: Summary of profile-line combinations used in TR-114

VDSL2 Band-profile	Specific line-setting	Profile-line combination
Annex A		
AA8a	RA_I_098_058	AA8a_UPBO_RA_I_098_058
AA12a	RA_I_098_058	AA12a_UPBO_RA_I_098_058
AA17a	RA_I_150_096	AA17a_UPBO_RA_I_150_096
AA17a	RA_R-17/2/41_150_096	AA17a_UPBO_RA_R-17/2/41_150_096
AA8d	RA_I_096_056	AA8d_UPBO_RA_I_096_056
AA8d	FX_I_027_002	AA8d_UPBO_FX_I_027_002
AA8d	FX_I_014_001	AA8d_UPBO_FX_I_014_001
AA8d	FX_I_040_006	AA8d_UPBO_FX_I_040_006
Annex B		
BA8b	RA_R_17/2/41_150_150	BA8b_RA_R-17/2/41_150_150
BA8b	RA_I_150_150	BA8b_RA_I_150_150
BA17a0	RA_R_17/2/41_150_150	BA17a0_RA_R-17/2/41_150_150
BA17a0	RA_I_150_150	BA17a0_RA_I_150_150
BA17a0_D&UPBO	RA_R_17/2/41_150_150	BA17a0_D&UPBO_RA_R-17/2/41_150_150
BA17a0_D&UPBO	RA_I_150_150	BA17a0_D&UPBO_RA_I_150_150
BA17a0_D&UPBO	FX_I_050_020	BA17a0_D&UPBO_FX_I_050_020
BA17ade_D&UPBO	RA_R-17/2/41_150_150	BA17ade_D&UPBO_RA_R-17/2/41_150_150
BA17ade_D&UPBO	RA_I_150_150	BA17ade_D&UPBO_RA_I_150_150
BA17ade_D&UPBO	FX_R-17/2/41_050_020	BA17ade_D&UPBO_FX_R-17/2/41_050_020
BA17ade_D&UPBO	FX_I_047_019	BA17ade_D&UPBO_FX_I_047_019
BA17ade_D&UPBO	FX_I_033_014	BA17ade_D&UPBO_FX_I_033_014
BA17ade_D&UPBO	FX_I_018_005	BA17ade_D&UPBO_FX_I_018_005
BA17ade_D&UPBO	FX_I_010_002	BA17ade_D&UPBO_FX_I_010_002

BA17ade_D&UPBO	RA_HI_150_150	BA17ade_D&UPBO_RA_HI_150_150
BA17ade_D&UPBO	FX_HI_011_004	BA17ade_D&UPBO_FX_HI_011_004
BA17ade_D&UPBO	FX_HI_009_003	BA17ade_D&UPBO_FX_HI_009_003
BB8b	RA_F_150_150	BB8b_RA_F_150_150
BB8b	RA_I_150_150	BB8b_RA_I_150_150
BB12a	RA_F_150_150	BB12a_RA_F_150_150
BB12a	RA_I_150_150	BB12a_RA_I_150_150
BB17a	RA_F_150_150	BB17a_RA_F_150_150
BB17a	RA_I_150_150	BB17a_RA_I_150_150
BB17a_D&UPBO	RA_F_150_150	BB17a_D&UPBO_RA_F_150_150
BB17a_D&UPBO	RA_I_150_150	BB17a_D&UPBO_RA_I_150_150
BB17a_D&UPBO	FX_I_050_015	BB17a_D&UPBO_FX_I_050_015
Annex C		
CG8d	RA_I_105_105	CG8d_RA_I_105_105
CG12a	RA_I_105_105	CG12a_RA_I_105_105
CG17a	RA_I_105_105	CG17a_RA_I_105_105
CG30a	RA_I_105_105	CG30a_RA_I_105_105

Appendix IV. Crosstalk impairment for AA8d performance testing (informative)

Table 186: Annex A testing CPE Noise

Freq (kHz)	0.3 (kft)	0.6 (kft)	0.9 (kft)	1.2 (kft)	1.6 (kft)	2.0 (kft)	2.4 (kft)
1	−140.0	−140.0	−140.0	−140.0	−140.0	−140.0	−140.0
4	−140.0	−140.0	−140.0	−140.0	−140.0	−140.0	−140.0
16	−125.7	−123.8	−123.0	−122.6	−122.2	−122.0	−121.9
24	−110.5	−108.5	−107.7	−107.2	−106.9	−106.7	−106.6
36	−105.4	−103.5	−102.7	−102.2	−101.9	−101.7	−101.6
52	−103.0	−101.1	−100.3	−99.8	−99.5	−99.3	−99.2
78	−100.3	−98.4	−97.6	−97.2	−96.8	−96.6	−96.5
112	−97.9	−96.0	−95.2	−94.7	−94.4	−94.2	−94.1
134	−96.6	−94.8	−94.0	−93.5	−93.2	−93.0	−92.9
138	−96.4	−94.6	−93.8	−93.3	−92.9	−92.8	−92.7
142	−99.0	−97.2	−95.1	−94.6	−95.6	−95.4	−95.3
512	−108.6	−107.3	−107.2	−107.6	−108.6	−109.8	−111.2
1104	−103.4	−102.2	−102.9	−104.1	−106.1	−108.4	−110.8
1516	−100.4	−100.3	−101.5	−103.1	−105.7	−108.6	−111.6
2208	−97.8	−98.3	−100.1	−102.4	−105.8	−109.6	−113.5
3748	−94.7	−96.4	−99.2	−102.4	−106.8	−110.5	−112.7
3750	−119.3	−117.4	−114.0	−113.7	−113.7	−113.8	−113.8
3752	−119.5	−117.5	−114.1	−109.8	−103.9	−97.9	−91.9
3880	−123.9	−119.1	−114.6	−110.0	−103.9	−97.8	−91.7
4300	−125.3	−120.2	−115.4	−110.6	−104.2	−97.8	−91.3
5000	−127.2	−121.9	−116.7	−111.5	−104.6	−97.7	−90.8
5176	−121.3	−120.4	−116.8	−111.8	−104.7	−97.7	−90.7
5198	−118.9	−119.2	−116.6	−111.8	−104.8	−97.7	−90.6
5200	−118.7	−119.1	−116.5	−111.8	−111.6	−111.7	−111.7
5202	−94.3	−96.8	−100.5	−104.1	−108.5	−110.8	−111.6
6000	−93.5	−96.4	−100.7	−105.4	−112.1	−119.1	−126.1
7000	−92.6	−96.1	−100.8	−106.1	−113.4	−121.1	−128.6
8498	−91.6	−95.8	−101.2	−107.1	−115.4	−123.9	−131.7
8500	−116.6	−120.7	−126.0	−131.2	−136.3	−138.0	−138.3
8502	−116.9	−121.0	−126.2	−131.5	−136.4	−138.1	−138.3
8752	−137.2	−137.9	−138.2	−138.3	−138.3	−138.3	−138.3
9300	−137.2	−137.9	−138.2	−138.2	−138.3	−138.3	−138.3
12000	−137.2	−137.9	−138.2	−138.2	−138.3	−138.3	−138.3
16000	−137.2	−137.9	−138.2	−138.2	−138.3	−138.3	−138.3
Freq (kHz)	**2.8 (kft)**	**3.2 (kft)**	**3.6 (kft)**	**4.0 (kft)**	**4.5 (kft)**	**5.5 (kft)**	**6.5 (kft)**
1	−140.0	−140.0	−140.0	−140.0	−140.0	−140.0	−140.0
4	−140.0	−140.0	-140.0	−140.0	−140.0	−140.0	−140.0
16	−121.9	−121.8	-121.8	−121.8	−121.4	−121.4	−121.4
24	−106.5	−106.5	-106.4	−106.4	−106.0	−105.9	−105.9
36	−101.5	−101.5	-101.4	−101.4	−100.9	−100.9	−100.9
52	−99.1	−99.0	-99.0	−99.0	−98.5	−98.5	−98.5
78	−96.4	−96.4	-96.3	−96.9	−95.8	−96.4	−96.4
112	−94.0	−94.0	-94	−94.0	−93.5	−93.5	−93.5
134	−92.8	−92.8	-92.8	−92.8	−92.3	−92.3	−92.3
138	−92.6	−92.6	-92.6	−92.6	−92.1	−92.1	−92.1

142	−95.3	−95.3	-95.2	−95.2	−94.7	−94.8	−94.8
512	−112.8	−114.4	-116.1	−116.1	−108.8	−113.5	−118.3
1104	−113.4	−116.1	-118.8	−118.8	−113.9	−121.1	−128.3
1516	−114.8	−118.1	-121.4	−121.4	−125.0	−132.9	−138.0
2208	−117.5	−121.6	-125.7	−125.7	-132.6	−138.4	−139.5
3748	−113.6	−113.9	-114	−114.0	−138.9	−139.2	−139.2
3750	−113.8	−113.8	-113.8	−113.8	−139.2	−139.2	−139.2
3752	−86.8	−86.8	-86.8	−86.8	−139.2	−139.2	−139.2
3880	−86.6	−86.6	-86.6	−86.6	−139.2	−139.2	−139.2
4300	−85.9	−85.9	-85.9	−85.9	−139.0	−139.0	−139.0
5000	−84.9	−84.9	-84.9	−84.9	−138.8	−138.8	−138.8
5176	−84.7	−84.7	-84.7	−84.7	−138.8	−138.8	−138.8
5198	−84.7	−84.7	-84.7	−84.7	−138.7	−138.7	−138.7
5200	−111.7	−111.7	-111.7	−111.7	−138.7	−138.7	−138.7
5202	−111.8	−111.9	-138.5	−111.9	−138.7	−138.7	−138.7
6000	−132.5	−136.9	-138.6	−138.5	−138.5	−138.5	−138.5
7000	−134.8	−137.8	-138.4	−138.6	−138.2	−138.2	−138.2
8498	−136.7	−138.1	-138.4	−138.4	−137.7	−137.7	−137.7
8500	−138.4	−138.4	-138.4	−138.4	−137.7	−137.7	−137.7
8502	−138.4	−138.4	-138.3	−138.4	−137.7	−137.7	−137.7
8752	−138.3	−138.3	−138.3	−138.3	−137.6	−137.6	−137.6
9300	−138.3	−138.3	−138.3	−138.3	−138.3	−138.3	−138.3
12000	−138.3	−138.3	−138.3	−138.3	−138.3	−138.3	−138.3
16000	−138.3	−138.3	−138.3	−138.3	−138.3	−138.3	−138.3

Table 187: Annex A testing DSLAM noise

Freq (kHz)	0.3 (kft)	0.6 (kft)	0.9 (kft)	1.2 (kft)	1.6 (kft)	2.0 (kft)	2.4 (kft)
0.001	-140	-140	-140	-140	-140	-140	-140
4	-140	-140	-140	-140	-140	-140	-140
16	-135.5	-134.1	-133.4	-133	-132.8	-132.7	-132.7
24	-121.1	-119.1	-118.2	-117.7	-117.5	-117.4	-117.4
36	-115.3	-113.2	-112.4	-111.9	-111.6	-111.6	-111.7
52	-112.1	-110.1	-109.2	-108.7	-108.5	-108.6	-108.8
78	-108.6	-106.6	-105.7	-105.3	-105.2	-105.4	-105.8
112	-105.4	-103.4	-102.6	-102.2	-102.2	-102.6	-103.2
134	-103.5	-101.6	-100.7	-100.4	-100.5	-100.9	-101.5
138	-103.2	-101.2	-100.4	-100.1	-100.2	-100.5	-101.1
142	-105.3	-103.3	-102.5	-102.2	-102.3	-102.6	-103
512	-102.6	-100.9	-100.3	-100.1	-99.9	-99.9	-99.9
1104	-96.6	-95.3	-95	-94.9	-94.9	-94.9	-94.9
1516	-94.1	-93.1	-92.9	-92.8	-92.8	-92.8	-92.8
2208	-91.3	-90.5	-90.4	-90.4	-90.3	-90.3	-90.3
3748	-87.8	-87.4	-87.3	-87.3	-87.3	-87.3	-87.3
3750	-114.2	-113.7	-113.6	-113.7	-113.7	-113.8	-113.8
3752	-114.4	-113.9	-113.8	-113.7	-113.6	-113.6	-113.5
3880	-126.7	-125.3	-124.4	-123.8	-123.1	-122.6	-122.2
4300	-131.4	-129.1	-127.7	-126.8	-125.9	-125.2	-124.7
5000	-131.5	-129.9	-128.9	-128.2	-127.4	-126.9	-126.6
5176	-115.1	-114.8	-114.7	-114.7	-114.7	-114.7	-114.6
5198	-112.3	-111.9	-111.9	-111.9	-111.8	-111.8	-111.8
5200	-112	-111.7	-111.6	-111.6	-111.6	-111.7	-111.7
5202	-87	-86.7	-86.7	-86.7	-86.7	-86.7	-86.7
6000	-86	-85.8	-85.7	-85.7	-85.7	-85.7	-85.7
7000	-85	-84.7	-84.7	-84.7	-84.7	-84.7	-84.7
8498	-83.6	-83.5	-83.5	-83.5	-83.5	-83.5	-83.5
8500	-108.6	-108.5	-108.5	-108.5	-108.5	-108.5	-108.5
8502	-108.9	-108.8	-108.8	-108.8	-108.8	-108.8	-108.8
8752	-134.1	-134.1	-134.1	-134.1	-134.1	-134.1	-134.1
9300	-134.3	-134.2	-134.2	-134.2	-134.2	-134.2	-134.2
12000	-134.3	-134.2	-134.2	-134.2	-134.2	-134.2	-134.2
16000	-134.3	-134.2	-134.2	-134.2	-134.2	-134.2	-134.2
Freq (kHz)	**2.8 (kft)**	**3.2 (kft)**	**3.6 (kft)**	**4.0 (kft)**	**4.5 (kft)**	**5.5 (kft)**	**6.5 (kft)**
0.001	-140	-140	-140	-140	-140	-140	-140
4	-140	-140	-140	-140	-140	-140	-140
16	-132.8	-132.9	-133.1	-133.3	133.3	-134	-134.9
24	-117.6	-117.8	-118.1	-118.5	-118.6	-120	-121.5
36	-112	-112.4	-112.8	-113.4	-113.7	-115.5	-117.4
52	-109.2	-109.8	-110.4	-111.1	-111.6	-113.6	-115.8
78	-106.4	-107.1	-107.9	-108.7	-109.3	-111.5	-113.9
112	-103.9	-104.6	-105.4	-106.1	-106.6	-108.7	-110.6
134	-102.1	-102.7	-103.4	-103.3	-102.6	-103.6	-104.2
138	-101.6	-102.2	-102.9	-102.5	-101.5	-102.3	-102.8

142	-103.5	-104	-104.6	-103.6	-96.6	-96.7	-96.8
512	-99.9	-99.9	-99.9	-97.2	-88.5	-88.5	-88.5
1104	-94.9	-94.9	-94.9	-92.2	-83.5	-83.5	-83.5
1516	-92.8	-92.8	-92.8	-90.1	-88.8	-88.8	-88.8
2208	-90.3	-90.3	-90.3	-88.2	-88.4	-88.4	-88.4
3748	-87.3	-87.3	-87.3	-87.3	-89.1	-89.1	-89.1
3750	-113.8	-113.8	-113.8	-113.8	-115.6	-115.6	-115.6
3752	-113.5	-113.9	-114.0	-114.0	-115.8	-115.8	-115.8
3880	-122.6	-125.9	-127.4	-127.9	-129.8	-129.8	-129.8
4300	-125.3	-130.6	-134.6	-136.5	-137.8	-137.8	-137.8
5000	-127.1	-131.4	-133.4	-138.1	-138.7	-138.7	-138.7
5176	-114.7	-114.8	-114.8	-138.1	-138.6	-138.6	-138.6
5198	-111.8	-111.9	-111.9	-138.1	-138.6	-138.6	-138.6
5200	-111.7	-111.7	-111.7	-138.4	-138.6	-138.6	-138.6
5202	-86.7	-86.7	-86.7	-138.4	-138.6	-138.6	-138.6
6000	-85.7	-85.7	-85.7	-138.1	-138.4	-138.4	-138.4
7000	-84.7	-84.7	-84.7	-137.8	-138.0	-138.0	-138.0
8498	-83.5	-83.5	-83.5	-137.2	-137.5	-137.5	-137.5
8500	-108.5	-108.5	-108.5	-137.2	-137.5	-137.5	-137.5
8502	-108.8	-108.8	-108.8	-137.2	-137.5	-137.5	-137.5
8752	-134.1	-134.1	-134.1	-137.1	-137.4	-137.4	-137.4
9300	-134.2	-134.2	-134.2	-137	-137.3	-137.3	-137.3
12000	-134.2	-134.2	-134.2	-137	-137.3	-137.3	-137.3
16000	-134.2	-134.2	-134.2	-137	-137.3	-137.3	-137.3

Appendix V. Definition of the PEIN Test Sequence (informative)

Table 188: PEIN test sequence

PSD (dBm/ Hz)	Pulse Duration (s)	PSD (dBm/ Hz)	Pulse Duration (s)	PSD (dBm/ Hz)	Pulse Duration (s)	PSD (dBm/ Hz)	Pulse Duration (s)
-114	0.0012	-114	0.0024	-108	0.0012	-110	0.0024
-140	239.6863	-140	77.1503	-140	332.1614	-140	80.4826
-102	0.0036	-94	0.0012	-114	0.0012	-98	0.0036
-140	356.9171	-140	10.1132	-140	10.8805	-140	439.2413
-108	0.0012	-112	0.0024	-98	0.0024	-112	0.0036
-140	563.6294	-140	586.1201	-140	96.0786	-140	10.0494
-106	0.0024	-104	0.0012	-90	0.0024	-112	0.0024
-140	65.7596	-140	20.5420	-140	201.8782	-140	11.1764
-108	0.0012	-106	0.0012	-112	0.0012	-90	0.0036
-140	338.3679	-140	5.0986	-140	24.0057	-140	317.8878
-106	0.0012	-112	0.0012	-94	0.0024	-110	0.0012
-140	6.7483	-140	79.7198	-140	10.7293	-140	46.2431
-112	0.0024	-112	0.0012	-108	0.0024	-98	0.0012
-140	430.9218	-140	86.3793	-140	776.8734	-140	324.9239
-90	0.0012	-92	0.0012	-106	0.0012	-88	0.0012
-140	4.0486	-140	45.9375	-140	285.0463	-140	10.0279
-110	0.0012	-108	0.0012	-106	0.0012	-110	0.0012
-140	55.2019	-140	22.0592	-140	38.0893	-140	307.7382
-102	0.0036	-114	0.0036	-106	0.0036	-112	0.0036
-140	30.1464	-140	12.2951	-140	278.8883	-140	4.6997
-98	0.0024	-114	0.0012	-92	0.0012	-114	0.0012
-140	465.2506	-140	19.2707	-140	146.2292	-140	1034.461
-104	0.0012	-108	0.0036	-110	0.0012	-114	0.0012
-140	186.3316	-140	12.0422	-140	232.6348	-140	607.3705
-100	0.0012	-98	0.0036	-100	0.0012	-104	0.0012
-140	5.1288	-140	27.6377	-140	493.7815	-140	6.0715
-114	0.0012	-114	0.0012	-114	0.0024	-96	0.0012
-140	36.2142	-140	58.8883	-140	32.7880	-140	8.2482
-104	0.0012	-100	0.0012	-114	0.0024	-108	0.0024
-140	7.5879	-140	57.1679	-140	99.8566	-140	30.9200
-100	0.0012	-102	0.0036	-114	0.0024	-112	0.0024
-140	535.9689	-140	804.6132	-140	6.8442	-140	989.6293
-112	0.0012	-96	0.0012	-114	0.0012	-110	0.0012
-140	69.7433	-140	8.9752	-140	8.1342	-140	400.7583
-94	0.0012	-104	0.0036	-108	0.0036	-106	0.0036
-140	59.3769	-140	136.6322	-140	7.3911	-140	111.1603
-98	0.0024	-96	0.0024	-106	0.0012	-110	0.0012
-140	4.8960	-140	57.0489	-140	111.6616	TOTAL	14400
-112	0.0012	-108	0.0012	-102	0.0024		
-140	126.0826	-140	155.2323	-140	233.5790		

PEIN Test Sequence Graphs

The following three charts present compare the target probability distributions against the actual probability distributions embodied within the PEIN test sequence. This comparison is presented for the parameters of inter-arrival time, pulse duration and pulse power.

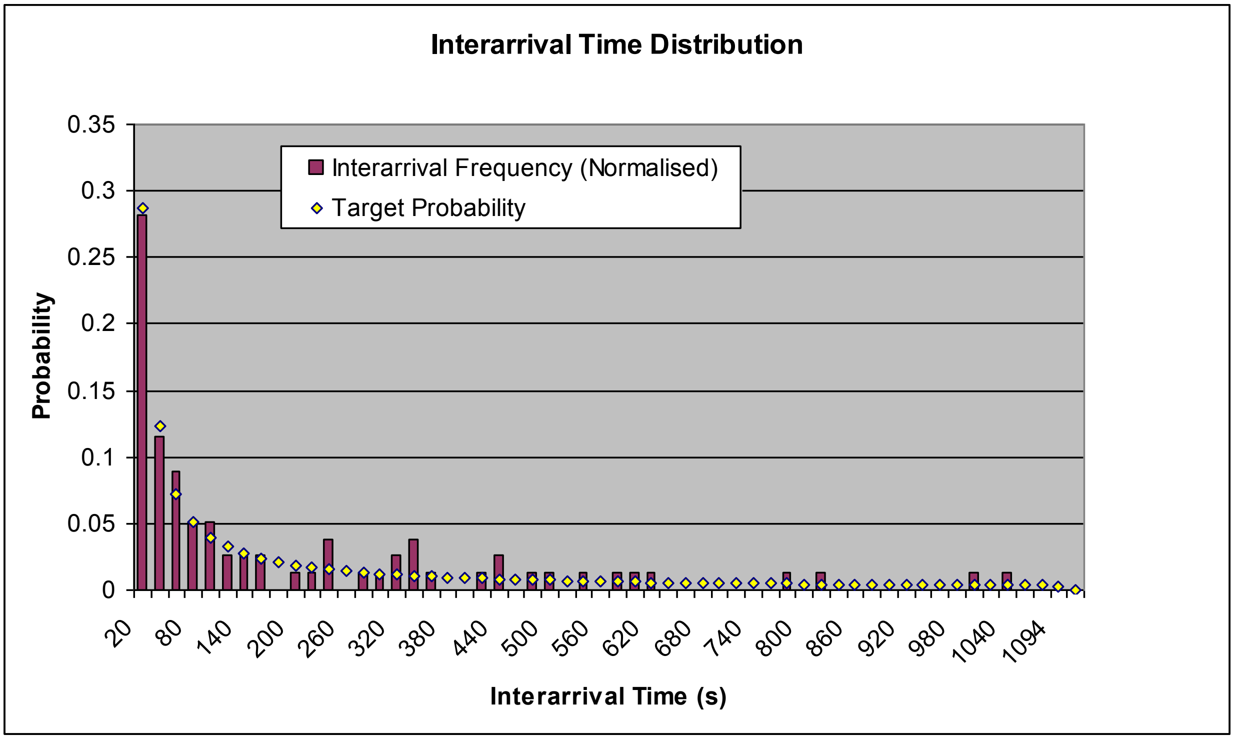

Figure 10: Interarrival Time Distribution

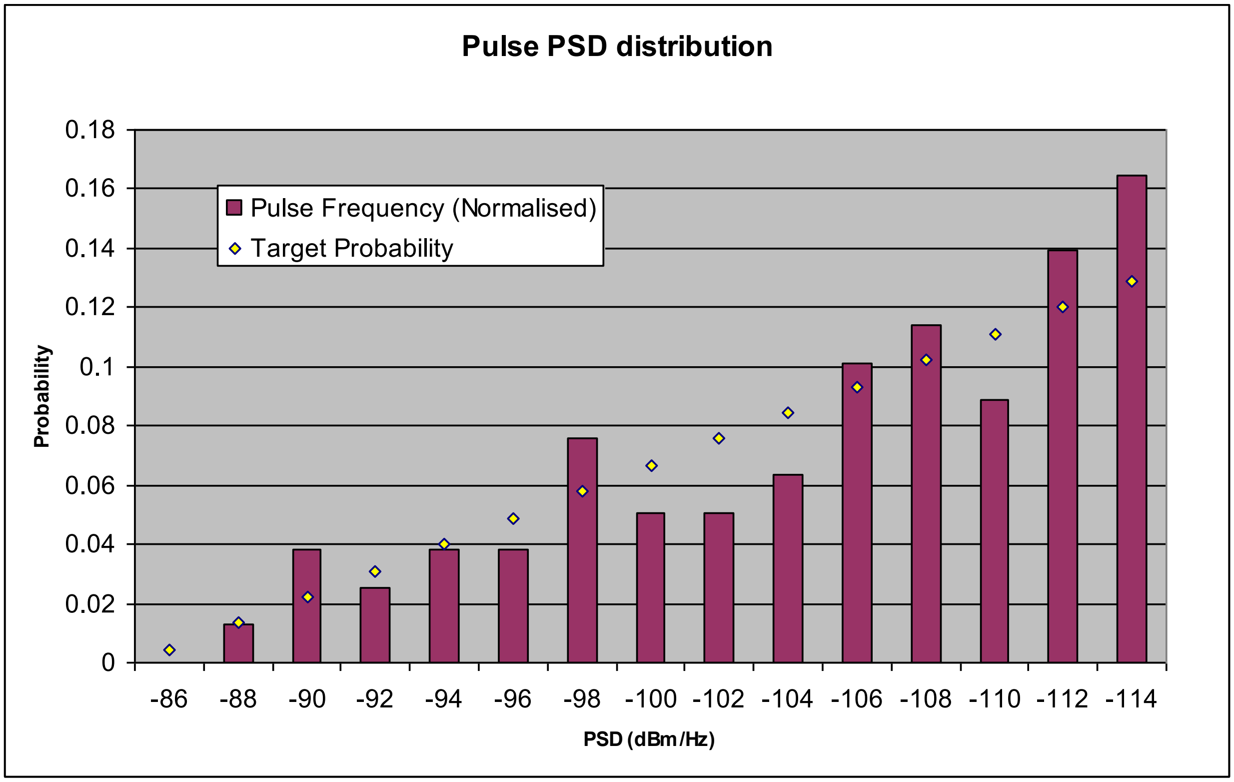

Figure 11: Pulse PSD Distribution

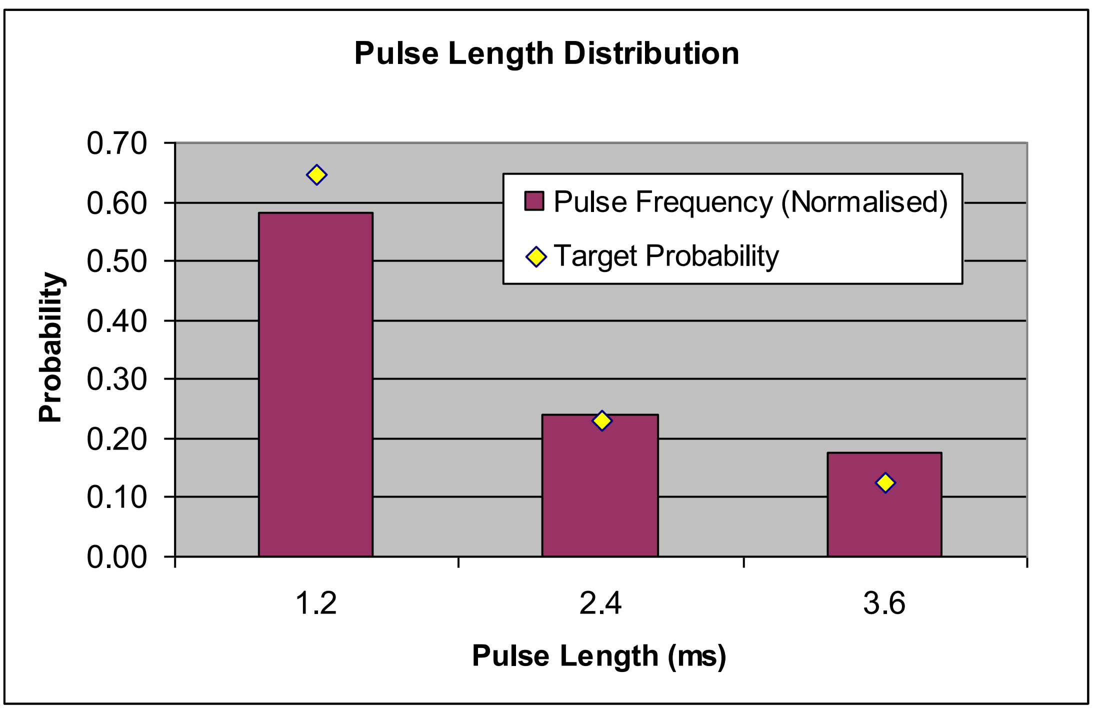

Figure 12: Pulse Length Distribution

Appendix VI. Definition of the Fluctuating Crosstalk Noise Power Test Sequence (19 Self Crosstalk disturbers)

Table 189: Fluctuating crosstalk test sequence

Time (s)	Relative Power (dB)	Time (s)	Relative Power (dB)
0	-67.80	7472	-6.91
72	-13.61	7643	-5.61
223	-8.80	7726	-4.72
409	-7.86	7906	-4.30
416	-4.76	7994	-3.82
451	-4.08	8184	-3.46
539	-3.73	8416	-3.11
816	-3.38	8500	-2.76
849	-3.08	8624	-2.50
1073	-2.67	8727	-2.14
1801	-2.32	8945	-1.91
2336	-2.02	9014	-1.66
2399	-1.77	9174	-1.41
2489	-1.38	9388	-1.11
2526	-1.15	9822	-0.64
2640	-0.95	9850	-0.37
2740	-0.74	10385	-0.16
3277	-0.48	10477	0.00
3299	-0.32	10974	-0.14
3507	0.00	11329	-0.31
3779	-0.17	11745	-0.61
3913	-0.33	12188	-0.78
4113	-0.50	12196	-1.26
4213	-0.78	12374	-1.47
4406	-1.12	12402	-1.93
4484	-1.34	12899	-2.17
4608	-1.55	13067	-2.56
4655	-1.76	13074	-2.91
4767	-2.25	13145	-3.32
4849	-2.56	13147	-3.88
5143	-2.82	13331	-6.23
5240	-3.62	13453	-7.06
5296	-4.08	13552	-7.87
5513	-4.47	13777	-9.40
5623	-5.07	13849	-11.26
6163	-5.86	13887	-14.13
6349	-10.53	14239	-67.80
6708	-13.14	14400	END
7072	-67.80		
7201	-7.67		

Appendix VII. Crosstalk impairment for Annex B performance tests (informative)

BA8b_0300m.xlsx file contains the crosstalk impairment for BA8b performance tests with 300m PE04 loop.

BA17a0_0450m.xlsx file contains the crosstalk impairment for BA17a0 performance tests with 450m PE04 loop.

BA17a0_0450m_PBO.xlsx file contains the crosstalk impairment for BA17a0_D&UPBO performance tests with 450m PE04 loop.

End of Broadband Forum Technical Report TR-114

