TECHNICAL REPORT

TR-114

VDSL2 Performance Test Plan

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Issue History

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Executive Summary

This Broadband Forum Technical Report, 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.

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.

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 points 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.

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

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 [1].

Table 1: TR-114 requirements terminology

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 adjective “RECOMMENDED”, means that there may 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 may exist valid reasons in particular circumstances when the particular behavior is acceptable or even useful, but the full implications should be understood and the case carefully weighed before implementing any behavior described with this label.
MAY	This word, or the adjective “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.

Table 2: TR-114 list of references

[1] RFC 2119	*Key words for use in RFCs to Indicate Requirement Levels*	IETF	1997
[2] G.993.2	*Very high speed subscriber line transceivers 2 (VDSL2)*	ITU-T	2006

[3] G.993.2 Amd 1	*Very high speed digital subscriber line transceivers 2 (VDSL2) Amdendment 1*	ITU-T	April, 2007
[4] G.997.1	*Physical Layer Management for Digital Subscriber Line (DSL) Transceivers.*	ITU-T	2009
[5] 0600417.2003	*Spectrum Management for Loop Transmission System*	ATIS	2003
[6] TS101271 v1.1.1	*Access Terminals Transmission and Multiplexing (TM); Access transmission system on metallic pairs; Very High Speed digital subscriber line system (VDSL2)*	ETSI	January, 2009
[7] TS101388 v1.3.1	*ADSL - European Specific Requirements*	ETSI	May, 2002
[8] TR-115	*VDSL2 Functionality Test Plan*	Broadband Forum	2009
[9] TS101952-2	*Specification of ADSL splitters for European deployment.*	ETSI	April, 2002

2.3 Definitions

The following terminology is used throughout this Technical Report.

Table 3: TR-114 definitions

net data rate	Sum of net data rates of all bearer channels
bit rate	term used interchangeably with net data rate
micro-interuption	Disconnection of the loop for a very short time period
null Loop	DSLAM/CPE wired “back to back”
showtime	DSLAM and CPE trained up to the point of passing data
fdelta	The maximum frequency separation between two consecutive samples of loop attenuation or noise power during calibration
sync rate	term used interchangeably with net data rate
SOS	VDSL2 function defined to avoid retrains by rapid reduction of bandwidth

2.4 Abbreviations

This Technical Report uses the following abbreviations:

Table 4: TR-114 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
AWG	American Wire Gauge
AWGN	Additive White Gaussian Noise
BER	Bit Error Rate
CPE	Customer Premises Equipment (modem)
dBm	decibels relative to milliwatts
DPBO	Downstream Power Backoff
DS	Downstream
DSLAM	Digital Subscriber Line Access Multiplexer
EDC	Erasure Decoding
EMI	Electromagnetic Interference
ES	Errored Second
ETSI	European Telecommunications Standards Institute
EU	Extended Upstream
EUT	Equipment Under Test
FEXT	Far-End Crosstalk
INP	Impulse Noise Protection
ISDN	Integrated Service Digital Network
ITU	International Telecommunications Union
L0	Link state zero (G.993.2 [2] §12.1.1)
L3	Link state three (G.993.2 [2] §12.1.1)
MAC	Media Access Control
MAE	Mean Absolute Error
MD	Medium Density
ME	Mean Error
MODEM	End user device or CPE. Concatenation of Modulator-Demodulator
NEXT	Near-End Crosstalk
OLR	On-line Reconfiguration
PE	Polyethylene
POTS	Plain Old Telephone Service
PSD	Power Spectral Density
RA	Rate Adpative
RFI	Radio Frequency Ingress
SES	Severely Errored Second
SRA	Seamless Rate Adaptation (G.993.2 [2], G.993.2 Amd 1 [3])
STP	Shielded Twisted Pair
SUT	System Under Test
UPBO	Upstream Power Backoff
US	Upstream
UTP	Unshielded Twisted Pair
VDSL2	Very high speed digital subscriber line transceivers 2 (G.993.2 [2])

3 Technical Report Impact

3.1 Energy Efficiency

TR-114 has no impact on Energy Efficiency.

3.2 IPv6

TR-114 has no impact on IPv6.

3.3 Security

TR-114 has no impact on Security.

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 5, Table 6, Table 7 and Table 8 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 5: 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	

Table 6: 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 tested	
VDSL2 optional features tested	
TPS-TC encapsulation tested (ATM, PTM)	

Table 7: CO Splitter Information

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

Table 8: 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 9 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 9: 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.

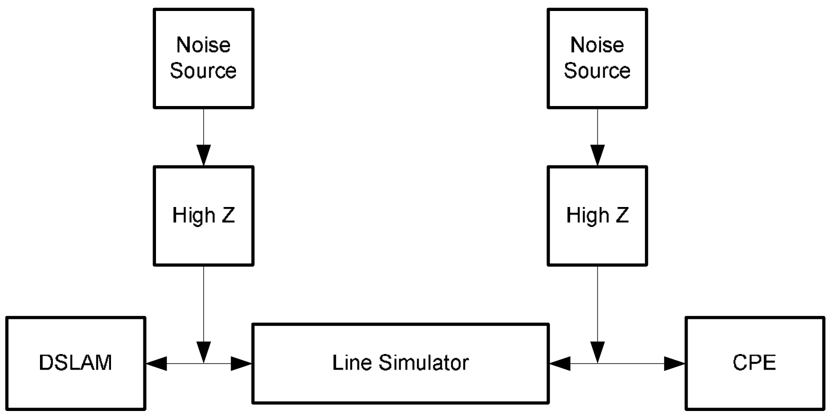

Figure 1: Test configuration for Annex A testing over POTS

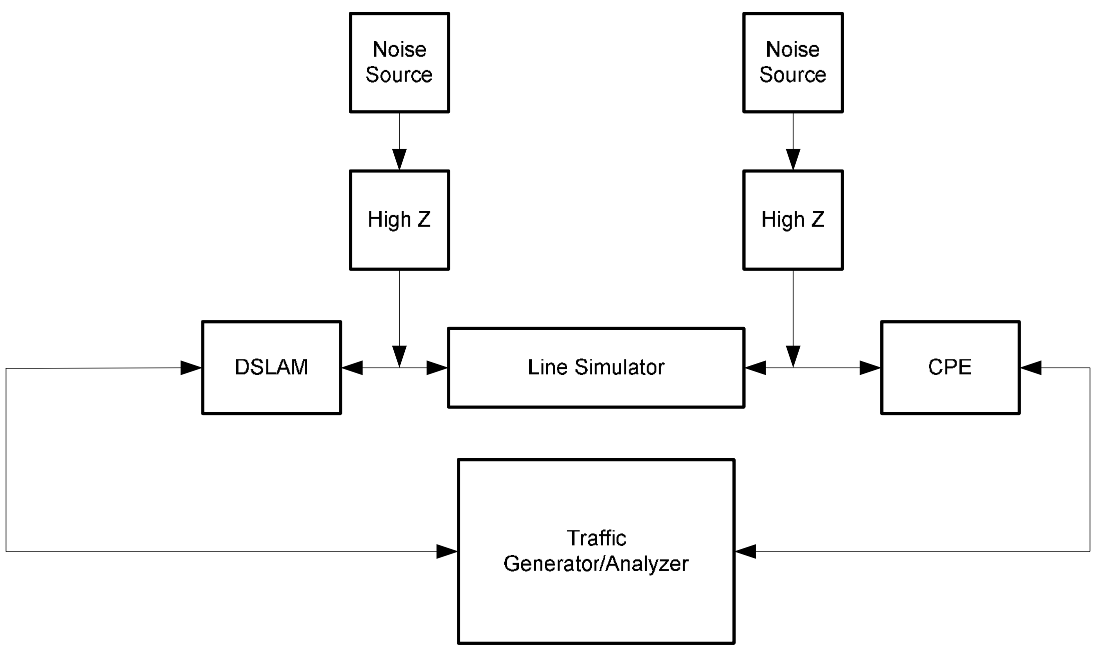

Figure 2: Test setup for configurations using data layer

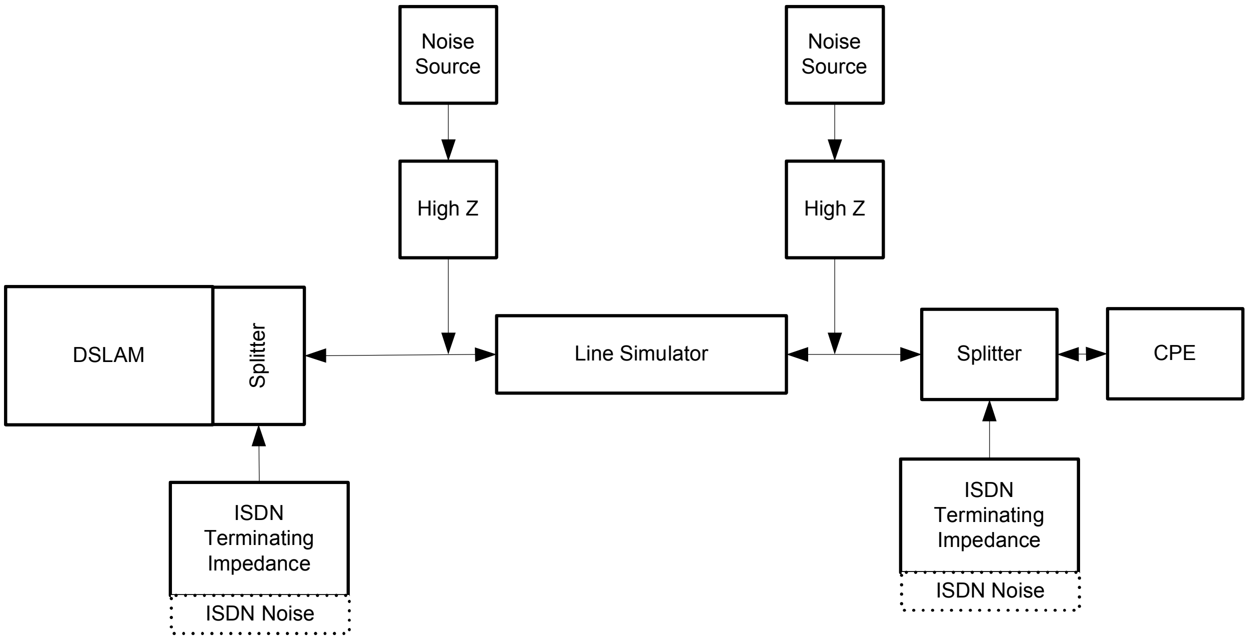

Figure 3: Test configuration for Annex B over ISDN and Annex C over TCM-ISDN testing

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 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 10.

Table 10: Common Band Profiles

Annex A				
VDSL2 band profile	AA8d			
Profile	8d			
Annex	A			
Limit PSD Mask	Table A.1/G.993.2			
US0 type	EU32 (see Table A.2/G.993.2)			
MAXNOMATPds	+14.5 dBm			
Annex B				
VDSL2 Band-profile	BA8b	BA8c	BA12a	BA17a
Profile	8b	8c	12a	17a
Annex	B	B	B	B

Limit PSD Mask (short name)	998-M2x-A (B8-4)	997-M1c-A-7	998-M2x-A (B8-4)	998E17-M2x-NUS0 (B8-8)
US0 type	A	A	A	N/A
MAXNOMATPds	+20.5 dBm	+11.5 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 Amd.1	Tables C-9 and C-10/ G.993.2 Amd.1	Tables C-9 and C-10/ G.993.2 Amd.1	Tables C-9 and C-10/ G.993.2 Amd.1
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 11.

Table 11: 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 & C
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 12.

Table 12: General line settings

General line-setting	Parameter	Setting	Description
F-1/0	$delay\_max_n$ ds	S1	Special value S1 as defined in G.997.1 section 7.3.2.2 indicating that S and D SHALL be selected such that S ≤ 1 and D=1
	$delay\_max_n$ us	S1	Special value S1 as defined in G.997.1 section 7.3.2.2 indicating that S and D 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 G.997.1 section 7.3.2.2 indicating a delay bound of 1 ms.
	$delay\_max_n$ us	S2	Special value S2 as defined in G.997.1 section 7.3.2.2 indicating a delay bound of 1 ms.
	INP_min_n ds	0 symbols	
	INP_min_n us	0 symbols	
I-32/16	$delay\_max_n$ ds	32 ms	
	$delay\_max_n$ us	32 ms	
	INP_min_n ds	16 symbols	
	INP_min_n us	16 symbols	

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 13 (Fast or Interleaved).

- The following two numbers are the upper limits of the downstream and upstream rates rounded and expressed in Mbps.

Table 13: Specific line settings

Specific line-setting	General line-setting	RA-Mode	DS net data rate (kbit/s) (max- min)	US net data rate (kbit/s) (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
FX_HI_010_004	I-32/16	Manual	10000-10000	4000-4000
FX_HI_006_003	I-32/16	Manual	6000-6000	3500-3500
FX_HI_011_003	I-32/16	Manual	11000-11000	3000-3000
FX_I_027_009	I-8/2	Manual	27000-27000	9000-9000
FX_I_024_008	I-8/2	Manual	24000-24000	8000-8000
FX_I_014_005	I-8/2	Manual	14000-14000	5000-5000
FX_I_010_003	I-8/2	Manual	10000-10000	3000-3000
FX_I_005_001	I-8/2	Manual	5000-5000	1000-1000

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 14 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 14: Concatenated common settings, testing combination description

Band-profile	Specific line-setting	Profile-line combination
AA8d	RA_ I_096_056	AA8d_RA_ I_096_056
BA12a	RA_I_150_150	BA12a_RA_I_150_150
BB17a	RA_F_150_150	BB17a_RA_F_150_150
BA8c_ D&UPBO	FX_HI_010_004	BA8c_ D&UPBO_FX_HI_010_004
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 10, 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 TS101952-2 [9].

6.3.1.2 Splitter Requirements for Annex C Testing

Splitter requirements for Annex C are as defined in G.993.2 Amd.1 Annex C §C.5 (Service Splitter). 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 15. The 26 AWG bridged tapped loops have the topology shown in Figure 4.

Table 15: 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

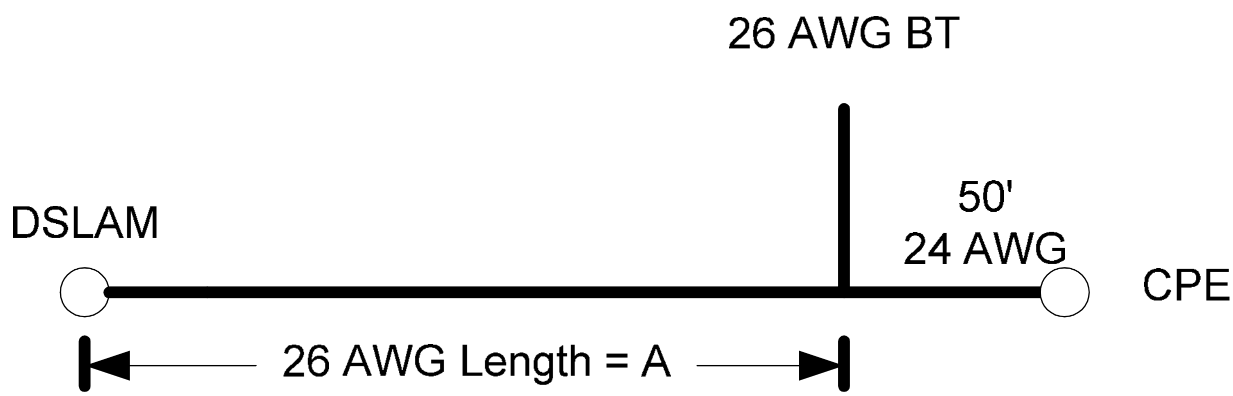

Figure 4: North American bridged tap topology

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 TS101271 [6] Annex ZA.3. Loop type PE04 shall be used for all Annex B band profiles (Table 10), except the BA8c, for which the loop TP100 shall apply.

6.3.2.2.1 Mixed Impedance Loop Models

For further study.

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 Amd.1 Annex C section C.6.1.

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 16. 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 [5] Annex A to produce the crosstalk noise for each loop length. Tables with the crosstalk noise are provided for information only in Appendix D, Table 149 and Table 150.

Table 16: VDSL2 transmit level for noise calculations

Loops ≤ 3600’		Loops ≤ 4000’		Loops > 3600’		Loops > 4000’	
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				

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 for profile 8c 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_BA12a	BA12a	MD_CAB27	15	See Annex D.2

n_BB12a	BB12a	MD_CAB27		
n_BA17a	BA17a	MD_CAB27		
n_BB17a	BB17a	MD_CAB27		

6.3.3.3 Noise Models for Annex C testing

The noise models for Annex C are defined in section C.4.2/G.993.2 Amendment 1. 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 (ref G.996.1 5.1.2.1) 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
- protocol traffic simulator/analyzer with matching network interfaces
- Ethernet switch/router
- PC with USB/Ethernet interface
- 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. The Ethernet switch/router and PC used for throughput testing SHALL have adequate performance such that they do not affect the measured throughput over the VDSL2 link. The Ethernet switch or simulator MAY be removed if traffic simulator/analyzer in use is capable of terminating the IP traffic directly from the DSLAM.

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 ATIS-0600417 [5] Section B.3.1 (for both straight loops and loops with bridge taps).
The RLCG cable parameters SHALL be as specified in ATIS-0600417 [5] 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".

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 ATIS-0600417 [5] Section B.3.1. The line constants for PE04 and TP100 cables are specified in Annex ZA.2 of TS101271 [6] table ZA.13.

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 G.993.2 Amd.1 Annex C sections C.6.1.2 and C.6.1.3.

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

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

Formula 7- 2: Calculating ME

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

[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 .
Ni 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
Nj 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 ATIS-0600417 [5] Section B.3.1 (for both straight loops and loops with bridge taps).
The RLCG cable parameters SHALL be as specified in ATIS-0600417 [5] 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"

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 ATIS-0600417 [5] Section B.3.1. The line constants for PE04 and TP100 cables are specified in Annex ZA.2 (normative) of TS101271 [6] table ZA.13. The line constants for TP150 cable are specified in Annex ZA.2 (normative) of TS101271 [6] table ZA.14.

7.1.1.3.3 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 same appropriate termination impedance in each case. For North American noises this is 100 Ohms, for European noises, this SHALL be according TS101388 [7], section 5.1.

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 G.993.2 Amd.1 Annex C sections C.6.1.2 and C.6.1.3.

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 ATIS-0600417 [9] Section B.3.1 (for both straight loops and loops with bridge taps). The RLCG cable parameters SHALL be as specified in ATIS-0600417 [5] 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".

7.1.1.4.2 European Region:
Phase SHALL be calculated from RLCG parameters using two-port ABCD modeling methodology as specified in ATIS-0600417 Section B.3.1. The line constants for PE04 and TP100 cables are specified in Annex ZA.2 of TS101271 [6] table ZA.13. The line constants for TP150 cable are specified in Annex ZA.2 of TS101271 [6] table ZA.14.

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

Formula 7- 5:Mean average percent error

$$\mathrm{MAPE(PD)} = 100 \cdot \frac{1}{N} \cdot \left[\sum_N \left(\left| \frac{PD_{cable} - PD_{sim}}{PD_{cable}} \right| \right) \right]$$

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

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

where:
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 |GDcable| 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

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

Where
phase is the unwrapped phase in radians
the difference in frequency between fi+1 and fi 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 zero-length loop. For North American cases, both VTUs are replaced by an 100 Ohm (±1%) resistor. For European cases the methodology in TS101271 [6] ZA.1.1.1 SHALL be used. 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

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

Formula 7- 9: Noise ME calculation

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

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 for, 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

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

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

$$\text{ULimit}_\text{i} = 10^{(0.802 - 1.24 \cdot a_i)} \qquad 4 \le a_i \le 4.68$$

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

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

$$= 0 \qquad a_i > 5$$

7.1.2.1.2 European Region:

Noise impairments used in this specification for Annex B (Europe) SHALL comply with the following specifications which are based on section ZA1.3.4.3 of TS101271 [6].

7.1.2.2 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. For all loops with bridged taps at modem side, the modem interconnect cable shall be included in the calculations. The modem cable used for these tests shall have an attenuation of 6ft 26 AWG.

For straight loops the length of this cable section is not important, as it is taken into account during the compensation procedure. 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.

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 VDSL. 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 7.1.2.3 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.

7.1.2.3 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 bitswap, 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.

8.1 Verification of CRC error reporting CPE

The purpose of this test described in Table 22 is to verify that the CPE (or optionally the DSLAM) correctly reports CRC errors. CRC error counts are the basis of margin verification tests.

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 regional annexes (A and B) 2. Test configuration (test loops, noise impairment) shall be according to regional annexes (A.1.5 and B.11). Annex B testing consists of two test conditions randomly selected from the 3 described in the table for any given profile-line combination.
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 2 minutes 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. 5. Repeat step 3 every 10 seconds, for a total test time of 120 seconds (i.e. a total of 12 micro-interruptions are issued).
Expected Result	1. For CPE test: If each micro-interruption does not result in at least one reported downstream CRC error, then the CPE has **failed** the CPE error-reporting test. 2. For DSLAM test: If each micro-interruption does not result in at least one reported upstream CRC error, then the DSLAM has **failed** the DSLAM error-reporting test.

8.2 Margin Verification Test

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

Table 23: 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 24: Test procedure for margin verification

Test Configuration	1. Configure the SUT according to the settings of the profile-line combination under test defined in regional annexes (A and B). 2. Test configuration (test loops, noise conditions) shall be according to regional annexes (A.1.6, B.12 and B.13). Annex B testing consists of two test conditions randomly selected from the 3 described in the table for any given profile-line combination.
Method of Procedure	1. Configure CPE and DSLAM according to the band-profile as indicated in the regional annexes. 2. 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. 3. Force a new initialization and wait for modems to sync. 4. Wait for 2 minutes for bit swaps to settle. 5. Check reported margin and document as initial_reported_margin. 6. For CPE margin verification tests increase the noise power level by 1 dB at CPE side only. 7. For DSLAM margin verification tests increase the noise power level by 1 dB at DSLAM side only. 8. Wait for 1 minute. 9. Repeat steps 6 and 7 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. 10. 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. 11. If the estimated BER > the limit value or the link re-initializes during steps 4-10 then the test for that loop option SHALL be repeated once.

	12. Repeat steps 2 to 10 for every test loop.
Expected Result	1. The SUT passes the margin verification test, if for every test loop: Estimated BER is less than the limit value in the margin verification table of that loop option 2. If the estimated BER > the limit value or the link re-initializes during the second attempt, the test fails. 3. No SES has been reported

An explanation of the regional margin verification tables (Table 89 − Table 94) is given below.

Column 1 of each table specifies the profile-line combination (e.g. BA8b_RA_F_150_150)

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

Column 3 specifies the crosstalk impairment (e.g. n_BA8b).

Column 4 specifies the anticipated data rate (kbps).

Column 5 It is required that the achieved DS(US) 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 data rate is close to the anticipated data rate. If the actual 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) 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 8 asks for the computation of the estimated BER from the number of observed CRC error events according toTable 23. If the estimated BER is smaller than the BER limit in this column, then the test PASSES, else it FAILS.

Column 9 asks for the insertion of "PASS" or "FAIL".

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 a G.997.1 parameter that:

- when set to ONE, indicates that the CPE receiver SHALL set the impulse noise protection according to the formula specified in G.993.2 section 9.6. 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 G.993.2 section 9.6. 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 25: 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 148. 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 2. Configure the loop simulator according to the band-profiles under test: • 8d profile 1.2 kft 26 AWG loop (Region A) • 17a and 12a profiles 450 m PE04 (Region B) • 8b profiles - 1200 m PE04 (Region B) • 8c profile - 600 m TP-100 loop (Region B) 3. Inject -120dBm/Hz noise at both ends of the loop 4. The REIN noise impairment consists of pulses at a level of -90 dBm/Hz with a repetition rate of 120 Hz (Region A) or 100 Hz (Region B). Each pulse SHALL be a burst of pseudo random AWGN. The REIN noise is injected at the CPE side. 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	Configure the SUT in the FORCEINP=1 mode. For each INP_min setting, do the following steps: 1. Inject the background noise at both sides (including DSLAM noise from the upstream adaptive rate test for the same loop length) 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 $\{-\delta + [(INP\_min -1)…(2 \times INP\_min -3)] \times T_s\}$ 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
Expected Test Result	For a CPE claiming support of Erasure Decoding, For each pulse width and each loop distance: 1. Reported number of downstream code violations ≤ 1 per minute 2. Actual INP ≥ INP_min and actual delay ≤ delay_max

Table 26: Short loop erasure decoding test 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					

Table 27: Long loop erasure decoding test 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 28: 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 148. 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 2. Configure the loop simulator according to the band-profiles under test: • 8d profile 1.2 kft 26 AWG loop (Region A) • 17a and 12a profiles 450 m PE04 (Region B) • 8b profiles - 1200 m PE04 (Region B) • 8c profile - 600 m TP-100 loop (Region B) 3. Inject -120dBm/Hz noise at both ends of the loop 4. The REIN noise impairment consists of pulses at a level of -90 dBm/Hz with a repetition rate of 120 Hz (Region A) or 100 Hz (Region B). Each pulse SHALL be a burst of pseudo random AWGN. The REIN noise is injected at the CPE side. 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	Configure the SUT in the FORCEINP=0 mode. For each INP_min setting, do the following steps: 1. Inject the background noise at both sides (including DSLAM noise from the upstream adaptive rate test for the same loop length) 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
Expected Test 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 29: 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 Verification of downstream fine gains

The downstream fine gain adjustment gi values SHALL be verified prior to collecting the performance measurements according to section 10.3.4.2 in G.993.2 [2]. The procedure and expected results are provided in Table 30.

Table 30: Verification of downstream gi settings (bits, gains & NOMATP values)

Test Configuration	1. As per VDSL2 band-profile to be tested, configure the SUT with one of the profile-line combinations associated to that band-profile (see section 6.2.3). If, for the specific band-profile, profile-line combinations are defined with DPBO and/or UPBO enabled, these SHALL be applied. 2. The DSLAM and CPE are connected in turn through TBD test loops.
Method of Procedure	1. Select randomly one test loop from the set 1. 2. Train the modem. 3. Repeat steps 1 and 2 for one randomly selected loop from set 2. 4. Repeat steps 1 and 2 for one randomly selected loop from set 3.
Expected Result to Pass	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 value of NOMATPds defined as follows: $\text{NOMATP} = 10\log_{10}\Delta f + 10\log_{10}\left(\sum_{i\in\text{MEDLEY set}}\left(10^{\frac{\text{MREFPSD}[i]}{10}} g_i^2\right)\right)$ SHALL NOT exceed the CO-MIB parameter MAXNOMATPds and SHALL NOT exceed the maximum power specified for the VDSL2 profile from G.993.2 table 6-1.

8.5 Mixed Loop Impedance Testing

for further study.

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 32 describes the test procedure for the PTM packet throughput test. Test setup is shown in Figure 2. PTM mode testing is specified for only two annex A, profile-line combinations Table 31 for the initial release of TR-114.

Table 31: Packet throughput test bitrates

Profile-line combination	DS bitrate (Mbps)	US bitrate (Mbps)	Loop Length (ft)
AA8d_ FX_I_040_006	40.4	5.7	600
AA8d_ FX_I_027_002	27.0	2.0	2400

16 individual tests – 16 tests SHALL be passed

Table 32: 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 equivalent length 0.4 mm cable, with 24-self noise injected at the VTU-x 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 DSLAM to the profile line configuration forcing maximum and minimum rates to those in Table 9-1. 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 VDSL2 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 VDSL2 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 PPS 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 33: Throughput Test Results: Connect Rates DS: 40.4 Mbps US: 5.7 Mbps.

Analyzer Recorded Ethernet FPS			Max 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 34: Throughput Test Results: Connect Rates DS: 27 Mbps US: 2 Mbps.

Analyzer Recorded Ethernet FPS			Max 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				

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

A.1 Annex A specific test setup information

With reference to section 6.2 Table 35 indicates which test configuration shall be applied for tests related to the specific profiles associated with Annex A.

Table 35: Annex A test configuration

Type of VDSL2 deployment	Band-profile	Test configuration
VDSL2oPOTS	AA8d	Refer to Figure 1 (configuration without splitters)

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 randomly-selected 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.

The impact on the rate requirements contained herein and ways to improve test conditions are under study. A future version of this document MAY address this issue.

Following loops SHALL be used (ATIS-0600417 [5] 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 [5] 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 Table 16 in section 6.3.3.1 and the loop transfer functions from ATIS-0600417 [5]

- NEXT SHALL be calculated using the "Simplified Next Equation" from ATIS-0600417 [5] section A.3.2.1.1. 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 ATIS-0600417 [5] section A.3.2.2 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 37
- 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 [5].

- NEXT SHALL be calculated using the "Simplified Next Equation" from ATIS-0600417 [5] section A.3.2.1.1 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 ATIS-0600417 [5] section A.3.2.2 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
- -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.

Common line settings for band profile AA8d.

Table 36: Upstream PBO settings for Annex A testing

Parameter	Setting	Description
UPBOKLF	1	CPE SHALL be forced to use the kl0 of the CO-MIB (UPBOKL) to compute the UPBO
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	
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

Table 37: 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 38: 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 39 outlines the pass/fail criteria on the reported noise margin.

Table 39: 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 net 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 5.8dB, 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 40 lists the number of test points per section corresponding to the 10% and 25% limits mentioned above.

Table 40: 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 41

Table 41: CRC reporting tests for RA_I_096_056

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

Table 42:CRC reporting tests for FX_I_027_002

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

A.1.6 Test cases for CPE Margin verification test

Test loops and noise impairment for CPE margin verification test defined in section 8.2 are listed inTable 43.

Table 43: 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	Achieved (test start) (test end)					
AA8d	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 + -140 dBm/Hz AWGN	≥ 4500		15				

Note: Maximum BER is 1.5×10^{-7}

Table 44 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	Achieved (test start) (test end)					
AA8d	2000	24 AA8d self + -140 dBm/Hz AWGN	≥ 27000		*5*				
	2400		≥ 27000		*5*				

Note: Maximum BER is 1.5×10^{-7}

Bi's and gi's SHALL be verified prior to collecting the performance measurements. The procedure and expected results are provided in Table 45.

Table 45: Verification of downstream gains bi/gi settings (bits, gains & NOMATP values)

Test Configuration	1. Configure the SUT in AA8d_RA_I_096_056 profile-line combination, with the UPBO settings from Table 36. 2. The DSLAM and CPE are connected in turn through 3 randomly selected test loops (one from each of the sets below): 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
Method of Procedure	Train the modem in the chosen testl oop and band-profile. Not sooner than two minutes after entering steady state operation (a.k.a. showtime), read from the DSLAM the bi and gi values**.**
Expected Result to Pass	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 value of NOMATPds defined as follow $\text{NOMATP} = 10\log_{10}\Delta f + 10\log_{10}\left(\sum_{i\in\text{MEDLEY set}}\left(10^{\frac{\text{MREFPSD}[i]}{10}} g_i^2\right)\right)$ SHALL NOT exceed the CO-MIB parameter MAXNOMATPds and SHALL NOT exceed the maximum power specified for the VDSL2 profile 8d.

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 46: Profile-line combination AA8d_RA_I_096_056

Loop Length (ft, 26 AWG loop)	AA8d_RA_I_096_056							
	Downstream				Upstream			
	Sync Rate (kbps)			Noise Margin, Reported (dB)	Sync 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 47: Profile-line combination AA8d_RA_I_096_056

Length of A (ft, 26 AWG loop)	Length of Tap (ft, 26 AWG loop)	**AA8d_RA_I_096_056**							
		Downstream				**Upstream**			
		Sync Rate (kbps)			**Noise Margin, Reported (dB)**	**Sync 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 files 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 48: Profile-line combination AA8d_FX_I_027_002

Loop Length (ft, 26 AWG loop)	AA8d_FX_I_027_002							
	Downstream				Upstream			
	Sync Rate (Mbps)			Pass/Fail	Sync 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 49: Profile-line combination AA8d_FX_I_014_001

Loop Length (ft, 26 AWG loop)	AA8d_FX_I_014_001							
	Downstream				Upstream			
	Sync Rate (Mbps)			Pass/Fail	Sync 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 test procedure is described in Table 50. Reported data rate and noise margin SHALL NOT be considered in the pass/fail criteria.

Formula A 1: Annex A REIN Impulse PSD

$$Noise_{REI}(f) = \begin{cases} -116\, dBm/Hz\; f < 2.2MHz \\ \max\left(-116 - 40\times\log_{10}\left(f / 2.2\times10^{6}\right), -150\right) dBm/Hz; f \geq 2.2MHz \end{cases}$$

$where: f$ is in Hz

Table 50: REIN testing for AA8d

Test Configuration	1. Configure the SUT in AA8d_RA_I_096_056 profile-line combination, with the UPBO settings from Table 36. 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 46) 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	For each INP_min setting, do the following steps: 1. Inject the crosstalk impairment and let the system train. 2. Wait for 3 minutes for bitswaps to settle. 3. Record the net data rate and reported noise margin. 4. Apply the REIN impairment for 2 minutes and record the number of ES. 5. Record the net data rate and reported noise margin.
Expected Test Result	For each loop distance: 1. Reported number of downstream code violations ≤ 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 51: Long term stability test procedure

Test Configuration	1. Configure the SUT for PTM transport in AA8d_FX_I_027_002 profile-line combination as defined in Table 10, with the UPBO settings from Table 36: The following parameters shall be indicated as follows: • TARSNMRds = 9 dB • MAXSNRMds = 18 dB • packet size: 1500 bytes 2. The loop simulator SHALL be configured to 2,000 feet, 26 AWG, no bridged tap. 3. 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 a rate 85% the full bit-rate of the channel. 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 lose synchronization at any time during the test. 2. If during any 4 hour sliding window there are fewer than 3 ES 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 52: Fluctuating noise test

Test Configuration	1. Configure the SUT for PTM transport in AA8d_FX_I_027_002 profile-line combination as defined in Table 10, with the UPBO settings from Table 36. 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 2 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 a rate 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.

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

B.1 Annex B-specific Test Setup Information

With reference to section “6.2.1 Band Profiles” Table 53 indicates which test configurations SHALL be applied for tests related to specific band-profiles associated to VDSL2oPOTS or VDSL2oISDN deployments:

Table 53: Annex B test configurations

Type of VDSL2 deployment	Band-profile	Test configuration
VDSL2 over POTS (VDSL2oPOTS)	BA8b	Refer to Figure 1 (configuration without splitters)
	BA8c_D&UPBO	
	BA12a	
	BA17a	
	BA17a D&UPBO	
VDSL2 over ISDN (VDSL2oISDN)	BB8b	Refer to Figure 3 (configuration with splitters)
	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 net 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 54 outlines the pass/fail criteria on the reported noise margin.

Table 54: 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 55 lists the number of test points per section or table corresponding to the 10% limit mentioned above.

Table 55: Pass/fail criteria for rate adaptive testing

Section number	Number of test cases	10% limit
B.2.	20	2
B.3.	16	2
B.5	20	2
B.6	16	2
B.7	16	2
B.9	16	2
B.10	20	2
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 TS101271 [6] and includes the crosstalk noise and the white noise (NEXT noise generator G1, FEXT noise generator G2 and the white noise generator G4).

The noise injection SHALL be calibrated as defined in TS101271 [6].

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 TS101388 [11], 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 TS101388 [11], Annex F. In this case the ISDN port of the splitter SHALL be used for injecting the line sharing noise.

B.1.2.1 Settings for Noise Generator G1, G2 and G4

The settings for noise generators G1, G2 and G4 SHALL be as follows.
The crosstalk coupling functions NEXT and FEXT SHALL be calculated using the transfer function equations from TS101271 [10], section ZA.1.3.3.
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 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), coherently with ITU-T G.993.2.

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 TS101271[10], section 9.3.3.
At CO 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 56 and describe the self-crosstalk portion of an equivalent disturber co-located at the LT and NT end of the loop.

Table 56: Power calculation of the XS profiles LT and NT

	MD_EX	MD_CAB27	19self_BA8c
XS.LT.n_XYZ	$P_{SingleSelf-XYZ,LT}$ + 6.68dB	$P_{SingleSelf-XYZ,LT}$ + 7.06dB	$P_{SingleSelf-XYZ,LT}$ + 7.67dB
XS.NT.n_XYZ	$P_{SingleSelf-XYZ,NT}$ + 6.68dB	$P_{SingleSelf-XYZ,NT}$ + 7.06dB	$P_{SingleSelf-XYZ,NT}$ + 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 $P_{SingleSelf-XYZ,SS}$ 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 PSingleSelf-XYZ,SS. The basic PSD template corresponds to the associated VDSL2 Band-profile XYZ as per ITU-T G.993.2/Amd.1, sections B.2.4 and B.2.5 and is defined in accordance with the ITU-T G.993.2/Amd.1, section B.4. This is considered constant regardless of the loop length corresponding to the specific test point. The single self-disturber PSD PSingleSelf-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 down such that the power in all bands under the resulting template (all-bands) is less or equal, within a 0.1 dBm difference, to the MAXNOMATP of the associated VDSL2 Band-profile XYZ (as per Table 6-1/G.993.2), both for upstream and downstream. The calculated flattened PSD template corresponds to the $P_{SingleSelf-XYZ,SS}$

B.2 Rate adaptive performance tests for BA8b

Noise n_BA8b settings as defined in section 6.3.3.2

Data rate criterion: 20 individual tests – 18 tests SHALL be passed

Table 57: Performance tests with BA8b_RA_F_150_150

Loop Length (m, PE0.4mm loop)	BA8b_RA_F_150_150							
	Downstream				Upstream			
	Sync Rate (kbps)			Noise Margin, Reported (dB)	Sync Rate (kbps)			Noise Margin, Reported (dB)
	Expected	Measured	Pass/Fail		Expected	Measured	Pass/Fail	
150	44192				9488			
300	40712				8292			
750	27076				5760			
1200	17328				328			
1800	8380				148			

Table 58: Performance tests with BA8b_RA_I_150_150.

Loop Length (m, PE0.4mm loop)	BA8b_RA_I_150_150							
	Downstream				Upstream			
	Sync Rate (kbps)			Noise Margin, Reported (dB)	Sync 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.3 Rate adaptive performance tests for BA12a

Noise n_BA12a settings as defined in section 6.3.3.2.

Data rate criterion:16 individual tests – 14 tests SHALL be passed

Table 59: Performance tests with BA12a_RA_F_150_150

Loop Length (m, PE0.4mm loop)	BA12a_RA_F_150_150							
	Downstream				Upstream			
	Sync Rate (kbps)			Noise Margin, Reported (dB)	Sync Rate (kbps)			Noise Margin, Reported (dB)
	Expected	Measured	Pass/Fail		Expected	Measured	Pass/Fail	
150	44728				23056			
450	34332				15684			
1050	20172				2184			
1500	13096				640			

Table 60: Performance tests with BA12a_RA_I_150_150

Loop Length (m, PE0.4mm loop)	BA12a_RA_I_150_150							
	Downstream				Upstream			
	Sync Rate (kbps)			Noise Margin, Reported (dB)	Sync Rate (kbps)			Noise Margin, Reported (dB)
	Expected	Measured	Pass/Fail		Expected	Measured	Pass/Fail	
150	42696				21112			
450	33896				15188			
1050	19956				2216			
1500	12584				632			

B.4 Rate adaptive performance tests for BA17a

Noise n_BA17a settings as defined in section 6.3.3.2.

Data rate criterion: 6 individual tests – 5 tests SHALL be passed

Table 61: Performance tests with BA17a_RA_F_150_150

Loop Length (m, PE0.4mm loop)	BA17a_RA_F_150_150							
	Downstream				Upstream			
	Sync Rate (kbps)			Noise Margin, Reported (dB)	Sync Rate (kbps)			Noise Margin, Reported (dB)
	Expected	Measured	Pass/Fail		Expected	Measured	Pass/Fail	
150	54892				28728			
450	38712				19536			
900	23960				3560			

Data rate criterion: 6 individual tests – 5 tests SHALL be passed

Table 62: Performance tests with BA17a_RA_I_150_150

Loop Length (m, PE0.4mm loop)	BA17a_RA_I_150_150							
	Downstream				Upstream			
	Sync Rate (kbps)			Noise Margin, Reported (dB)	Sync Rate (kbps)			Noise Margin, Reported (dB)
	Expected	Measured	Pass/Fail		Expected	Measured	Pass/Fail	
150	53256				26724			
450	39144				19020			
900	23360				3688			

B.5 Rate adaptive performance tests for BB8b

Noise n_BB8b settings as defined in section 6.3.3.2

Data rate criterion: 20 individual tests – 18 tests SHALL be passed

Table 63: Performance tests with BB8b_RA_F_150_150

Loop Length (m, PE0.4mm loop)	BB8b_RA_F_150_150							
	Downstream				Upstream			
	Sync Rate (kbps)			Noise Margin, Reported (dB)	Sync 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 64: Performance tests with BB8b_RA_I_150_150

Loop Length (m, PE0.4mm loop)	BB8b_RA_I_150_150							
	Downstream				Upstream			
	Sync Rate (kbps)			Noise Margin, Reported (dB)	Sync 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.

Data rate criterion: 16 individual tests – 14 tests SHALL be passed

Table 65: Performance tests with BB12a_RA_F_150_150

Loop Length (m, PE0.4mm loop)	BB12a_RA_F_150_150							
	Downstream				Upstream			
	Sync Rate (kbps)			Noise Margin, Reported (dB)	Sync 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 66: Performance tests with BB12a_RA_I_150_150

Loop Length (m, PE0.4mm loop)	BB12a_RA_I_150_150							
	Downstream				Upstream			
	Sync Rate (kbps)			Noise Margin, Reported (dB)	Sync 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.

Data rate criterion: 16 individual tests – 14 tests SHALL be passed

Table 67: Performance tests with BB17a_RA_F_150_150

Loop Length (m, PE0.4mm loop)	BB17a_RA_F_150_150							
	Downstream				Upstream			
	Sync Rate (kbps)			Noise Margin, Reported (dB)	Sync 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 68: Performance tests with BB17a_RA_I_150_150

Loop Length (m, PE0.4mm loop)	BB17a_RA_I_150_150							
	Downstream				Upstream			
	Sync Rate (kbps)			Noise Margin, Reported (dB)	Sync 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 BA17a with DPBO and UPBO

The basic BA17a Band Profile SHALL be applied with the following modifications to the “Common Line Settings” specified in Table 11 to define the new shaped-PSD Band Profile BA17a_D&UPBO:

Table 69: Common Line Settings for BA17a_D&UPBO Band Profile

Parameter	Setting	Description
All parameters but those specified below	Value as specified in Table 11	

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 PE 0.4mm 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 70: Profile-line combinations for BA17a_D&UPBO

Profile-line combination	Band-profile	Specific line-setting
BA17a_D&UPBO_RA_F_150_150	BA17a_D&UPBO	RA_F_150_150
BA17a_D&UPBO_RA_I_150_150	BA17a_D&UPBO	RA_I_150_150

The noise model n_BA17a_D&UPBO defined in the following SHALL be used, which is coherent with the noise models framework specified in section 6.3.3.2:

Table 71: Noise model n_BA17a_D&UPBO

Noise model	Associated band-profile	Self noise disturbers	Alien noise disturbers
n_BA17a_D&UPBO	BA17a_D&UPBO	MD_Cab27	ETSI MD_Cab27 Table 141 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 69 above using as klo values for calculation of the single self-disturber PSD are listed in Table 72.

Table 72: kl_0 for calculation of the single self-disturber PSD for BA17a_D&UPBO

Loop Length (m, PE0.4mm loop)	kl_0 (UPBOKL) (dB @ 1MHz)
150	3.7
450	11.1
900	22.3

Data rate criterion: 6 individual tests – 5 tests SHALL be passed

Table 73: Performance tests with BA17a_D&UPBO_RA_F_150_150

Loop Length (m, PE0.4mm loop)	BA17a_D&UPBO_RA_F_150_150							
	Downstream				Upstream			
	Sync Rate (kbps)			Noise Margin, Reported (dB)	Sync Rate (kbps)			Noise Margin, Reported (dB)
	Expected	Measured	Pass/Fail		Expected	Measured	Pass/Fail	
150	51336				19596			
450	37744				16172			
900	19700				3968			

Data rate criterion: 6 individual tests – 5 tests SHALL be passed

Table 74: Performance tests with BA17a_D&UPBO_RA_I_150_150

Loop Length (m, PE0.4mm loop)	BA17a_D&UPBO_RA_I_150_150							
	Downstream				Upstream			
	Sync Rate (kbps)			Noise Margin, Reported (dB)	Sync Rate (kbps)			Noise Margin, Reported (dB)
	Expected	Measured	Pass/Fail		Expected	Measured	Pass/Fail	
150	51728				20080			
450	37924				15748			
900	18828				4184			

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 11 to define the new shaped-PSD Band Profile BB17a_D&UPBO:

Table 75: Common Line Settings for BB17a_D&UPBO Band Profile

Parameter	Setting	Description
All parameters but those specified below	Value as specified in Table 11	
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 PE 0.4mm 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 76: 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 the following SHALL be used, which is coherent with the noise models framework specified in section 6.3.3.2:

Table 77: 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 141Annex D.2

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 75above using as klo values for calculation of the single self-disturber PSD are listed in Table 78..

Table 78: kl_0 for calculation of the single self-disturber PSD for BB17a_D&UPBO

Loop Length (m, PE0.4mm loop)	kl_0 (UPBOKL) (dB)
150	3.7
450	11.1
1050	26.0
1500	37.1

Data rate criterion: 16 individual tests – 14 tests SHALL be passed

Table 79: Performance tests with BB17a_D&UPBO_RA_F_150_150

Loop Length (m, PE0.4mm loop)	BB17a_D&UPBO_RA_F_150_150							
	Downstream				Upstream			
	Sync Rate (kbps)			Noise Margin, Reported (dB)	Sync 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 80: Performance tests with BB17a_D&UPBO_RA_I_150_150

Loop Length (m, PE0.4mm loop)	BB17a_D&UPBO_RA_I_150_150							
	Downstream				Upstream			
	Sync Rate (kbps)			Noise Margin, Reported (dB)	Sync 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 Rate adaptive performance tests for BA8c with DPBO and UPBO

The basic BA8c Band Profile SHALL be applied with the following modifications to the "Common Line Settings" specified in Table 11 to define the new shaped-PSD Band Profile BA8c_D&UPBO:

Table 81: Common Line Settings for BA8c_D&UPBO Band Profile

Parameter	Setting	Description
All parameters but those specified below	Value as specified in Table 11	
DPBOEPSD	ADSL2plus Annex A	PSD mask that is assumed to be permitted at the exchange
DPBOESEL	27dB@1MHz	E-side electrical length
DPBOESCMA	0.4218	Model of the frequency dependent loss of E-side cable: scalars DPBOESCMA (f^0) - G.997.1 form = 364
DPBOESCMB	0.8136	Model of the frequency dependent loss of E-side cable: scalars DPBOESCMB (f^0.5) - G.997.1 form = 464
DPBOESCMC	0.4417	Model of the frequency dependent loss of E-side cable: scalars DPBOESCMC (f) - G.997.1 form = 369
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	17	B value US band 1
NOTE: the values of DPBOESCMA, B and C are referred to a PE 0.4mm loop @ 300kHz. 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 EUT:

Table 82: BA8c D&UPBO testing descriptions

Profile-line combination	Band-profile	Specific line-setting
BA8c_D&UPBO_RA_I_150_150	BA8c_D&UPBO	RA_I_150_150
BA8c_D&UPBO_RA_F_150_150	BA8c_D&UPBO	RA_F_150_150

The noise model n_BA8c_D&UPBO defined in the following table SHALL be used:

Table 83: Noise model n_BA8c_D&UPBO

Noise model	Associated band-profile	Self noise disturbers	Alien noise disturbers
n_BA8c_D&UPBO	BA8c_D&UPBO	19self_BA8c	none

In the table above the 19 self BA8c 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 84 as kl_0 values for calculation of the single self-disturber PSD are listed in Table 81. The UPBOKLE shall be reported.

Table 84: kl_0 for calculation of the single self-disturber PSD for BA8c_D&UPBO

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

Data rate criterion: 20 individual tests – 18 tests SHALL be passed

Table 85: Performance tests with BA8c_D&UPBO_RA_F_150_150

Loop Length (m, TP-100 loop)	BA8c_D&UPBO_RA_F_150_150								
	Downstream				Upstream				Reported UPBOKLE
	Sync Rate (kbps)			Noise Margin, Reported (dB)	Sync Rate (kbps)			Noise Margin, Reported (dB)	
	Expected	Measured	Pass/Fail		Expected	Measured	Pass/Fail		
150	25450				8850				
450	22800				8800				
1050	15700				4700				
1200	12950				3750				
1500	10050				750				

Table 86: Performance tests with BA8c_D&UPBO_RA_I_150_150

Loop Length (m, TP-100 loop)	BA8c_D&UPBO_RA_F_150_150								
	Downstream				Upstream				Reported UPBOKLE
	Sync Rate (kbps)			Noise Margin, Reported (dB)	Sync Rate (kbps)			Noise Margin, Reported (dB)	
	Expected	Measured	Pass/Fail		Expected	Measured	Pass/Fail		
150	23600				8200				
450	21100				8250				
1050	14650				4700				
1200	12400				3750				
1500	9150				700				

B.11 VDSL2oPOTS and VDSL2oISDN 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. 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 are listed in Table 87 and Table 88.

Table 87: VDSL2oPOTS test cases for CRC error reporting verification test

Profile-line combination	Loop length and type		Noise impairment	SES Count	CRC Count	Pass/Fail
BA8b_RA_F_150_150	150 m	0.4mm PE	n_BA8b			
	750 m					
	1800 m					
BA8b_RA_I_150_150	150 m	0.4mm PE	n_BA8b			
	750 m					
	1800 m					
BA8c_D&UPBO_RA_F_150_150	150 m	TP-100	n_BA8c_D&UPBO			
	1050 m					
	1500 m					
BA8c_D&UPBO_RA_I_150_150	150 m	TP-100	n_BA8c_D&UPBO			
	1050 m					
	1500 m					
BA12a_RA_F_150_150	150 m	0.4mm PE	n_BA12a			
	1050 m					
	1500 m					
BA12a_RA_I_150_150	150 m	0.4mm PE	n_BA12a			
	1050 m					
	1500 m					
BA17a_RA_F_150_150	150 m	0.4mm PE	n_BA17a			
	450 m					
	900 m					
BA17a_RA_I_150_150	150 m	0.4mm PE	n_BA17a			
	450 m					
	900 m					
BA17a_D&UPBO_RA_F_150_150	150 m	0.4mm PE	n_BA17a_D&UPBO			
	450 m					
	900 m					
BA17a_D&UPBO_RA_I_150_150	150 m	0.4mm PE	n_BA17a_D&UPBO			
	450 m					
	900 m					

Table 88: VDSL2oISDN test cases for CRC error reporting verification test

Profile-line combination	Loop length and type		Noise impairment	SES Count	CRC Count	Pass/Fail
BB8b_RA_F_150_150	150 m	0.4mm PE	n_BB8b			
	750 m					
	1800 m					
BB8b_RA_I_150_150	150 m	0.4mm PE	n_BB8b			
	750 m					
	1800 m					
BB12a_RA_F_150_150	150 m	0.4mm PE	n_BB12a			
	1050 m					
	1500 m					
BB12a_RA_I_150_150	150 m	0.4mm PE	n_BB12a			
	1050 m					

	1500 m					
BB17a_RA_F_150_150	150 m	0.4mm PE	n_BB17a			
	1050 m					
	1500 m					
BB17a_RA_I_150_150	150 m	0.4mm PE	n_BB17a			
	1050 m					
	1500 m					
BB17a_D&UPBO_RA_F_150_150	150 m	0.4mm PE	n_BB17a_D&UPBO			
	1050 m					
	1500 m					
BB17a_D&UPBO_RA_I_150_150	150 m	0.4mm PE	n_BB17a_D&UPBO			
	1050 m					
	1500 m					

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

Downstream margin verification testing for Region B SHALL be performed in rate adaptive mode according to section 8.2 and Table 89, Table 90 and Table 91. Testing consists of two test conditions randomly selected from the 3 described in the tables for any given profile-line combination.

Table 89: **Downstream Margin verification for VDSL2oPOTS (0.4mm PE)**

Profile-line combination	Length (m)	Crosstalk	DS net data rate (kbps)		Test Time (minutes)	SES Count	CRC Count	Estimated BER	Pass/Fail
			Anticipated	Achieved (test start) (test end)					
BA8b_RA_F_150_150	300	n_BA8b	≥ 40712		5				
	1200		≥ 17880		5				
	1800		≥ 8380		5				
BA8b_RA_I_150_150	300	n_BA8b	≥ 37928		5				
	1200		≥ 16828		5				
	1800		≥ 7792		10				
BA12a_RA_F_150_150	150	n_BA12a	≥ 44728		5				
	1050		≥ 20172		5				
	1500		≥ 13552		5				
BA12a_RA_I_150_150	150	n_BA12a	≥ 42696		5				
	1050		≥ 19956		5				
	1500		≥ 12584		10				
BA17a_RA_F_150_150	150	n_BA17a	≥ 54892		5				
	450		≥ 38712		5				
	900		≥ 23960		5				

BA17a_RA_I_150_150	150	n_BA17a	≥ 53256		5				
	450		≥ 39144		5				
	900		≥ 23360		5				
BA17a_D&UPBO_RA_F_150_150	150	n_BA17a_D&UPBO	≥ 51336		5				
	450		≥ 39348		5				
	900		≥ 19700		5				
BA17a_D&UPBO_RA_I_150_150	150	n_BA17a_D&UPBO	≥ 51728		5				
	450		≥ 37924		5				
	900		≥ 18828		5				

Table 90: Downstream margin verification for VDSL2oPOTS (TP-100)

Profile-line combination	Length (m)	Crosstalk	DS net data rate (kbps)		Test Time (minutes)	SES Count	CRC Count	Estimated BER	Pass/Fail
			Anticipated	Achieved (test start) (test end)					
BA8c_D&UPBO_RA_F_150_150	150	n_BA8c	≥ 25450		5				
	1050		≥ 15700		5				
	1500		≥ 10050		5				
BA8c_D&UPBO _RA_I_150_150	150	n_BA8c	≥ 23600		5				
	1050		≥ 14650		5				
	1500		≥ 9150		10				

Table 91: Downstream margin verification (0.4mm PE)

Profile-line combination	Length (m)	Crosstalk	DS net data rate (kbps)		Test Time (minutes)	SES Count	CRC Count	Estimated BER	Pass/Fail
			Anticipated	Achieved (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&UPBO_RA_F_150_150	150	n_BB17a_D&UPBO	≥ 54716		5				
	1050		≥ 11304		5				
	1500		≥ 2648		10				
BB17a_D&UPBO_RA_I_150_150	150	n_BB17a_D&UPBO	≥ 53036		5				
	1050		≥ 10920		10				
	1500		≥ 2952		25				

B.13 VDSL2oPOTS and VDSL2oISDN test cases for upstream margin verification test (optional)

Upstream margin verification testing for Region B SHALL be performed in rate adaptive mode according to section 8.2 with parameters provided in Table 92, Table 93 and Table 94. Testing consists of two test conditions randomly selected from the 3 described in the tables for any given profile-line combination.

Note: The upstream rate reach performance numbers assume that margin verification can be passed.

Table 92: Upstream margin verification for VDSL2oPOTS (0.4mm PE)

Profile-line combination	Length (m)	Crosstalk	US net data rate (kbps)		Test Time (minutes)	SES Count	CRC Count	Estimated BER	Pass/Fail
			Anticipated	Achieved (test start) (test end)					
BA8b_RA_F_150_150	300	n_BA8b	≥ 8292		5				
	750		≥ 5760		5				
	1200		≥ 328		40 (note 3)				
BA8b_RA_I_150_150	300	n_BA8b	≥ 7888		10				
	750		≥ 5792		15				
	1200		≥ 368		55 (note 2)				
BA12a_RA_F_150_150	150	n_BA12a	≥ 23056		5				
	1050		≥ 2412		15				
	1500		≥ 640		40				

BA12a_RA_I_150_150	150	n_BA12a	≥ 21112		5				
	1050		≥ 2216		35				
	1500		≥ 632		55 (note 3)				
BA17a_RA_F_150_150	150	n_BA17a	≥ 28728		5				
	450		≥ 19536		5				
	900		≥ 3560		10				
BA17a_RA_I_150_150	150	n_BA17a	≥ 26724		5				
	450		≥ 19020		5				
	900		≥ 3688		20				
BA17a_D&UPBO_RA_F_150_150	150	n_BA17a_D&UPBO	≥ 19596		5				
	450		≥ 16172		5				
	900		≥ 3968		10				
BA17a_D&UPBO_RA_I_150_150	150	n_BA17a_D&UPBO	≥ 20080		5				
	450		≥ 15748		5				
	900		≥ 4184		20				

Note 2: 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.

Note 3: Due to the low data rates under this loop and noise condition, the observation of 10 error events takes a very long time 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.

Table 93: Upstream Margin verification for VDSL2oPOTS (TP-100)

Profile-line combination	Length (m)	Crosstalk	US net data rate (kbps)		Test Time (minutes)	SES Count	CRC Count	Estimated BER	Pass/Fail
			Anticipated	Achieved (test start) (test end)					
BA8c_D&UPBO_RA_F_150_150	150	n_BA8c	≥ 8850		5				
	1050		≥ 4700		10				
	1500		≥ 750		35				
BA8c_D&UPBO_RA_I_150_150	150	n_BA8c	≥ 8200		10				
	1050		≥ 4700		15				
	1500		≥ 700		50 (note 4)				

Note 4: 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.

Table 94: Upstream Margin Verification for VDSL2oISDN(0.4mm PE)

Profile-line combination	Length (m)	Crosstalk	US net data rate (kbps)		Test Time (minutes)	SES Count	CRC Count	Estimated BER	Pass/Fail
			Anticipated	Achieved (test start) (test end)					
BB8b_RA_F_150_150	300	n_BB8b	≥ 8832		5				
	750		≥ 6208		5				
	1200		≥ 616		45				
BB8b_RA_I_150_150	300	n_BB8b	≥ 8284		10				
	750		≥ 6128		15				
	1200		≥ 600		60 (note 5)				
BB12a_RA_F_150_150	450	n_BB12a	≥ 15804		5				
	1050		≥ 2320		15				
	1500		≥ 652		40				
BB12a_RA_I_150_150	450	n_BB12a	≥ 15316		5				
	1050		≥ 2600		30				
	1500		≥ 680		50 (note 5)				
BB17a_RA_F_150_150	450	n_BB17a	≥ 14644		5				
	1050		≥ 2264		15				
	1500		≥ 648		40				
BB17a_RA_I_150_150	450	n_BB17a	≥ 14228		5				
	1050		≥ 2536		30				
	1500		≥ 684		50 (note 5)				
BB17a_D&UPBO_RA_F_150_150	150	n_BB17a_D&UPBO	≥ 16668		5				
	1050		≥ 2800		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 5)				

Note 5: 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.14 REIN Testing for BA8c

B.14.1 Common Line Setting Variations

The test set-up is to be configured according to Section 6.1 as appropriate for the modems under test. The test loops SHALL have straight homogeneous loop topology and with TP100 cable characteristics.

Table 95: Common Line Settings for BA8c_D&UPBO Band Profile REIN Testing

Parameter	Setting	Description
All parameters but those specified below	Value as specified in Table 11	
DPBOEPSD	ADSL2plus Annex A	PSD mask that is assumed to be permitted at the exchange
DPBOESEL	27dB@1MHz	E-side electrical length
DPBOESCMA	0.421875	Model of the frequency dependent loss of E-side cable: scalars DPBOESCMA (f^0) - G.997.1 form = 364
DPBOESCMB	0.8125	Model of the frequency dependent loss of E-side cable: scalars DPBOESCMB (f^0.5) - G.997.1 form = 464
DPBOESCMC	0.441406	Model of the frequency dependent loss of E-side cable: scalars DPBOESCMC (f) - G.997.1 form = 369
DPBOMUS	-101.5 dBm/Hz	Minimum usable receive PSD mask
DPBOESCMA	0.4218	Model of the frequency dependent loss of E-side cable: scalars DPBOESCMA (f^0)
DPBOESCMB	0.8136	Model of the frequency dependent loss of E-side cable: scalars DPBOESCMB (f^0.5)
DPBOESCMC	0.4417	Model of the frequency dependent loss of E-side cable: scalars DPBOESCMC (f)
DPBOMUS	-101.5 dBm/Hz	Minimum usable receive signal PSD
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	17	B value US band 1
NOTE: the values of DPBOESCMA, B and C are referred to a PE 0.4mm loop @ 300kHz. Values that are configured according to G.997.1 SHALL be rounded to the nearest scalar value.		

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

Table 96: Modified BA8c D&UPBO Profile-line-combinations for REIN testing

Profile-line combination	Band-profile	Specific line-setting
BA8c_D&UPBO_RA_I_150_150	BA8c_D&UPBO	RA_I_150_150
BA8c_D&UPBO_FX_I_027_009	BA8c_D&UPBO	FX_I_027_009
BA8c_D&UPBO_FX_I_024_008	BA8c_D&UPBO	FX_I_024_008
BA8c_D&UPBO_FX_I_014_005	BA8c_D&UPBO	FX_I_014_005
BA8c_D&UPBO_FX_I_010_003	BA8c_D&UPBO	FX_I_010_003

B.14.2 **REIN Noise Models**

The noise model n_BA8c_D&UPBO defined in Table 97 SHALL be used.

Table 97: REIN noise model n_BA8c_D&UPBO

Noise model	Associated band-profile	Self noise disturbers	Alien noise disturbers
n_BA8c_D&UPBO	BA8c_D&UPBO	19self_BA8c	none

The REIN test 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- 2 REIN Impulse PSD for BA8c

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

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

B.14.3 **REIN testing in rate adaptive mode**

The test procedure is described in Table 98.

Table 98: 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 loops SHALL have straight homogeneous loop topology and with TP100 cable characteristics. 2. Configure the SUT in the Rate Adaptive profile-line combination, as defined in BA8c_D&UPBO_RA_I_150_150. Target noise margin shall be set to 6 dB, unless otherwise specified. 3. The DSLAM and VTU-R are connected in turn through each loop specified in Table 99 and Table 100. 4. The crosstalk noise impairment n_BA8c_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 additive Gaussian White Noise.
Method of Procedure	1. The target margin is set according to Table 99 and Table 100. 2. The link is trained in the presence of the crosstalk noise, additive Gaussian White Noise and REIN impairments. 3. Wait for 3 minutes after initialization for bit-swaps to settle. 4. Record the net data rate R (kbps) and count 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 test pass requires that the expected results in Table 99 and Table 100 are achieved.

The two tables Table 99 and Table 100 together define a set of eight separate tests. The SUT SHALL pass a minimum of seven of these separate tests.

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

Table 99: REIN testing in rate adaptive mode - downstream

VDSL2 band-profile BA8c_D&UPBO_RA_I_150_150							
loop length (m, TP100)	**Target Margin (dB)**	**Modem trained and did not lose sync? (Y/N)**	**Minimum DS sync rate (kbps)**	**Measured DS sync rate (kbps)**	**Downstream Noise Margin, Reported (dB)**	**Measured D/S Errored Seconds**	**Pass / Fail**
100	6		26350				
300	9		20350				
500	9		18350				
1000	9		12850				

Table 100: REIN testing in rate adaptive mode - upstream

VDSL2 band-profile BA8c_D&UPBO_RA_I_150_150							
loop length (m, TP100)	**Target Margin dB**	**Modem trained and did not lose sync? (Y/N)**	**Minimum US sync rate (kbps)**	**Measured US sync rate (kbps)**	**Upstream Noise Margin, Reported (dB)**	**Measured U/S Errored Seconds**	**Pass / Fail**
100	6		8950				
300	9		7250				
500	9		6750				
1000	9		3600				

B.14.4 **REIN testing in fixed rate mode**

The test procedure is described in Table 101.

Table 101: REIN test procedure – fixed rate 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 loops SHALL have straight homogeneous loop topology and with TP100 cable characteristics. 2. Configure the SUT in the required BA8c Fixed-Rate profile-line combination from Table 96. Target noise margin shall be set to 6 dB. 3. The DSLAM and CPE are connected in turn through each loop specified in Table 110 and Table 111. 4. The crosstalk noise impairment n_BA8c_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 the additive Gaussian White Noise.
Method of Procedure	1. The link is trained in the presence of the crosstalk noise, additive Gaussian White Noise and REIN impairments. 2. Wait for 3 minutes after initialization for bit-swaps to settle. 3. Record the net data rate R (kbps) and count the number of Errored Seconds 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

The two tables Table 102 and Table 103 define a set of 10 separate tests. The modem SHALL pass a minimum of 9 of these separate tests.

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

Table 102: DS Target REIN Reach impairment, Fixed Rate Profile

Loop Length (m, TP100)	Test profile, with delay set to 8 ms.	Modem Trained and did not loose sync? (Y/N)	Downstream Noise Margin, Reported (dB)	Measured D/S Bit Rate	Measured D/S Errored Seconds	Pass / Fail
100	FX_I_027_009					
400	FX_I_024_008					
900	FX_I_014_005					
1300	FX_I_010_003					
1500	FX_I_005_001					

Table 103: US Target REIN Reach impairment, Fixed Rate Profile

Loop Length (m, TP100)	Test profile, with delay set to 8 ms.	Modem Trained and did not loose sync? (Y/N)	Upstream Noise Margin, Reported (dB)	Measured U/S Bit Rate	Measured U/S Errored Seconds	Pass / Fail
100	FX_I_027_009					
400	FX_I_024_008					
900	FX_I_014_005					
1300	FX_I_010_003					
1500	FX_I_005_001					

B.15 Single High Impulse Noise (SHINE) Testing for BA8c

B.15.1 Common Line Setting Variations

The basic BA8c Band Profile SHALL be applied with the following modifications in Table 104 to the “Common Line Settings” specified in Table 11 to define the new shaped-PSD Band Profile BA8c_D&UPBO:

Table 104: Common line settings for BA8c_D&UPBO band-profile SHINE testing

Parameter	Setting	Description
All parameters but those specified below	Value as specified in Table 11	
DPBOEPSD	ADSL2plus Annex A	PSD mask that is assumed to be permitted at the exchange
DPBOESEL	27dB@1MHz	E-side electrical length
DPBOESCMA	0.421875	Model of the frequency dependent loss of E-side cable: scalars DPBOESCMA (f^0) - G.997.1 form = 364
DPBOESCMB	0.8125	Model of the frequency dependent loss of E-side cable: scalars DPBOESCMB (f^0.5) - G.997.1 form = 464
DPBOESCMC	0.441406	Model of the frequency dependent loss of E-side cable: scalars DPBOESCMC (f) - G.997.1 form = 369
DPBOMUS	-101.5 dBm/Hz	Minimum usable receive PSD mask
DPBOESCMA	0.4218	Model of the frequency dependent loss of E-side cable: scalars DPBOESCMA (f^0)
DPBOESCMB	0.8136	Model of the frequency dependent loss of E-side cable: scalars DPBOESCMB (f^0.5)
DPBOESCMC	0.4417	Model of the frequency dependent loss of E-side cable: scalars DPBOESCMC (f)
DPBOMUS	-101.5 dBm/Hz	Minimum usable receive signal PSD
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	17	B value US band 1
NOTE: the values of DPBOESCMA, B and C are referred to a PE 0.4mm loop @ 300kHz. Values that are configured according to G.997.1 SHALL be rounded to the nearest scalar value.		

The SUT profile-line combinations SHALL be configured as in Table 105.

Table 105: BA8c D&UPBO profile-line combinations – SHINE testing

Profile-line combination	Band-profile	Specific line-setting
BA8c_D&UPBO_RA_I_150_150	BA8c_D&UPBO	RA_I_150_150

B.15.2 SHINE Noise Models

The noise model n_BA8c_D&UPBO defined in Table 106 SHALL be used.

Table 106: Noise model n_BA8c_D&UPBO SHINE testing

Noise model	Associated band-profile	Self noise disturbers	Alien noise disturbers
n_BA8c_D&UPBO	BA8c_D&UPBO	19self_BA8c	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.15.3 SHINE testing in rate adaptive mode

The test procedure is described in Table 107.

Table 107: 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 loops SHALL have straight homogeneous loop topology and with TP100 cable characteristics. 2. Configure the SUT in the Rate Adaptive profile-line combination, as defined in BA8c_D&UPBO_RA_I_150_150. Target noise margin shall be set to 6 dB. 3. The DSLAM and CPE are connected in turn through each loop specified in Table 108. 4. The crosstalk noise impairment n_BA8c_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 the additive Gaussian White Noise.
Method of Procedure	1. The link is trained in the presence of the crosstalk noise and the additive Gaussian White Noise impairments. 2. Wait for 60 s after initialization for bit-swaps to settle. 3. The SHINE is applied at the CPE. The duration of the SHINE is as specified in Table 108. 4. Wait for 10 s after the end of the SHINE. 5. Record the ES count that occurs during the following 60 s.

Expected Result	1. The modem SHALL NOT retrain during the application of the SHINE event and for 70 s after the end of the SHINE event; 2. The number of reported ES that occur between 10 s and 70 s after the SHINE event shall be ≤ 1

Table 108 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 108: SHINE test loop and burst lengths

Loop Length (m, TP100)	Burst length[1] (ms)
1500	1000
1500	100

Note 1: The burst length SHOULD be controllable with a resolution of ten milliseconds.

B.16 Combined Noise Impairment for BA8c

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.16.1. Type 2 test procedure is defined in section B.16.2.

B.16.1 Type 1 combined threat noise test including high level REIN

This combined threat noise test uses a combination of REIN, 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 REIN SHALL be on during training and for at least 2 minutes afterwards.

The system under test SHALL be tested for Interleaved rate adaptive and Interleaved fixed rate profiles.

The test procedures are described in Table 109 and Table 110.

Table 109: Combined noise test procedure Type 1 – Rate Adaptive mode

Test Configuration	1. Configure the SUT in the profile-line combinations as defined in section 6.2. Target noise margin shall be set to 6dB, unless otherwise specified. 2. The DSLAM and CPE are connected in turn through each loop specified in Table 115. 3. The fluctuating crosstalk noise impairment shall be applied at the CPE. Constant crosstalk shall be injected at the DSLAM. The condition during training shall be 1 disturber at the CPE side and 19 disturbers at the DSLAM side. In showtime, number of disturbers at the VTU-R side shall fluctuate between 0 and 19, as described in D.3.4. 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 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. 4. The expected results in Table 116 shall be met.

Table 110: Combined noise test procedure Type 1 – Fixed Rate mode

Test Configuration	1. Configure the SUT in the profile-line combinations as defined in section 6.2. 2. The DSLAM and CPE are connected in turn through each loop specified in Table 115. 3. The fluctuating crosstalk noise impairment shall be applied at the CPE. Constant crosstalk shall be injected at the DSLAM. The condition during training shall be 1 disturber at the CPE side and 19 disturbers at the DSLAM side. In showtime, number of disturbers at the CPE side shall fluctuate between 0 and 19, as described in Appendix D.3.4. 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 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. 4. The expected results in Table 117 shall be met.

B.16.2 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 Interleaved rate adaptive and Interleaved fixed rate profiles with an INP=16 and a delay=32ms.

The test procedures are described in Table 111 and Table 112

Table 111: Combined noise test procedure Type 2 – Rate Adaptive mode

Test Configuration	1. Configure the SUT in the profile-line combinations as defined in section 6.2. Target noise margin shall be set to 6dB, unless otherwise specified. 2. The DSLAM and CPE are connected in turn through each loop specified in Table 115. 3. The fluctuating crosstalk noise impairment shall be applied at the CPE. Constant crosstalk shall be injected at the DSLAM. The condition during training shall be 1 disturber at the CPE side and 19 disturbers at the DSLAM side. In showtime, number of disturbers at the CPE side shall fluctuate between 0 and 19, as described in Appendix D.3.4. 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 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 118 shall be met.

Table 112: Combined noise test procedure Type 2 – Fixed Rate mode

Test Configuration	1. Configure the SUT in the profile-line combinations as defined in section 6.2. 2. The DSLAM and CPE are connected in turn through each loop specified in Table 115. 3. The fluctuating crosstalk noise impairment shall be applied at the CPE. Constant crosstalk shall be injected at the DSLAM. The condition during training shall be 1 disturber at the CPE side and 19 disturbers at the DSLAM side. In showtime, number of disturbers at the CPE side shall fluctuate between 0 and 19, as described in Appendix D.3.4. 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 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 119 shall be met.

B.16.3 Common Settings for Combined Threat Noise Tests

The basic BA8c Band Profile SHALL be applied with the modifications defined in Table 113 to the "Common Line Settings" specified in Table 11 to define the new shaped-PSD Band Profile BA8c_D&UPBO:

Table 113: Common line setting for BA8c_D&UPBO band-profile combined threat testing

Parameter	Setting	Description
All parameters but those specified below	Value as specified in Table 11	
DPBOEPSD	ADSL2plus Annex A	PSD mask that is assumed to be permitted at the exchange
DPBOESEL	24dB@300kHz	E-side electrical length
DPBOESCMA	0.421875	Model of the frequency dependent loss of E-side cable: scalars DPBOESCMA (f^0) - G.997.1 form = 364
DPBOESCMB	0.8125	Model of the frequency dependent loss of E-side cable: scalars DPBOESCMB (f^0.5) - G.997.1 form = 464
DPBOESCMC	0.441406	Model of the frequency dependent loss of E-side cable: scalars DPBOESCMC (f) - G.997.1 form = 369
DPBOMUS	-101.5 dBm/Hz	Minimum usable receive PSD mask

DPBOESCMA	0.4218	Model of the frequency dependent loss of E-side cable: scalars DPBOESCMA (f^0)
DPBOESCMB	0.8136	Model of the frequency dependent loss of E-side cable: scalars DPBOESCMB (f^0.5)
DPBOESCMC	0.4417	Model of the frequency dependent loss of E-side cable: scalars DPBOESCMC (f)
DPBOMUS	-101.5 dBm/Hz	Minimum usable receive signal PSD
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	17	B value US band 1
NOTE: the values of DPBOESCMA, B and C are referred to a PE 0.4mm loop @ 300kHz. Values that are configured according to G.997.1 SHALL be rounded to the nearest scalar value.		

The following profile-line combination SHALL be configured on the SUT:

Table 114: BA8c D&UPBO testing descriptions

Profile-line combination	Band-profile	Specific line-setting
Type 1		
BA8c_D&UPBO RA_HI_150_150	BA8c_D&UPBO	RA_HI_150_150
BA8c_ D&UPBO_FX_HI_010_004	BA8c_D&UPBO	FX_HI_010_004
BA8c_ D&UPBO_FX_HI_006_003	BA8c_D&UPBO	FX_HI_006_003
Type 2		
BA8c_ D&UPBO_RA_HI_150_150	BA8c_D&UPBO	RA_HI_150_150
BA8c_ D&UPBO_FX_HI_011_003	BA8c_D&UPBO	FX_HI_011_003

The fluctuating crosstalk noise as defined in Annex D.5.4 SHALL be injected at the CPE and constant crosstalk according to BA8c_D&UPBO at the DSLAM.

In addition to the crosstalk noise at the CPE, the REIN as described in Annex D.4.1 is injected with a repetition frequency of 100Hz, and the PEIN as defined in Annex D.4.3 at the CPE end.

The RFI is injected at the CPE end.

The target margin for rate adaptive profile test SHALL be configured as indicated in Table 116 and Table 118. The long and short loop lengths SHALL be selected from Table 115 for the profile to be tested.

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 115.

Table 115: Combined threat noise test loops

Loop Length (m, TP-100 loop)	Kl0 (UPBOKL) (dB@ 1MHz)
500	9.0
900	16.2

B.16.3.1 Performance Tests with Type 1 Combined Threat Noise

From a total of 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 116: Combined noise impairment 1, rate adaptive profile

Test profile BA8c_D&UPBO RA_HI_150_150 with INPmin 16, max delay = 32ms											
					Measured						
loop length (m, TP100)	Target Margin D/S (dB)	Modem trained and did not lose sync? (Y/N)	Expected DS sync rate	Expected US sync rate	DS sync rate (kbps)	Initial DS Noise Margin, (dB)	DS Errored Seconds	US sync rate (kbps)	Initial US Noise Margin, (dB)	Pass / Fail
500	9		11000	4000						
900	9		6000	3500						

Table 117: Combined noise impairment 1, fixed rate profile

Test profile BA8c_D&UPBO FIX_HI_X_X with INPmin 16, max delay = 32ms								
		Measured						
Loop length (m, TP100.)	Test profile, with delay set to 32 ms.	Modem Trained and did not loose sync? (Y/N)	DS Bit Rate (kbps)	Initial DS Noise Margin,(dB)	DS Errored Seconds	US Bit Rate (kbps)	Initial US Noise Margin (dB)	Pass / Fail
500	FX_HI_010_004							
900	FX_HI_006_003							

B.16.3.2 Performance Tests with Type 2 Combined Threat Noise

From a total of 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 118: Combined noise impairment 2, rate adaptive profile

Test profile BA8c_D&UPBO RA_HI_150_150 with INPmin 16, max delay = 32ms										
					Measured					
loop length (m, TP100)	Target Margin D/S (dB)	Modem trained and did not lose sync? (Y/N)	Expected DS sync rate	Expected US sync rate	DS sync rate (kbps)	Initial DS Noise Margin, (dB)	DS Errored Seconds	US sync rate (kbps)	Initial US Noise Margin, (dB)	Pass / Fail
500	9		11500	3500						
900	9		12000	3000						

Table 119: Combined noise impairment 2, fixed rate profile

Test profile BA8c_D&UPBO FIX_HI_X_X with INPmin 16, max delay = 32ms									
			Measured						
Loop length (m, TP100.)	Test profile, with delay set to 32 ms.	Modem Trained and did not loose sync? (Y/N)	DS Bit Rate (kbps)	Initial DS Noise Margin,(dB)	DS Errored Seconds	US Bit Rate (kbps)	Initial US Noise Margin (dB)	Pass / Fail	
500	FX_HI_011_003								
900	FX_HI_011_003								

B.17 Performance Tests with mixed impedance loop for BB8b with UPBO

For further study.

B.18 Performance Tests with mixed impedance loop for BB17a with D&UPBO

For further study.

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

C.1 Annex C-Specific Test Setup Information

With reference to section 6.2, the following table indicates which test configurations SHALL be applied for tests related to specific band-profiles associated to VDSL2–over–TCM-ISDN deployments.

Table 120: Annex C Test Configuration

Type of VDSL2 deployment	Band-profile	Test configuration	Line setting	Noise impairment
VDSL2 over TCM-ISDN	CG8d CG12a CG17a CG30a	Refer to Figure 3 (configuration with ISDN splitters)	UPBO active RA_I_105_105 I-1/0	AWGNr AWGNc XTr+AWGNr XTc+AWGNc (Refer to section 6.3.3.3.)

Note-1: For definition of test loops see 6.3.2.3.
Note-2: UPBO PSD mask SHALL be as defined G.993.2 Amd.1 Annex C Section C.4.

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

Table 121: 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 sync-rate is greater than or equal to the expected sync-rate, then the DSLAM/CPE pair passes the sync-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 122: Noise margin chart outlines the pass/fail criteria on the reported noise margin.

Table 122: 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 123 lists the number of test points per section corresponding to the overall pass/fail criteria (10% limit).

Table 123: Reported margin requirements

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 124: Noise AWGNr CG8d impairment, profile-line combination CG8d_ RA_I_105_105

Loop Length (m, PE0.4mm loop)	CG8d_RA_I_105_105									
	Downstream					Upstream				
	Sync Rate (kbps)		CRC error count	Pass/Fail	Noise Margin, Reported(dB)	Sync 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 125: Noise AWGNr CG12a impairment, profile-line combination CG12a_ RA_I_105_105

Loop Length (m, PE0.4mm loop)	CG12a_RA_I_105_105									
	Downstream					Upstream				
	Sync Rate (kbps)		CRC error count	Pass/Fail	Noise Margin, Reported(dB)	Sync 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 126: Noise AWGNr CG17a impairment, profile-line combination CG17a_ RA_I_105_105

Loop Length (m, PE0.4mm loop)	CG17a_RA_I_105_105									
	Downstream					Upstream				
	Sync Rate (kbps)		CRC error count	Pass/Fail	Noise Margin, Reported (dB)	Sync 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 127: Noise AWGNr CG30a impairment, profile-line combination CG30a_ RA_I_105_105

Loop Length (m, PE0.4mm loop)	CG30a_RA_I_105_105									
	Downstream					Upstream				
	Sync Rate (kbps)		CRC error count	Pass/Fail	Noise Margin, Reported(dB)	Sync 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 128: Noise AWGNc CG8d impairment, profile-line combination CG8d_ RA_I_105_105

Loop Length (m, PE0.4mm loop)	CG8d_RA_I_105_105									
	Downstream					Upstream				
	Sync Rate (kbps)		CRC error count	Pass/Fail	Noise Margin, Reported(dB)	Sync 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 129: Noise AWGNc CG12a impairment, profile-line combination CG12a_ RA_I_105_105

Loop Length (m, PE0.4mm loop)	CG12a_RA_I_105_105									
	Downstream					Upstream				
	Sync Rate (kbps)		CRC error count	Pass/Fail	Noise Margin, Reported(dB)	Sync 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 130: Noise AWGNc CG17a impairment, profile-line combination CG17a_ RA_I_105_105

Loop Length (m, PE0.4mm loop)	CG17a_RA_I_105_105									
	Downstream					Upstream				
	Sync Rate (kbps)		CRC error count	Pass/Fail	Noise Margin, Reported(dB)	Sync 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 131:Noise AWGNc CG30a impairment, profile-line combination CG30a_ RA_I_105_105

Loop Length (m, PE0.4mm loop)	CG30a_RA_I_105_105									
	Downstream					Upstream				
	Sync Rate (kbps)		CRC error count	Pass/Fail	Noise Margin, Reported(dB)	Sync 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 132: Noise (XTr+AWGNr) CG8d impairment, profile-line combination CG8d_ RA_I_105_105

Loop Length (m, PE0.4mm loop)	CG8d_RA_I_105_105									
	Downstream					Upstream				
	Sync Rate (kbps)		CRC error count	Pass/Fail	Noise Margin, Reported(dB)	Sync 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 133: Noise (XTr+AWGNr) CG12a impairment, profile-line combination CG12a_ RA_I_105_105

Loop Length (m, PE0.4mm loop)	CG12a_RA_I_105_105									
	Downstream					Upstream				
	Sync Rate (kbps)		CRC error count	Pass/Fail	Noise Margin, Reported(dB)	Sync 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 134: Noise (XTr+AWGNr) CG17a impairment, profile-line combination CG17a_ RA_I_105_105

Loop Length (m, PE0.4mm loop)	CG17a_RA_I_105_105									
	Downstream					Upstream				
	Sync Rate (kbps)		CRC error count	Pass/Fail	Noise Margin, Reported(dB)	Sync 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 135: Noise (XTr+AWGNr) CG30a impairment, profile-line combination CG30a_ RA_I_105_105

Loop Length (m, PE0.4mm loop)	CG30a_RA_I_105_105									
	Downstream					Upstream				
	Sync Rate (kbps)		CRC error count	Pass/Fail	Noise Margin, Reported(dB)	Sync 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 136: Noise (XTc+AWGNc) CG8d impairment, profile-line combination CG8d_ RA_I_105_105

Loop Length (m, PE0.4mm loop)	CG8d_RA_I_105_105									
	Downstream					Upstream				
	Sync Rate (kbps)		CRC error count	Pass/Fail	Noise Margin, Reported (dB)	Sync 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 137: Noise (XTc+AWGNc) CG12a impairment, profile-line combination CG12a_ RA_I_105_105

Loop Length (m, PE0.4mm loop)	CG12a_RA_I_105_105									
	Downstream					Upstream				
	Sync Rate (kbps)		CRC error count	Pass/Fail	Noise Margin, Reported(dB)	Sync 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 138: Noise (XTc+AWGNc) CG17a impairment, profile-line combination CG17a_ RA_I_105_105

Loop Length (m, PE0.4mm loop)	CG17a_RA_I_105_105									
	Downstream					Upstream				
	Sync Rate (kbps)		CRC error count	Pass/Fail	Noise Margin, Reported (dB)	Sync 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 139: Noise (XTc+AWGNc) CG30a impairment, profile-line combination CG30a_ RA_I_105_105

Loop Length (m, PE0.4mm loop)	CG30a_RA_I_105_105									
	Downstream					Upstream				
	Sync Rate (kbps)		CRC error count	Pass/Fail	Noise Margin, Reported (dB)	Sync 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 & 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 140: 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 141: 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 100 Hz for profile BA8c 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 142

Table 142: 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 143.

Table 143: 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

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 19 active disturbers at the DSLAM. The DSLAM noise remains constant at 19 active disturbers and the noise injected at the CPE 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 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 TS101388[8],

Formula D- 1

$$XS.NT.n\_BA8c\_FLX() = \sum_{1}^{19} a_n \cdot P_{SingleSelf\text{-}BA8c\_FLX,\ NT}(n)$$

$$XS.LT.n\_BA8c\_FLX() = \sum_{1}^{19} a_n \cdot P_{SingleSelf\text{-}BA8c\_FLX,\ LT}(n)$$

Pair number $n \in 1..19$

Activation $a_n \in True, False$

Per - line crosstalk contribution $P_{SingleSelf\text{-}BA8c\_D\&UPBO\_FLX,\ NT}(n) = P_{SingleSelf\text{-}BA8c\_D\&UPBO,\ NT}(n) \cdot 10^{CCFV(n)/10}$

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

Table 144: 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 ETSI 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 145: Fluctuating crosstalk power test pattern

Time (s)	Power
0	-93.5
1	-93.5
2	-37.5
3	-37.5
4	-28.0
5	

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 1.000_000_001 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.

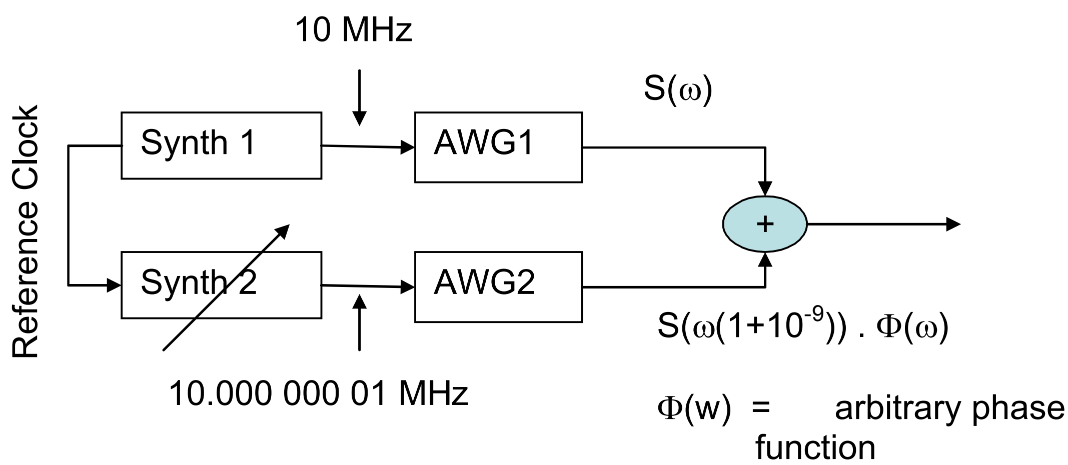

Figure 5: Example of creation of fluctuating noise

Table 146 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 ETSI TS101388 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 ITU G.227 Conventional Telephone signal 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 200 ms. 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 146: 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.

Appendix A Amateur Radio Bands (informative)

Amateur radio bands MAY interfere with some regions of the VDSL2 spectrum. Table 1 below provides the frequency ranges of these amateur radio bands as related to frequencies relevant to VDSL2.

Table 147:Amateur Radio Band Frequency Ranges (MHz)

ITU-R Region 1 (Europe)	ITU-R Region 2 (Americas)	ITU-R Region 3 (Asia-Pacific)
1.81-1.85	1.80-2.00	1.80-2.00
3.50-3.80	3.50-4.00	3.50-3.90
7.00-7.20	7.00-7.30	7.00-7.20
10.1-10.15		
14-14.35		
18.068-18.168		
21-21.45		
24.89-24.99		
28-29.7		

Appendix B Inside Wiring Topologies (informative)

Testing with inside wiring topologies are for further study.

The segment of twisted pair outside wire has been addressed by previous contributions to the DSL Forum (DSLF2005-560). The splitter is normally located at the NID (network interface device). While the DSL Forum VDSL2 testing specification MAY make reference to the applicable industry requirement for splitters, we recommend 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.

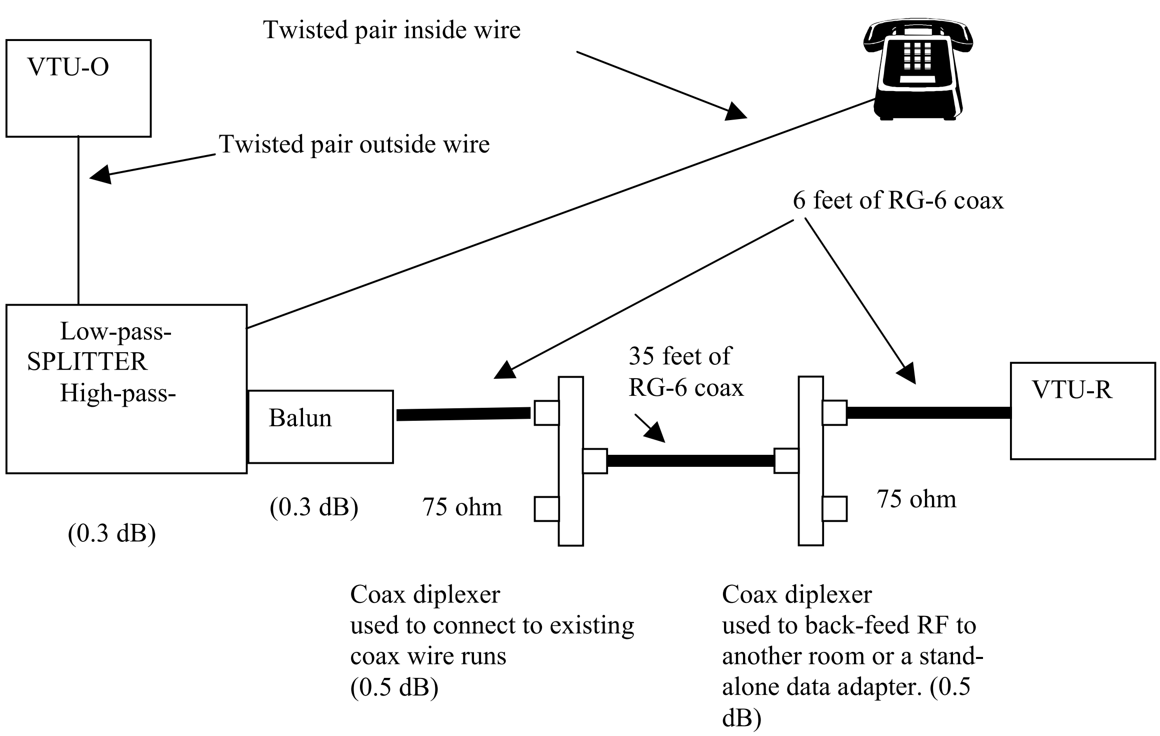

Figure 6:VDSL2 inside wire configuration 1

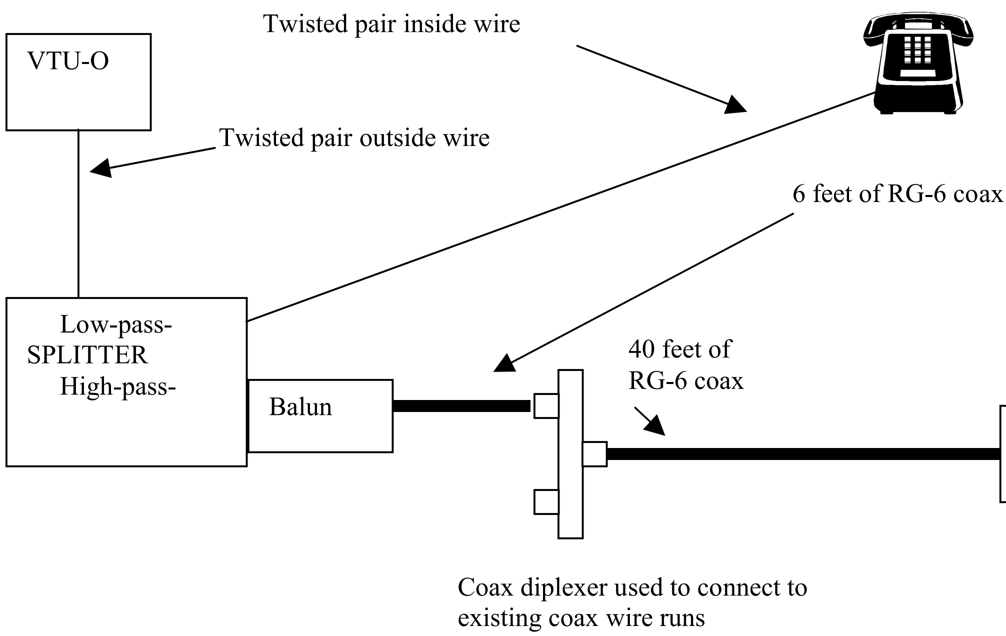

Figure 7: VDSL2 inside wire configuration 2 (diplexer function and home data networking functions MAY be integrated within CPE)

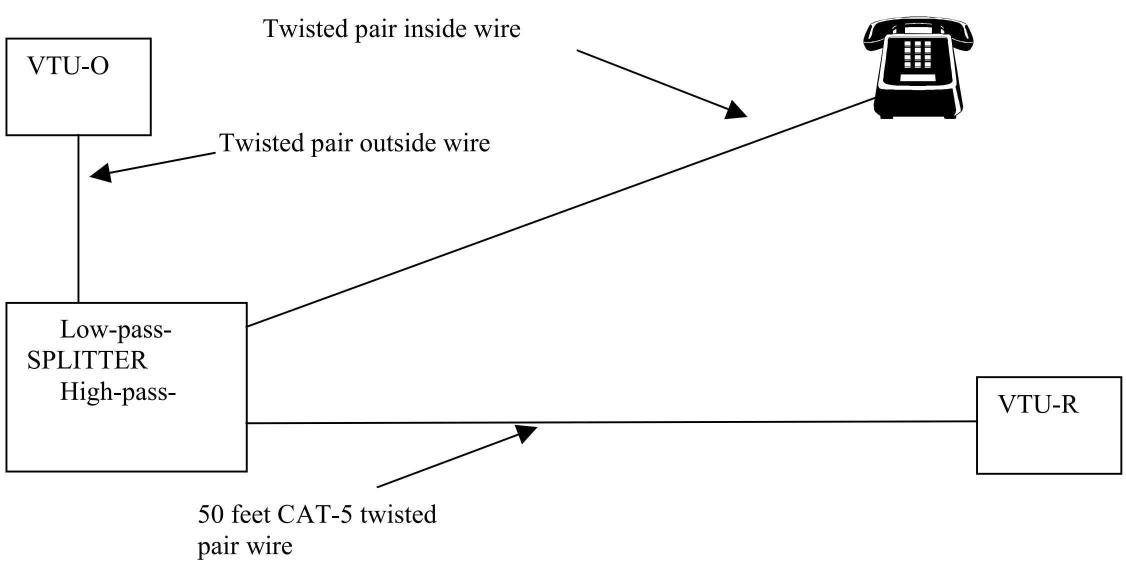

Figure 8: VDSL2 inside wire configuration 3 (typical home without coax)

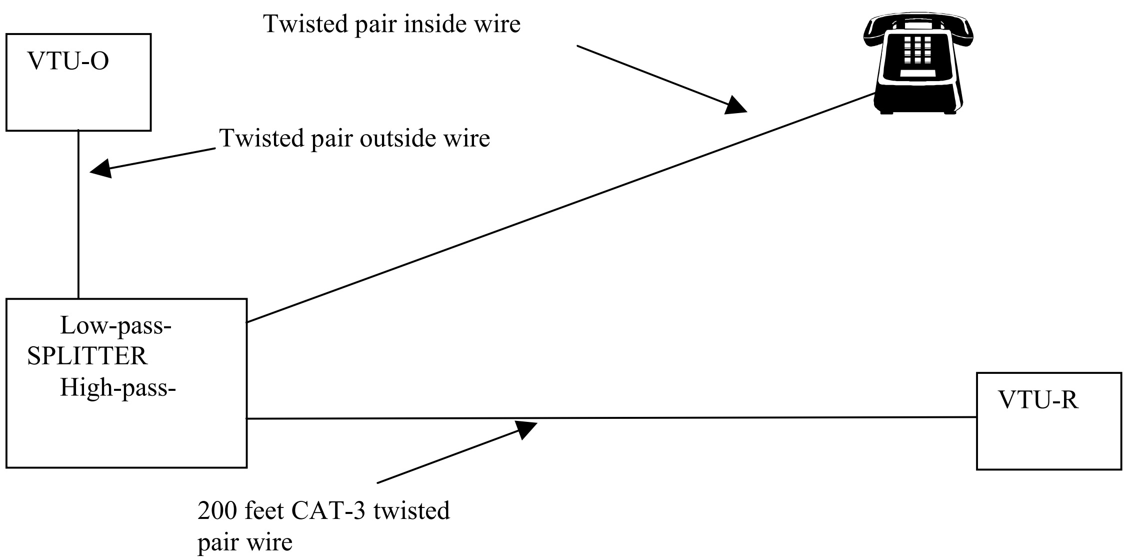

Figure 9: VDSL2 inside wire configuration 4 (typical MDU without coax)

Appendix C Summary of Profile and Line Combinations (informative)

Table 148: Summary of profile-line combinations used in TR-114

VDSL2 Band-profile	Specific line-setting	Profile-line combination
AA8d	RA_I_096_056	AA8d_RA_I_096_056
AA8d	FX_I_027_002	AA8d_ FX_I_027_002
AA8d	FX_I_014_001	AA8d_ FX_I_014_001
AA8d	FX_I_040_006	AA8d_ FX_I_040_006
BA8b	RA_F_150_150	BA8b_RA_F_150_150
BA8b	RA_I_150_150	BA8b_RA_I_150_150
BB8b	RA_F_150_150	BB8b_RA_F_150_150
BB8b	RA_I_150_150	BB8b_RA_I_150_150
BA8c_D&UPBO	RA_F_150_150	BA8c_D&UPBO_RA_F_150_150
BA8c_D&UPBO	RA_I_150_150	BA8c_ D&UPBO_RA_I_150_150
BA8c_D&UPBO	RA_HI_150_150	BA8c_ D&UPBO_RA_HI_150_150
BA8c_D&UPBO	FX_HI_010_004	BA8c_ D&UPBO_FX_HI_010_004
BA8c_D&UPBO	FX_HI_006_003	BA8c_ D&UPBO_FX_HI_006_003
BA8c_D&UPBO	FX_HI_011_003	BA8c_ D&UPBO_FX_HI_011_003
BA8c_D&UPBO	FX_I_027_009	BA8c_ D&UPBO_FX_I_027_009
BA8c_D&UPBO	FX_I_024_008	BA8c_ D&UPBO_FX_I_024_008
BA8c_D&UPBO	FX_I_014_005	BA8c_ D&UPBO_FX_I_014_005
BA8c_D&UPBO	FX_I_010_003	BA8c_ D&UPBO_FX_I_010_003
BA8c_D&UPBO	FX_I_005_001	BA8c_ D&UPBO_FX_I_005_001
CG8d	RA_I_105_105	CG8d_RA_ I_105_105
BA12a	RA_F_150_150	BA12a_RA_F_150_150
BA12a	RA_I_150_150	BA12a_RA_I_150_150
BB12a	RA_F_150_150	BB12a_RA_F_150_150
BB12a	RA_I_150_150	BB12a_RA_I_150_150
CG12a	RA_ I_105_105	CG12a_RA_ I_105_105

BA17a	RA_F_150_150	BA17a_RA_F_150_150
BA17a	RA_I_150_150	BA17a_RA_I_150_150
BA17a_D&UPBO	RA_F_150_150	BA17a_ D&UPBO_RA_F_150_150
BA17a_D&UPBO	RA_I_150_150	BA17a_ D&UPBO_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
CG17a	RA_ I_105_105	CG17a_RA_ I_105_105
CG30a	RA_ I_105_105	CG30a_RA_ I_105_105

Appendix D Crosstalk impairment for AA8d performance testing (informative)

Table 149: 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)	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	−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	−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	−121.9	−121.8	-121.8	−121.8	−121.4	−121.4	−121.4
24	−110.5	−108.5	−107.7	−107.2	−106.9	−106.7	−106.6	−106.5	−106.5	-106.4	−106.4	−106.0	−105.9	−105.9
36	−105.4	−103.5	−102.7	−102.2	−101.9	−101.7	−101.6	−101.5	−101.5	-101.4	−101.4	−100.9	−100.9	−100.9
52	−103.0	−101.1	−100.3	−99.8	−99.5	−99.3	−99.2	−99.1	−99.0	-99.0	−99.0	−98.5	−98.5	−98.5
78	−100.3	−98.4	−97.6	−97.2	−96.8	−96.6	−96.5	−96.4	−96.4	-96.3	−96.9	−95.8	−96.4	−96.4
112	−97.9	−96.0	−95.2	−94.7	−94.4	−94.2	−94.1	−94.0	−94.0	-94	−94.0	−93.5	−93.5	−93.5
134	−96.6	−94.8	−94.0	−93.5	−93.2	−93.0	−92.9	−92.8	−92.8	-92.8	−92.8	−92.3	−92.3	−92.3
138	−96.4	−94.6	−93.8	−93.3	−92.9	−92.8	−92.7	−92.6	−92.6	-92.6	−92.6	−92.1	−92.1	−92.1
142	−99.0	−97.2	−95.1	−94.6	−95.6	−95.4	−95.3	−95.3	−95.3	-95.2	−95.2	−94.7	−94.8	−94.8
512	−108.6	−107.3	−107.2	−107.6	−108.6	−109.8	−111.2	−112.8	−114.4	-116.1	−116.1	−108.8	−113.5	−118.3
1104	−103.4	−102.2	−102.9	−104.1	−106.1	−108.4	−110.8	−113.4	−116.1	-118.8	−118.8	−113.9	−121.1	−128.3
1516	−100.4	−100.3	−101.5	−103.1	−105.7	−108.6	−111.6	−114.8	−118.1	-121.4	−121.4	−125.0	−132.9	−138.0
2208	−97.8	−98.3	−100.1	−102.4	−105.8	−109.6	−113.5	−117.5	−121.6	-125.7	−125.7	-132.6	−138.4	−139.5
3748	−94.7	−96.4	−99.2	−102.4	−106.8	−110.5	−112.7	−113.6	−113.9	-114	−114.0	−138.9	−139.2	−139.2
3750	−119.3	−117.4	−114.0	−113.7	−113.7	−113.8	−113.8	−113.8	−113.8	-113.8	−113.8	−139.2	−139.2	−139.2
3752	−119.5	−117.5	−114.1	−109.8	−103.9	−97.9	−91.9	−86.8	−86.8	-86.8	−86.8	−139.2	−139.2	−139.2
3880	−123.9	−119.1	−114.6	−110.0	−103.9	−97.8	−91.7	−86.6	−86.6	-86.6	−86.6	−139.2	−139.2	−139.2
4300	−125.3	−120.2	−115.4	−110.6	−104.2	−97.8	−91.3	−85.9	−85.9	-85.9	−85.9	−139.0	−139.0	−139.0
5000	−127.2	−121.9	−116.7	−111.5	−104.6	−97.7	−90.8	−84.9	−84.9	-84.9	−84.9	−138.8	−138.8	−138.8
5176	−121.3	−120.4	−116.8	−111.8	−104.7	−97.7	−90.7	−84.7	−84.7	-84.7	−84.7	−138.8	−138.8	−138.8
5198	−118.9	−119.2	−116.6	−111.8	−104.8	−97.7	−90.6	−84.7	−84.7	-84.7	−84.7	−138.7	−138.7	−138.7
5200	−118.7	−119.1	−116.5	−111.8	−111.6	−111.7	−111.7	−111.7	−111.7	-111.7	−111.7	−138.7	−138.7	−138.7
5202	−94.3	−96.8	−100.5	−104.1	−108.5	−110.8	−111.6	−111.8	−111.9	-138.5	−111.9	−138.7	−138.7	−138.7
6000	−93.5	−96.4	−100.7	−105.4	−112.1	−119.1	−126.1	−132.5	−136.9	-138.6	−138.5	−138.5	−138.5	−138.5
7000	−92.6	−96.1	−100.8	−106.1	−113.4	−121.1	−128.6	−134.8	−137.8	-138.4	−138.6	−138.2	−138.2	−138.2
8498	−91.6	−95.8	−101.2	−107.1	−115.4	−123.9	−131.7	−136.7	−138.1	-138.4	−138.4	−137.7	−137.7	−137.7
8500	−116.6	−120.7	−126.0	−131.2	−136.3	−138.0	−138.3	−138.4	−138.4	-138.4	−138.4	−137.7	−137.7	−137.7
8502	−116.9	−121.0	−126.2	−131.5	−136.4	−138.1	−138.3	−138.4	−138.4	-138.3	−138.4	−137.7	−137.7	−137.7
8752	−137.2	−137.9	−138.2	−138.3	−138.3	−138.3	−138.3	−138.3	−138.3	−138.3	−138.3	−137.6	−137.6	−137.6
9300	−137.2	−137.9	−138.2	−138.2	−138.3	−138.3	−138.3	−138.3	−138.3	−138.3	−138.3	−138.3	−138.3	−138.3
12000	−137.2	−137.9	−138.2	−138.2	−138.3	−138.3	−138.3	−138.3	−138.3	−138.3	−138.3	−138.3	−138.3	−138.3
16000	−137.2	−137.9	−138.2	−138.2	−138.3	−138.3	−138.3	−138.3	−138.3	−138.3	−138.3	−138.3	−138.3	−138.3

Table 150: Annex A testing DSLAM noise (at DSLAM)

Freq (kHz)	0.3 (kft)	0.6 (kft)	0.9 (kft)	1.2 (kft)	1.6 (kft)	2.0 (kft)	2.4 (kft)	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	-140	-140	-140	-140	-140	-140	-140
4	-140	-140	-140	-140	-140	-140	-140	-140	-140	-140	-140	-140	-140	-140
16	-135.5	-134.1	-133.4	-133	-132.8	-132.7	-132.7	-132.8	-132.9	-133.1	-133.3	133.3	-134	-134.9
24	-121.1	-119.1	-118.2	-117.7	-117.5	-117.4	-117.4	-117.6	-117.8	-118.1	-118.5	-118.6	-120	-121.5
36	-115.3	-113.2	-112.4	-111.9	-111.6	-111.6	-111.7	-112	-112.4	-112.8	-113.4	-113.7	-115.5	-117.4
52	-112.1	-110.1	-109.2	-108.7	-108.5	-108.6	-108.8	-109.2	-109.8	-110.4	-111.1	-111.6	-113.6	-115.8
78	-108.6	-106.6	-105.7	-105.3	-105.2	-105.4	-105.8	-106.4	-107.1	-107.9	-108.7	-109.3	-111.5	-113.9
112	-105.4	-103.4	-102.6	-102.2	-102.2	-102.6	-103.2	-103.9	-104.6	-105.4	-106.1	-106.6	-108.7	-110.6
134	-103.5	-101.6	-100.7	-100.4	-100.5	-100.9	-101.5	-102.1	-102.7	-103.4	-103.3	-102.6	-103.6	-104.2
138	-103.2	-101.2	-100.4	-100.1	-100.2	-100.5	-101.1	-101.6	-102.2	-102.9	-102.5	-101.5	-102.3	-102.8
142	-105.3	-103.3	-102.5	-102.2	-102.3	-102.6	-103	-103.5	-104	-104.6	-103.6	-96.6	-96.7	-96.8
512	-102.6	-100.9	-100.3	-100.1	-99.9	-99.9	-99.9	-99.9	-99.9	-99.9	-97.2	-88.5	-88.5	-88.5
1104	-96.6	-95.3	-95	-94.9	-94.9	-94.9	-94.9	-94.9	-94.9	-94.9	-92.2	-83.5	-83.5	-83.5
1516	-94.1	-93.1	-92.9	-92.8	-92.8	-92.8	-92.8	-92.8	-92.8	-92.8	-90.1	-88.8	-88.8	-88.8
2208	-91.3	-90.5	-90.4	-90.4	-90.3	-90.3	-90.3	-90.3	-90.3	-90.3	-88.2	-88.4	-88.4	-88.4
3748	-87.8	-87.4	-87.3	-87.3	-87.3	-87.3	-87.3	-87.3	-87.3	-87.3	-87.3	-89.1	-89.1	-89.1
3750	-114.2	-113.7	-113.6	-113.7	-113.7	-113.8	-113.8	-113.8	-113.8	-113.8	-113.8	-115.6	-115.6	-115.6
3752	-114.4	-113.9	-113.8	-113.7	-113.6	-113.6	-113.5	-113.5	-113.9	-114.0	-114.0	-115.8	-115.8	-115.8
3880	-126.7	-125.3	-124.4	-123.8	-123.1	-122.6	-122.2	-122.6	-125.9	-127.4	-127.9	-129.8	-129.8	-129.8
4300	-131.4	-129.1	-127.7	-126.8	-125.9	-125.2	-124.7	-125.3	-130.6	-134.6	-136.5	-137.8	-137.8	-137.8
5000	-131.5	-129.9	-128.9	-128.2	-127.4	-126.9	-126.6	-127.1	-131.4	-133.4	-138.1	-138.7	-138.7	-138.7
5176	-115.1	-114.8	-114.7	-114.7	-114.7	-114.7	-114.6	-114.7	-114.8	-114.8	-138.1	-138.6	-138.6	-138.6
5198	-112.3	-111.9	-111.9	-111.9	-111.8	-111.8	-111.8	-111.8	-111.9	-111.9	-138.1	-138.6	-138.6	-138.6
5200	-112	-111.7	-111.6	-111.6	-111.6	-111.7	-111.7	-111.7	-111.7	-111.7	-138.4	-138.6	-138.6	-138.6
5202	-87	-86.7	-86.7	-86.7	-86.7	-86.7	-86.7	-86.7	-86.7	-86.7	-138.4	-138.6	-138.6	-138.6
6000	-86	-85.8	-85.7	-85.7	-85.7	-85.7	-85.7	-85.7	-85.7	-85.7	-138.1	-138.4	-138.4	-138.4
7000	-85	-84.7	-84.7	-84.7	-84.7	-84.7	-84.7	-84.7	-84.7	-84.7	-137.8	-138.0	-138.0	-138.0
8498	-83.6	-83.5	-83.5	-83.5	-83.5	-83.5	-83.5	-83.5	-83.5	-83.5	-137.2	-137.5	-137.5	-137.5
8500	-108.6	-108.5	-108.5	-108.5	-108.5	-108.5	-108.5	-108.5	-108.5	-108.5	-137.2	-137.5	-137.5	-137.5
8502	-108.9	-108.8	-108.8	-108.8	-108.8	-108.8	-108.8	-108.8	-108.8	-108.8	-137.2	-137.5	-137.5	-137.5
8752	-134.1	-134.1	-134.1	-134.1	-134.1	-134.1	-134.1	-134.1	-134.1	-134.1	-137.1	-137.4	-137.4	-137.4
9300	-134.3	-134.2	-134.2	-134.2	-134.2	-134.2	-134.2	-134.2	-134.2	-134.2	-137	-137.3	-137.3	-137.3
12000	-134.3	-134.2	-134.2	-134.2	-134.2	-134.2	-134.2	-134.2	-134.2	-134.2	-137	-137.3	-137.3	-137.3
16000	-134.3	-134.2	-134.2	-134.2	-134.2	-134.2	-134.2	-134.2	-134.2	-134.2	-137	-137.3	-137.3	-137.3

End of Broadband Forum Technical Report TR-114