TECHNICAL REPORT

TR-115
VDSL2 Functionality Test Plan

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Executive Summary

TR-115, as part of the Broadband Suite, provides a set of test methods to verify a significant subset of the transceiver functional requirements of VDSL2 modems implemented in accordance with ITU-T G.993.2 (Very high speed Digital Subscriber Line transceivers 2) as well as physical layer OAM configuration and performance monitoring parameters defined in ITU-T G.997.1. Its key value is in the verification of transceiver functionalities and management parameters such that network operators may deploy interoperable and successful VDSL2 services in their networks.

TR-115 accompanies TR-114 *"VDSL2 Performance Test Plan"* and TR-138 *"Accuracy Tests For Test Parameters"*. TR-114 provides a set of region specific performance requirements and test methods for VDSL2 modems implemented in accordance with 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

This test plan describes a series of functionality tests that are used to verify that a VTU (VTU-O or VTU-R) is functionally compliant to ITU-T Recommendation G.993.2 (Very High Speed Subscriber Line transceiver 2). A VTU is functionally compliant to this test plan if it implements correctly the required functions and features of the ITU-T Recommendation G.993.2. In addition, if a VTU implements a feature that is optional in the standard, the VTU is functionally compliant if it implements the optional feature as specified in the standard. TR-115 also defines tests for some of the VDSL2 optional features such as dual latency and Seamless Rate Adaptation (SRA).

This functionality test plan does not specify the rate/reach performance requirements for VDSL2 transceiver. Instead, the reader is referred to TR-114 (VDSL2 performance test plan).

1.2   Scope

This test plan facilitates VDSL2 over POTS and over ISDN functional testing. This test plan embodies operators' definitions of VDSL2 interoperability (between one VTU-O and one VTU-R at a time). The test plan focuses on physical layer testing, and also validation and verification of selected higher layer functionality. It does not replace operators' pre-deployment testing.

This test plan defines tests for various physical layer functionalities and some higher layer functionalities. A pass/fail indication result is provided for each functionality test

NOTE - There is no requirement for VDSL2 VTUs to interoperate with G.993.1 (VDSL1) VTUs.

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].

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 must 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.

[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 Recommendation	2006
[3] G.997.1	Physical Layer Management for Digital Subscriber Line (DSL) Transceivers.	ITU-T Recommendation	2009

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[4] T1.417 Issue 2	Spectrum Management for Loop Transmission System	ANSI Standard	2003
[5] RFC 1242	Benchmarking terminology for network interconnection devices.	IETF	1991
[6] RFC 2544	Benchmarking terminology for network interconnection devices (Test methodology).	IETF	1999
[7] TR-114	VDSL2 Performance Test Plan	Broadband Forum	2009
[8] O.9	Measuring arrangements to assess the degree of unbalance about earth	ITU-T	1999
[9] G.117	Transmission aspects of unbalance about earth	ITU-T	1996
[10] G.992.3	Asymmetric digital subscriber line transceivers 2 (ADSL2)	ITU-T Recommendation	2009
[11] G.992.5	Asymmetric Digital Subscriber Line (ADSL) transceivers - Extended bandwidth ADSL2 (ADSL2plus)	ITU-T Recommendation	2009
[12] TR-100	ADSL2/ADSL2plus Performance Test Plan	Broadband Forum	2007
[13] IEEE 802.3	CSMA/CD access method and physical layer specifications	IEEE	2005

2.3   Definitions

The following terminology is used throughout this Technical Report.

All Digital Loop   A digital subscriber line which is not shared by POTS
Net Data Rate   Sum of net data rates of all bearer channels
F_{max}   The lower of the lowest passband frequency in the upstream and downstream directions for the Limit PSD masks selected.
Showtime   VTU-O and VTU-R trained up to the point of passing data.
L0   State achieved after the initialization procedure has completed successfully
L3   State reached upon guided power removal, power loss or persistent link failures during Showtime
Null Loop   VTU-O/VTU-R wired "back to back" i.e. a zero length loop

2.4   Abbreviations

This Technical Report uses the following abbreviations:

ANSI	American National Standards Institute
ATIS	Alliance for Telecommunications Industry Solutions
ATP	Aggregate Transmit Power
ATTNDR	Attainable Net Data Rate
AWG	American Wire Gauge
AWGN	Additive White Gaussian Noise
BER	Bit error ratio
BS	Bitswap
CRC	Cyclic redundancy check
CV	Code Violations
DPBO	Downstream Power Back-Off
DS	Downstream
EE	Energy Efficiency
ER(n)	Expected Result step n
ES	Errored Seconds
ETSI	European Telecommunications Standards Institute
EU	Expanded Upstream
FX	Fixed Rate
HI	High Impulse Noise Protection
HLING	H(f) linear subcarrier group size
HLINps	H(f) linear representation
HLINSC	H(f) linear representation Scale
HLOGG	H(f) logarithmic subcarrier group size
HLOGMT	H(f) logarithmic Measurement Time
HLOGps	H(f) logarithmic representation
ID	Identification
IEEE	Institute of Electrical and Electronics Engineers
INP	Impulse Noise Protection
ISDN	Integrated Services Digital Network
ITU	International Telecommunication Union
LATN	Loop Attenuation
LCL	Longitudinal Conversion Loss
LD	Loop Diagnostic
LDSF	Loop Diagnostic Mode Forced
LLC	Link Layer Control
MAC	Medium Access Control
MAXNOMATP	Maximum Nominal Aggregate Transmit Power
MAXSNRM	Maximum Signal to Noise Ratio Margin
MIB	Management Information Base
MINSNRM	Minimum Signal to Noise Ratio Margin
MOP(n)	Method of Procedure step n
OAM	Operations, Administration and Maintenance
OLR	Online reconfiguration
PDU	Protocol Data Unit
PE	Poly Ethylene (cable type)

PMSF	Power Management State Forced
POTS	Plain Old Telephone Service
PSD	Power Spectral Density
PTM	Packet Transfer Mode
QLN	Quiet Line Noise
QLNG	QLN(f) sub-carrier group size
QLNMT	Quiet Line Noise PSD Measurement Time
QLNps	Quiet Line Noise representation
RA	Rate Adaptive
RFC	Request for Comments
RFI	Radio Frequency Interference
ROC	Robust Overhead Channel
SATN	Signal Attenuation
SES	Severely Errored Second
SNRG	SNR(f) sub-carrier group size
SNRM	Signal to Noise Ratio Margin
SNRMT	SNR Measurement Time
SNRps	SNR(f) representation
SRA	Seamless Rate Adaptation
SUT	System Under Test
TARSNRM	Target Signal to Noise Ratio Margin
TC(n)	Test Configuration step n
TR	Technical Report
UAS	Un-Available Seconds
UPBO	Upstream Power Back-Off
US	Upstream
VDSL2	Very high speed digital subscriber line transceivers 2
VN	Virtual Noise
VTU	VDSL2 Transceiver Unit
VTU-O	VTU at the ONU (or central office, exchange, cabinet, etc. i.e. operator end of the loop)
VTU-R	VTU at the remote site (i.e. subscriber end of the loop)

2.5   G.997.1 Parameters

Parameter	Section in G.997.1
ACTATP	7.5.1.24/25
ATTNDR	7.5.1.19/20
BITSpsds	7.5.1.29.1
BITSpsus	7.5.1.29.2
CRC-PFE	7.2.5.2.1
CV-C	7.2.2.1.1
CV-CFE	7.2.2.2.1
CV-PFE	7.2.5.2.2
DPBO	7.3.1.2.13
ES-L	7.2.1.1.2
ES-LFE	7.2.1.2.2
FORCEINP	7.3.2.5
HLING	7.5.1.26.2/8
HLINSC	7.5.1.26.1/7
HLINps	7.5.1.26.3/9
HLOGMT	7.5.1.26.4/10
HLOGG	7.5.1.26.5/11
HLOGps	7.5.1.26.6/12
LATN	7.5.1.9/10
LDSF	7.3.1.1.8
MAXNOMATPds	7.3.1.2.3
MAXNOMATPus	7.3.1.2.4
MAXSNRMds	7.3.1.3.3
MAXSNRMus	7.3.1.3.4
MAX-SOS-ds	7.3.1.10.7
MAX-SOS-us	7.3.1.10.8
MIBMASK	7.2.3
MINSNRMds	7.3.1.3.5
MINSNRMus	7.3.1.3.6
MIN-SOS-BR-ds	7.3.2.1.6

MIN-SOS-BR-us	7.3.2.1.7
MSGMINds	7.3.1.5.2
MSGMINus	7.3.1.5.1
PMSF	7.3.1.1.3
PMMode	7.3.1.1.4
PSDMASKds	7.3.1.2.9
PSDMASKus	7.3.1.2.12
QLNG	7.5.1.27.2/5
QLNMT	7.5.1.27.1/4
QLNps	7.5.1.27.3/6
RA-DSNRMds	7.3.1.4.7
RA-DSNRMus	7.3.1.4.8
RA-DTIMEds	7.3.1.4.9
RA-DTIMEus	7.3.1.4.10
RA-MODEds	7.3.1.4.1
RA-MODEus	7.3.1.4.2
RA-USNRMds	7.3.1.4.3
RA-USNRMus	7.3.1.4.4
RA-UTIMEds	7.3.1.4.5
RA-UTIMEus	7.3.1.4.6
SATN	7.5.1.11/12
SES-L	7.2.1.1.3
SES-LFE	7.2.1.2.3
SNRG	7.5.1.28.2/5
SNRMds	7.5.1.13
SNRMODEds	7.3.1.7.1
SNRMODEus	7.3.1.7.2
SNRMT	7.5.1.28.1/4
SNRMus	7.5.1.16
SNRps	7.5.1.28.3/6
SOS-CRC-ds	7.3.1.10.5
SOS-CRC-us	7.3.1.10.6

SOS-TIME-ds	7.3.1.10.1
SOS-TIME-us	7.3.1.10.2
SOS-NTONES-ds	7.3.1.10.3
SOS-NTONES-us	7.3.1.10.4
TARSNRMds	7.3.1.3.1
TARSNRMus	7.3.1.3.2
UAS-L	7.2.1.1.5
UAS-LFE	7.2.1.2.5
UPBO	7.3.1.2.14
VDSL2-CARMASK	7.3.1.2.8

3   Technical Report Impact

3.1   Energy Efficiency

TR-115 has no impact on Energy Efficiency.

3.2   IPv6

TR-115 has no impact on IPv6.

3.3   Security

TR-115 has no impact on Security.

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4   TEST STRUCTURE

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.

4.1   Test Configurations

For tests that do not require data layer Figure 1 SHALL be used.

For tests that do require data layer Figure 2 SHALL be used.
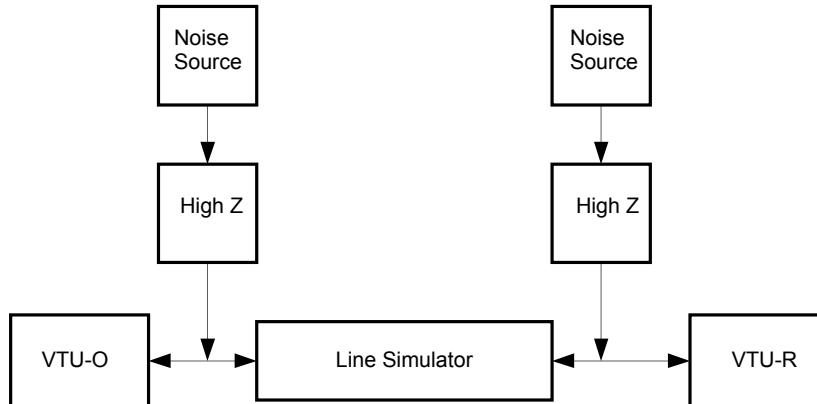
Figure 1 - Generic Test Configuration
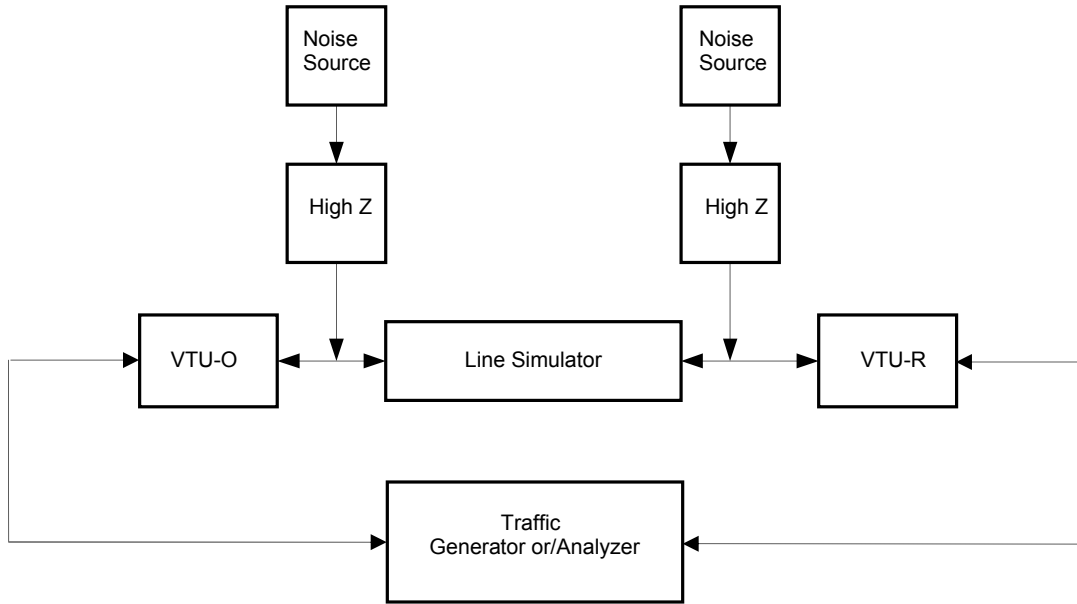
Figure 2 - Test Setup For Configurations Using Data Layer

Note 1 - The modem SHALL be set to a bridged configuration.
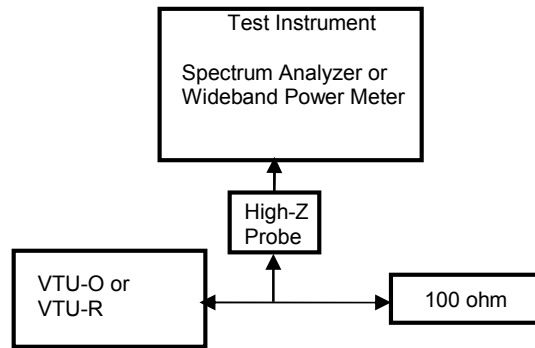
Figure 3 - Test Configuration for PSD Measurement Tests
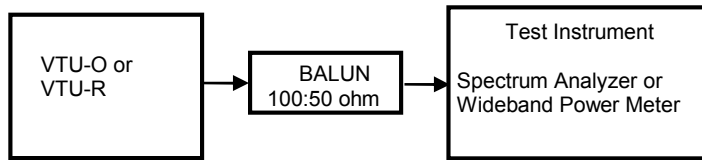
Figure 4 - Alternative Test Configuration for PSD Measurement Tests

NOTE – Test setups MAY use real cable instead of a loop simulator.

4.2   System Under Test Settings

4.2.1   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: Annex A/G.993.2 with US0 corresponding to Annex A/G.992.5 (VDSL2 over POTS).

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

- BB: Annex B/G.993.2 with US0 corresponding to Annex B/G.992.5 (VDSL2 over ISDN).

- CG: Annex C/G.993.2 (VDSL2 over TCM-ISDN). Note that US0 is not available.

The next symbols are the numeric and letter description of the profile itself (8b, 8c, 8d, 12a, 17a, 30a, etc.). Any VTU-O/VTU-R combination claiming TR-115 interoperability for a specific profile SHALL comply with the testing requirements for that profile. Claiming interoperability for several distinct profiles SHALL comply with each of the distinct profile test requirements. Common Band Profiles are provided in Table 1.

Table 1 - Common Band Profiles

Annex A/G.993.2				
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/G.993.2				
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	Not applicable
MAXNOMATPds	+20.5 dBm	+11.5 dBm	+14.5 dBm	+14.5 dBm
Annex B/G.993.2				
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/G.993.2				
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	Not applicable	Not applicable	Not applicable	Not applicable
MAXNOMATPds	+14.5dBm	+14.5dBm	+14.5dBm	+14.5dBm

4.2.2   Line Settings

4.2.2.1   Common Line Settings

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

Table 2 - List of Common Line Settings for VDSL2 Functionality 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 (LDSF)	0	
Automode cold start forced	0	
DPBO	off	
UPBO	off	
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	
SNRMODEds	1	
SNRMODEus	1	

Table 3 - Common Line Settings for BA17a_D&UPBO Band Profile

Parameter	Setting	Description
All parameters but those specified below	Value as specified in Table 2	
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)
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.		

Table 4 - Common Line Settings for BB17a_D&UPBO Band Profile

Parameter	Setting	Description
All parameters but those specified below	Value as specified in Table 2	
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)
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.		

Table 5 - Common Line Settings for BA8c_D&UPBO Band Profile

Parameter	Setting	Description
All parameters but those specified below	Value as specified in Table 2	
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 (NOTE)
DPBOESCMB	0.8136	Model of the frequency dependent loss of E-side cable: scalars DPBOESCMB (NOTE)
DPBOESCMC	0.4417	Model of the frequency dependent loss of E-side cable: scalars DPBOESCMC (NOTE)
DPBOMUS	-101.5 dBm/Hz	Minimum usable receive signal PSD mask
DPBOFMIN	138 kHz	Minimum frequency from which on the DPBO SHALL be applied
DPBOFMAX	2208 kHz	Maximum frequency up to which the DPBO SHALL be applied
UPBOKLF	0	Force CO-MIB electrical loop length (means that kl_0 is estimated during training)
UPBOKL	estimated during training	Upstream electrical loop length (kl_0)
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.		

Table 6 - UPBOA and UPBOB for band-profile AA8d

Parameter	Setting	Description
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 7 - UPBOA and UPBOB for band-profile BA17a_D&UPBO, BB17a_ D&UPBO

Parameter	Setting	Description
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: BB17a_D&UPBO does not have US3

Table 8 - UPBOA and UPBOB for band-profile BA8c_D&UPBO

Parameter	Setting	Description
UPBOA US0	40	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

Table 9 - UPBOA and UPBOB for band-profiles CG8d, CG12a, CG17a, CG30a

Parameter	Setting	Description
UPBOA US0	40	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	10.2	B value US band 1
UPBOA US2	60	A value US band 2
UPBOB US2	6.42	B value US band 2
UPBOA US3	40	A value US band 3
UPBOB US3	0	B value US band 3

Note: CG8d does not have US2 and US3.
Note: CG12a does not have US3.

4.2.2.2   General Line Settings

This section defines the profile, latency and impulse noise protection 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 10.

Table 10 - General Line Settings

General line-setting	Parameter	Setting	Description
F-1/0	delay_max$_n$ ds	S1	Special value S1 as defined in section 7.3.2.2/ G.997.1 indicating that S and D SHALL be selected such that $S \leq 1$ and D=1
	delay_max$_n$ us	S1	Special value S1 as defined in section 7.3.2.2/ G.997.1 indicating that S and D SHALL be selected such that $S \leq 1$ and D=1
	INP_min$_n$ ds	0 symbols	
	INP_min$_n$ us	0 symbols	
I-1/0	delay_max$_n$ ds	S2	Special value S2 as defined in Section 7.3.2.2/ G.997.1 indicating a delay bound of 1 ms.
	delay_max$_n$ us	S2	Special value S2 as defined in Section 7.3.2.2/ G.997.1 indicating a delay bound of 1 ms.
	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-16/2	delay_max$_n$ ds	16 ms	
	delay_max$_n$ us	16 ms	
	INP_min$_n$ ds	2 symbols	
	INP_min$_n$ us	2 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	

4.2.2.3 Specific Line Settings

The 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 11 (Fast or Interleaved).

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

Table 11 - Specific line settings

Specific line-setting	General line-setting	RA-Mode	DS net datarate (kbit/s) (max- min)	US net datarate (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_F_003_001	F-1/0	Manual	3000-3000	1000-1000
FX_I_010_001	I-8/2	Manual	10000-10000	1000-1000
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

4.2.3   Profile Line Combinations

Common band-profiles as described in Section 4.2.1 are combined with line settings described in Section 4.2.2 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 12 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/ G.993.2, Annex B/ G.993.2, and Annex C/ G.993.2 testing are specified in the test setup description and are listed in Annex A .

Table 12 - 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.

4.3   Test Plan Passing Criteria

For an SUT to pass this Test Plan for one of the VDSL2 band-profiles defined in Table 1, it is required that the SUT passes the mandatory test cases applicable to that band-profile and supported type of the TPS-TC layer.

4.4   Test Setup

See Section 6.3.2/TR-114, *Loop Models*, Section 6.3.3/TR-114, *Noise Models*, and Section 6.3.4/TR-114 *Noise Injection*.

4.5   Equipment Feature Tables

The listed tables SHALL be filled with the requested information before starting the tests in order to have all the information about the system under test and to have a reproducible test environment**.**

Table 13 - VTU-O Feature Table

Feature	Specification
System Vendor ID	
G.994.1 Vendor ID	
Version Number	
Serial Number	
VDSL2 Band-Profiles tested	
VDSL2 optional features tested	
TPS-TC encapsulation tested (ATM, PTM)	

Table 14 - VTU-R Feature Table

Feature	Specification
System Vendor ID	
G.994.1 Vendor ID	
Version Number	
Serial Number	
VDSL2 Band-Profiles tested	
VDSL2 optional features tested	
TPS-TC encapsulation tested (ATM, PTM)	

4.6   Equations for Estimating BER

See Table 23/TR-114 - *The equations for estimating BER*

5   Physical Layer Tests

5.1   Interleaving Delay Test

The purpose of this test is to verify the validity of Interleaving Delay. It assumes that the system delay without interleaving delay is constant within a tolerance of 1ms and that the reported interleaving delay is equal to the actual delay.

Table 15 - Interleaving Delay Test

Test Configuration	(1) See Section 4.1 for the test configuration depending on the customer interface of the modem. (2) According to the band-profile to be tested, configure the VTU-O with one of the profile line combinations using the general line setting I-8/2 associated to that band profile (see section 4.2.3). If for the specific band-profile, profile line combination is defined with DPBO and/or UPBO enabled, these SHALL be applied. (3) Set loop for Null Loop without noise. (4) Setup the traffic generator/analyzer to send frames in one direction with destination MAC address equal to the unicast source MAC address of frames sent in the opposite direction.
Method of Procedure	(1) Force a new initialization and wait for modems to sync. (2) Wait 1 minute after reaching Showtime. (3) Record Actual Interleaving Delay for both upstream and downstream as reported_delay_1_US and reported_delay_1_DS (4) Run Section 26/RFC 2544 with a frame size of 512 bytes. Set the throughput rate to 90% of the achieved net data rate. (5) Record the result as system_delay_1_US and system_delay_1_DS (6) Define "delta_delay_1" as the system delay without the interleaving delay in downstream and upstream; delta_delay_1_DS = system_delay_1_DS – reported_delay_1_DS delta_delay_1_US = system_delay_1_US – reported_delay_1_US (7) Configure the VTU-O to the profile-line combination using the general line setting I-16/2, which otherwise is the same as the profile line combination of TC(2). If, for the specific band-profile, profile line combination is defined with DPBO and/or UPBO enabled, these SHALL be applied. (8) Force a new initialization and wait for modems to sync. (9) Wait 1 minute after reaching Showtime. (10) Record Actual Interleaving Delay for both upstream and downstream as reported_Delay_2_US and reported_Delay_2_DS. (11) Run system delay test according to RFC 2544, with a frame size of 512. Set the throughput rate to 90% of the achieved net data rate (12) Record the result as system_delay_2_US and system_delay_2_DS .

	Define "delta_delay_2" as the system delay without the interleaving delay in downstream and upstream; delta_delay_2_DS = system_delay_2_DS – reported_delay_2_DS delta_delay_2_US = system_delay_2_US – reported_delay_2_US
Expected Result	The test is passed if the following conditions are met: (1) reported_delay_1_US ≤ 8 ms and reported_delay_1_DS ≤ 8 ms. (2) reported_delay_2_US ≤ 16 ms and reported_delay_2_DS ≤ 16 ms (3) |delta_delay_1_US – delta_delay_2_US| ≤ 1ms (4) |delta_delay_1_DS – delta_delay_2_DS| ≤ 1ms

5.2   Impulse Noise Protection Test

Table 16 - Capabilities of Impulse Noise Protection

Test Configuration	(1) See Section 4.1 for the test configuration depending on the customer interface of the modem. (2) According to the band-profile to be tested, configure the VTU-O with one of the high-delay profile line combinations associated to that band profile (see section 4.2.3). If for the specific band-profile, profile-line combination is defined with DPBO and/or UPBO enabled, these SHALL be applied. The initial setting for DS and US INP_min SHALL be 2 symbols. (3) Set up the loop simulator for 2700 ft 26AWG cable or 900 m PE 0.4mm cable, with white noise of -140dBm/Hz injected at both the VTU-O and VTU-R ends.
Method of Procedure	(1) Inject -110 dBm/Hz white noise disturber at the VTU-O end of the loop. (2) Wait for 1 minute after initialization. (3) Inject 15 impulses spaced at least 1 second apart into the circuit at the VTU-O end of the loop simulator over a maximum of a one minute period. Each impulse SHALL be a "burst of pseudorandom AWGN" of 200us duration at a level of -90dBm/Hz differential mode. (4) Test the VTU-R modem by repeating the steps above, injecting the white noise and impulses at the customer end of the loop.
Expected Result	The number of errored seconds measured after the initial wait period SHALL be ≤ 1 for the test to pass.

5.3   Dual Latency Test (Optional)

Table 17 - Verification of the Function of Dual Latency (Optional)

Test Configuration	(1) See Section 4.1 for the test configuration (2) According to the VDSL2 band-profile to be tested, configure the SUT with one of the profile-line combinations associated to that band-profile (see section 4.2.3). If, for the specific band-profile, profile-line combinations are defined with DPBO and/or UPBO enabled, these SHALL be applied. (3) Connect the VTU-R to the VTU-O through a loop simulator with Noise generator, and connect VTU-R and VTU-O to Traffic Analyzer. (4) Set two channels with the following channel profiles F-1/0 for channel_1 and I-8/2 for channel_2. (5) Set up the loop simulator for 2400 ft 26AWG cable or 750 m PE 0.4mm cable, with white noise of -140dBm/Hz injected at both the VTU-O and VTU-R ends.
Method of Procedure	(1) Inject -110dBm/Hz white noise disturber at the VTU-O end of the loop. (2) Train the modems using test profiles. (3) Wait for 1 minute after initialization. (4) Run Section 26.2/RFC2544 delay test using traffic analyzer in both channels, use frame size of 1514 bytes. Record the result; Delay1 for channel_1 and Delay2 for channel_2. (5) Inject 15 impulses of 200us duration，a level of -90dBm/Hz differential mode and interval of 1 second at VTU-O end of the loop. Each impulse SHALL be a "burst of pseudorandom AWGN". (6) Record the number of errored seconds reported. (7) Test the VTU-R modem by repeating the steps above, injecting the white noise and impulses at the customer end of the loop
Expected Result	(1) The measured delay on the low latency channel (Delay1) should be lower than the one of the higher latency (Delay2). (2) The number of reported code violations in channel_2 SHALL be less than that of channel_1.

5.4   On-Line Reconfiguration Tests

5.4.1   Bitswap Test

Table 18 - Bitswap Test

Test Configuration	(1) See Section 4.1 for the test configuration.
	
	(2) Set up the loop simulator to:
	
	    a. 1350 ft 26AWG
	       or
	
	    b. 450 m PE 0.4mm

	(3) According to the band-profile to be tested, configure the VTU-O with one of the profile line combinations associated to that band-profile (see section 4.2.3). If for the specific band-profile, profile-line combination is defined with DPBO and/or UPBO enabled, these SHALL be applied. The test SHALL be repeated for both the low and high-delay settings. (4) All single frequency tone amplitudes that are applied are referenced in terms of power levels (dBm) at the injection point on the loop, calibrated with the VTU-R and VTU-O modems replaced with calibrated 100 Ohm ±1% resistors. Measurements performed into a 1kHz resolution bandwidth. Note that with a 1kHz resolution bandwidth the power spectral density value (in dBm/Hz) will be 30dB less than the power level (in dBm), limited by the noise floor of the test equipment used for calibration.
Method of Procedure	(1) With -140dBm/Hz AWGN noise added at both the VTU-O and VTU-R ends, initialize the link to stable Showtime. (2) Wait for 1 minute after completion of initialization. (3) Record the bits allocation tables BITSpsus and BITSpsds. (4) Randomly select an integer value, n, the tone number in the range of one of the bands (DS or US) applicable to the chosen band-profile. Avoid the use of the pilot tone or any unpopulated tones. Ensure that the tone selected has assigned bits as described in the relevant bits per tone map. The frequency of the interfering tone SHALL be set to n x 4.3125 kHz. (5) The power of the interfering tone SHALL be -110 dBm or less. (6) Record and report the value of n used. (7) Record BITSpsus and BITSpsds, and document them as BITSpsus_Old and BITSpsds_Old respectively. (8) Calculate $\sum_i b_i$ of BITSpsus and BITSpsds, and document the results as Total_Bits_US_Old and Total_Bits_DS_Old respectively. (9) Increase the power of the interfering tone to -50 dBm. (10) Observe any bit-swapping operation without retraining of the modems or change in the net data rate. After 2 minutes verify the

	payload and CRC errors have stopped. (There MAY be some initial errors seen when the signal is first inserted on the line.)
	(11) 1 minute after increasing the tone power, record BITSpsus and BITSpsds, and document them as BITSpsus_New and BITSpsds_New respectively.
	(12) Calculate $\sum_i b_i$ of BITSpsus and BITSpsds, and document the results as Total_Bits_US_New and Total_Bits_DS_New respectively.
	(13) Execute a BER test for 2 minutes.
	(14) 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.
	(15) Record the estimated BER
	(16) Repeat steps 1 to 15 for each band applicable to the chosen band-profile.
Expected Result	(1) No retrain SHALL occur during the test.
	(2) BITSpsus_New recorded in step MOP(11) SHALL differ from BITSpsus_Old in step MOP(7), if tone n is in the bands of upstream direction.
	(3) BITSpsds_New recorded in step MOP(11) SHALL differ from BITSpsds_Old in step MOP(7), if tone n is in the bands of downstream direction.
	(4) Total_Bits_US_Old SHALL equal Total_Bits_US_New
	(5) Total_Bits_DS_Old SHALL equal Total_Bits_DS_New
	(6) SES (as recorded in step MOP(14)) SHALL NOT increase
	(7) The estimated BER SHALL NOT exceed $1e^{-7}$.

5.4.2   Wideband Bitswap Test

The noise to be used for the wideband bitswap test is defined in Table 19.
The test procedure for the DS wideband bitswap test is defined in Table 20.
The test procedure for the US wideband bitswap test is defined in Table 21.

Table 19 - Wideband Bit Swap Test Noise Definition

f in kHz	Noise B-AWGN dBm/Hz	Noise B-DS1a dBm/Hz	Noise B-DS1b dBm/Hz	Noise B-DS2 dBm/Hz	Noise B-US1a dBm/Hz	Noise B-US1b dBm/Hz	Noise B-US2 dBm/Hz
25-2500	-110	-110	-110	-110	-110	-110	-110
2500-3650	-110	-104	-98	-110	-110	-110	-110
3650-3850	-110	-110	-110	-110	-110	-110	-110
3850-5100	-110	-110	-110	-110	-104	-98	-110
5100-5300	-110	-110	-110	-110	-110	-110	-110
5300-8400	-110	-110	-110	-98	-110	-110	-110
8400-8600	-110	-110	-110	-110	-110	-110	-110
8600-11900	-110	-110	-110	-110	-110	-110	-98
11900-30M	-110	-110	-110	-110	-110	-110	-110

Table 20 - DS Wideband Bit Swapping Test

Test Configuration	(1) See Section 4.1 for the test configuration.
	(2) Set up the loop simulator to:
	    700 feet 26AWG cable for North America or
	    300 m PE04 for Europe
	(3) Set the noise generator at VTU-O side to B-AWGN noise
	(4) Set the noise generator at VTU-R side to B-DS2 noise
	(5) The VDSL2 profile line combination SHALL be configured as follows.
	    BA17a_RA_I_150_150 for European VDSL2overPOTS or
	    BB17a_RA_I_150_150 for European VDSL2overISDN
	(6) SRA SHALL be disabled

Method of Procedure	(1) Connect the VTU-O and VTU-R. Wait for the modems to sync. (2) Wait for 1 minute after initialization. (3) Record the bit allocation BITSpsds in the Downstream direction. Document it as BITSpsds_Old. (4) Change the noise at VTU-R side to B-AWGN (5) Wait 30 seconds for the bit-swapping to execute. (6) Change the noise at VTU-R side to B-DS1a noise (7) Wait for 30 seconds for the bit-swapping to execute (8) Change the noise at VTU-R side to B-DS1b noise (9) Wait for 30 seconds for the bit-swapping to execute (10) Record the bit allocation, BITSpsds, in the Downstream direction. Document it as BITSpsds_New (11) Start a CRC measurement for 1 minute in the downstream direction

Expected Result	(1) There SHALL be no retrain during the test. (2) BITSpsds_New recorded in MOP(10) SHALL differ from the bit allocation, BITSpsds_Old, in MOP(3), with band DS1 showing a decreased number of bits, and band DS2 showing an increased number of bits. (3) The number of measured CRC's during the measurement period in MOP(11) SHALL be ≤ 1

Table 21 - US Wideband Bit Swapping Test

Test Configuration	(1) See Section 4.1 for the test configuration. (2) Set up the loop simulator to: 700 feet 26AWG cable for North America or 300 m PE04 for Europe (3) Set the noise generator at VTU-R side to B-AWGN noise (4) Set the noise generator at VTU-O side to B-US2 noise (5) The VDSL2 profile line combination SHALL be configured as follows: BA17a_RA_I_150_150 for European VDSL2overPOTS or BB17a_RA_I_150_150 for European VDSL2overISDN (6) SRA SHALL be disabled.
Method of Procedure	(1) Connect the VTU-O and VTU-R. Wait for the modems to sync. (2) Wait for 1 minute after initialization. (3) Record the bit allocation BITSpsus in the Upstream direction. Document it as BITSpsus_Old. (4) Change the noise at VTU-O side to B-AWGN (5) Wait 30 seconds for the bit-swapping to execute. (6) Change the noise at VTU-O side to B-US1a noise (7) Wait 30 seconds for the bit-swapping to execute (8) Change the noise at VTU-O side to B-US1b noise (9) Wait for 30 seconds for the bit-swapping to execute (10) Record the bit allocation BITSpsus in the Upstream direction. Document it as BITSpsus_New. (11) Start a CRC measurement for 1 minute in the Upstream direction
Expected Result	(1) There SHALL be no retrain during the test. (2) BITSpsus_New recorded in MOP(10) SHALL differ from BITSpsus_Old in MOP(3), with band US1 showing an decreased number of bits, and band US2 showing a increased number of bits. (3) The number of measured CRC's during the measurement period in MOP(11) SHALL be ≤ 1

5.4.3   Seamless Rate Adaptation Test (Optional)

The purpose of this test is to verify the functionality of the SRA.

Table 22 - Functional SRA Test

Test Configuration	(1) See Section 4.1 for the test configuration (2) According to the band-profile to be tested, configure the VTU-O with one of the profile-line combinations associated to that band-profile (see section 4.2.3). If, for the specific band-profile, profile-line combinations are defined with DPBO and/or UPBO enabled, these SHALL be applied. (3) Specific Settings	
	Rate Adaptation Mode (RA-MODEds)	DYNAMIC
	Downstream Target Noise Margin (TARSNRMds)	6dB
	Downstream Downshift Noise Margin (RA-DSNRMds)	3dB
	Downstream Minimum Downshift Rate Adaptation Interval(RA-DTIMEds)	30sec
	Downstream Upshift Noise Margin (RA-USNRMds)	9dB
	Downstream Minimum Upshift Rate Adaptation Interval(RA-UTIMEds)	30sec
	Rate Adaptation Mode (RA-MODEus)	DYNAMIC
	Upstream Target Noise Margin (TARSNRMus)	6dB
	Upstream Downshift Noise Margin (RA-DSNRMus)	3dB
	Upstream Minimum Downshift Rate Adaptation Interval(RA-DTIMEus)	30sec
	Upstream Upshift Noise Margin(RA-USNRMus)	9dB
	Upstream Minimum Upshift Rate Adaptation Upstream (RA-UTIMEus)	30sec
Method of Procedure	(1) Connect VTU-O and VTU-R with a stable connection at 1350 ft 26AWG or 450 m PE 0.4mm with –120dBm/Hz AWGN noise added at both the VTU-O and VTU-R ends. (2) Force a new initialization and wait for modems to sync. (3) Wait for 1 minute. (4) Check reported margin, Record bit map, gi map, and the net data rate. Document DS and US net data rate as rate_ds and rate_us, respectively. (5) For Upstream SRA test, increase the noise power level by 1 dB at VTU-O side only For Downstream SRA test, increase the noise power level by 1 dB at VTU-R side only. (6) Wait for 1 minute, then check reported margin. (7) Repeat step 5 and step 6 until the reported margin ＜Downshift Noise	

	Margin(3dB)
	(8) For Upstream SRA test, hold the noise level until its duration > RA-DTIMEus (for Upstream)
	For Downstream SRA test, hold the noise level until its duration > RA-DTIMEds (for Downstream)
	(9) Wait for 2 minutes for SRA to settle
	(10) Check reported margin, and document as SRA_reported_margin_ downshift_us (for Upstream)
	SRA_reported_margin_ downshift_ds (for Downstream)
	(11) Record bi map, gi map, and the net data rate.
	Document DS net data rate for Downstream SRA test as SRA_downshift_rate_ds and US net data rate for Upstream SRA test as SRA_downshift_rate_us.
	(12) Execute a BER test for 7 minutes.
	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.
	(13) For Upstream SRA test, decrease the noise power level by 1 dB at VTU-O side only
	For Downstream SRA test, decrease the noise power level by 1 dB at VTU-R side only.
	(14) Wait for 1 minute, then check reported margin
	(15) Repeat step 13 and step 14 until the reported margin $>$ Upshift Noise Margin (9dB)
	(16) For Upstream SRA test, hold the noise level until its duration > RA-UTIMEus (for Upstream)
	For Downstream SRA test, hold the noise level until its duration > RA-UTIMEds (for Downstream)
	(17) Wait for 2 minute for SRA to settle.
	(18) Check reported margin, and document as SRA_reported_margin_ upshift_us (for Upstream)
	SRA_reported_margin_ upshift _ds (for Downstream)
	(19) Record bi map, gi map, and net data rate Document DS net data rate for Downstream SRA test as SRA_upshift_rate_ds and US net data rate for Upstream SRA test as SRA_upshift_rate_us
	(20) Execute a BER test for 7 minutes.
	(21) 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.
Expected Result	(1) No retrain SHALL occur during the test.
	(2) SRA_reported_margin_ downshift_us ≥RA-DSNRMus + 1 dB;
	SRA_reported_margin_ downshift_ds ≥RA-DSNRMds + 1 dB;
	SRA_reported_margin_ upshift_us≤RA-USNRMus - 1dB;

	SRA_reported_margin_ upshift_ds≤RA-USNRMds - 1dB.
	(3) SRA_downshift_rate_us < rate_us;
	SRA_downshift_rate_ds < rate_ds;
	SRA_upshift_rate_us > rate_us;
	SRA_upshift_rate_ds > rate_ds.
	(4) Estimated BER SHALL NOT exceed $1e^{-7}$, and no SES SHALL be reported.

5.4.4   SOS Test (Optional)

The purpose of this test is to verify that the optional OLR mechanism SOS is implemented according to the directions of Amendment 3 of ITU-T G.993.2. The test SHALL apply to the SOS functionality with enabled ROC (robust overhead channel)

Table 23 – SOS Test In The Downstream

Test Configuration	(1) See Section 4.1 for the test configuration
	(2) The test SHALL be performed with ONE of the following VDSL2 profile line combinations:
	a. BA17a_RA_I_150_150 with 450 m of PE 0.4mm (European VDSL2overPOTS) or
	b. BB17a_RA_I_150_150 with 450 m of PE 0.4mm (European VDSL2overISDN)
	(3) If, for the specific band-profile, profile-line combinations are defined with DPBO and/or UPBO enabled, these SHALL be applied.
Method of Procedure	(1) With -140dBm/Hz AWGN noise added at both the VTU-O and VTU-R ends, initialize the link to stable Showtime. Wait for 1 minute after completion of initialization.
	(2) Choose the following settings.
	a. DS Minimum SOS Bit Rate (MIN-SOS-BR-ds): 20000kbps.
	b. DS SOS time Window (SOS-TIME-ds): 64ms
	c. DS Minimum Percentage of Degraded Tones (SOS-NTONES-ds): 50
	d. DS Minimum Number of normalized CRC anomalies (SOS-CRC-ds): 1
	e. DS Maximum Number of SOS (MAX-SOS-ds): 15
	NOTE: SOS triggering condition specified by parameter SOS-NTONES is superseded with the number of degraded tones $\geq$129 (Section13.4.3.2/G.993.2).
	(3) Disable SOS function.
	(4) Add the crosstalk noise defined for the band-profile under test in TR-114 to the AWGN noise at VTU-R side only.
	(5) Force a new initialization.
	(6) Two minutes through the Showtime record the downstream net data rate as NDR_REINIT_DS (net data rate in the downstream with crosstalk noise achieved if a re-initialization is to occur).
	(7) Remove the crosstalk noise.
	(8) Enable SOS function.
	(9) Force a new initialization.
	(10) Allow to train for 60 seconds to achieve showtime.
	(11) Add the crosstalk noise defined for the band-profile under test in TR-114 to the AWGN noise at VTU-R side only.
	(12) Record the net data rate 1 second after the crosstalk is switched on as NDR_SOS_BEG_DS (net data rate in the downstream with crosstalk noise at the end of SOS).

	(13) Record the data rate 3 minutes after the crosstalk is switched on as the NDR_SOS_END_DS (net data rate in the downstream with crosstalk noise at the end of SRA).

Expected Result	(1) No retrain SHALL occur.
	(2) NDR_SOS_BEG_DS > MIN-SOS-BR-ds
	     NDR_SOS_END_DS> MIN-SOS-BR-ds
	     NDR_SOS_END_DS > 0.8*NDR_REINIT_DS

Table 24 - SOS Test In The Upstream

Test Configuration	(1) See Section 4.1 for the test configuration
	(2) The test SHALL be performed with ONE of the following VDSL2 profile line combinations:
	a. BA17a_RA_I_150_150 with 450 m of PE 0.4mm (European VDSL2overPOTS)
	or
	b. BB17a_RA_I_150_150 with 450 m of PE 0.4mm (European VDSL2overISDN)
	If, for the specific band-profile, profile-line combinations are defined with DPBO and/or UPBO enabled, these SHALL be applied.
Method of Procedure	(1) With -140dBm/Hz AWGN noise added at both the VTU-O and VTU-R ends, initialize the link to stable Showtime. Wait for 1 minute after completion of initialization..
	(2) Choose the following settings.
	a. US Minimum SOS Bit Rate (MIN-SOS-BR-us): 5000kbps.
	b. US SOS time Window (SOS-TIME-us): 64ms
	c. US Minimum Percentage of Degraded Tones (SOS-NTONES-us): 50
	d. US Minimum Number of normalized CRC anomalies (SOS-CRC-us): 1
	e. US Maximum Number of SOS (MAX-SOS-us): 15
	NOTE: SOS triggering condition specified by parameter SOS-NTONES is superseded with the number of degraded tones ≥ 129 (Section13.4.3.2/G.993.2).
	(3) Disable SOS function.
	(4) Add the crosstalk noise defined for the band-profile under test in TR-114 to the AWGN noise at VTU-R side only.
	(5) Force a new initialization.
	(6) Two minutes through the showtime record the downstream net data rate as NDR_REINIT_US (net data rate in the upstream with crosstalk noise achieved if a re-initialization is to occur).
	(7) Remove the crosstalk noise.
	(8) Enable SOS function.
	(9) Force a new initialization.
	(10) Allow to train for 60 seconds to achieve Showtime.
	(11) Add the crosstalk noise defined for the band-profile under test in TR-114 to the AWGN noise at VTU-O side only.
	(12) Record the net data rate 1 second after the crosstalk is switched on as NDR_SOS_BEG_US (net data rate in the

	upstream with crosstalk noise at the end of SOS).
	(13) Record the data rate 3 minutes after the crosstalk is switched on as the NDR_SOS_END_US (net data rate in the upstream with crosstalk noise at the end of SRA).

Expected Result	(1) No retrain SHALL occur.
	 (2) NDR_SOS_BEG_US > MIN-SOS-BR-us
	    NDR_SOS_END_US > MIN-SOS-BR-us
	    NDR_SOS_END_US > 0.8*NDR_REINIT_US

5.5   Loop Diagnostic Mode Test

The purpose of this test is to verify the functionality of the Loop Diagnostic mode. Loop Diagnostic mode is intended to identify channel conditions at both ends of the loop without transitioning to the L0 state. The modems SHALL return to L3 state after completion of the Loop Diagnostic mode. Test parameters exchanged during the Loop Diagnostic mode are defined in Section 11.4.1 of G.993.2 and Section 7.5.1 of G.997.1.

Table 25 - Test on Loop Diagnostic Mode requested by VTU-O

Test Configuration	(1) See Section 4.1 for the test configuration (2) 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 4.2.3). If, for the specific band-profile, profile-line combinations are defined with DPBO and/or UPBO enabled, these SHALL be applied. (3) Specific settings to force the VTU to perform the LD mode: set the line configuration parameter LDSF to 1. (4) Set the background Noise to -120 dBm/Hz.
Method of Procedure	(1) Connect VTU-O and VTU-R with a stable connection at 1350 ft 26AWG loop for the NA region or 450m PE04 or TP100 loop for the EU region with the background noise injected at both the VTU-O and VTU-R ends. (2) Force the line at the VTU-O side to the L3 state. (3) Force the VTU-O to perform the loop diagnostic mode. (4) Collect and record the following "per band" test parameters: LATN, SATN, SNRM, in both downstream and upstream. (5) Collect and record the following test parameters: ATTNDR and ACTATP, in both downstream and upstream. (6) Collect and record the following parameters for the linear channel characteristics function per subcarrier group: HLINSC, HLING, HLINps, in both downstream and upstream. (7) Collect and record the following parameters for the logarithmic channel characteristics function per subcarrier group: HLOGMT,

	HLOGG, HLOGps, in both downstream and upstream.
	(8) Collect and record the following parameters for the Quiet line noise PSD per subcarrier group: QLNMT, QLNG, QLNps, in both downstream and upstream.
	(9) Collect and record the following parameters for the Signal-to-noise ratio per subcarrier group: SNRMT, SNRG, SNRps in both downstream and upstream.
Expected Result	After successful completion of the Loop Diagnostic mode: (1) The line returns to the L3 state (2) Line configuration parameter LDSF set to 0 (3) The requirements for the line diagnostic parameters: Loop attenuation per band (LATN), Signal attenuation per band (SATN) and Signal-to-noise ratio margin per band (SNRM) apply within the specified ranges as specified in Section 7.5.1.9/10, 7.5.1.11/12 and 7.5.1.14/17 of G.997.1. (4) The requirements for the line diagnostic parameters: Attainable net data rate (ATTNDR) and Actual aggregate transmit power (ACTATP) apply within the specified ranges as specified in Section 7.5.1.19/20 and 7.5.1.24/25 of G.997.1. (5) The requirements for the linear channel characteristics function per subcarrier group: representation scale (HLINSC), group size (HLING) and an array of complex values in linear scale for Hlin(f) (HLINps) apply within the specified ranges as specified in Section 7.5.1.26.1-3 and 7.5.1.26.7-9 of G.997.1. (6) The requirements for the logarithmic channel characteristics function per subcarrier group: measurement time (HLOGMT), group size (HLOGG) and an array of real values in dB for Hlog(f) (HLOGps) apply within the specified ranges as specified in Section 7.5.1.26.4-6 and 7.5.1.26.10-12 of G.997.1. (7) The requirements for the Quiet line noise PSD per subcarrier group: measurement time (QLNMT), group size (QLNG) and an array of real values in dBm/Hz for QLN(f) (QLNps) apply within the specified ranges as specified in Section 7.5.1.27.1-3 and 7.5.1.27.4-6 of G.997.1. (8) The requirements for the Signal-to-noise ratio per subcarrier group: measurement time (SNRMT), group size (SNRG) and an array of real values in dB for SNR(f) (SNRps) apply within the specified ranges as specified in Section 7.5.1.28.1-3 and 7.5.1.28.4-6 of G.997.1.

Table 26 - Test on Loop Diagnostic Mode requested by VTU-R

Test Configuration	(1) See Section 4.1 for test configuration. (2) 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 4.2.3). If, for the specific band-profile, profile-line combinations are defined with DPBO and/or UPBO enabled, these SHALL be applied. (3) Specific settings to force the VTU to perform the LD mode: set the line configuration parameter LDSF to 1. (4) Set the background Noise to -120 dBm/Hz.
Method of Procedure	(1) Connect VTU-O and VTU-R with a stable connection at 1350 ft 26AWG loop for the NA region or 450m PE04 or TP100 loop for the EU region with the background noise injected at both the VTU-O and VTU-R ends. (2) Force the line at the VTU-R side to the L3 state. (3) Force the VTU-R to perform the loop diagnostic mode. (4) Collect and record the following "per band" test parameters: LATN, SATN, SNRM, in both downstream and upstream. (5) Collect and record the following test parameters: ATTNDR and ACTATP, in both downstream and upstream. (6) Collect and record the following parameters for the linear channel characteristics function per subcarrier group: HLINSC, HLING, HLINps, in both downstream and upstream. (7) Collect and record the following parameters for the logarithmic channel characteristics function per subcarrier group: HLOGMT, HLOGG, HLOGps, in both downstream and upstream. (8) Collect and record the following parameters for the Quiet line noise PSD per subcarrier group: QLNMT, QLNG, QLNps, in both downstream and upstream. (9) Collect and record the following parameters for the Signal-to-noise ratio per subcarrier group: SNRMT, SNRG, SNRps in both downstream and upstream.
Expected Result	After successful completion of the Loop Diagnostic mode: (1) The line returns to remain in the L3 state (2) Line configuration parameter LDSF set to 0 (3) The requirements for the line diagnostic parameters: Loop attenuation per band (LATN), Signal attenuation per band (SATN) and Signal-to-noise ratio margin per band (SNRM) apply within the specified ranges as specified in Section 7.5.1.9/10, 7.5.1.11/12 and 7.5.1.14/17 of G.997.1. (4) The requirements for the line diagnostic parameters: Attainable net data rate (ATTNDR) and Actual aggregate transmit power (ACTATP) apply within the specified ranges as specified in Section 7.5.1.19/20 and 7.5.1.24/25 of G.997.1. (5) The requirements for the linear channel characteristics function per subcarrier group: representation scale (HLINSC), group size (HLING) and an array of complex values in linear scale for Hlin(f) (HLINps) apply within the specified ranges as specified in Section 7.5.1.26.1-3 and 7.5.1.26.7-9 of G.997.1.

	(6) The requirements for the logarithmic channel characteristics function per subcarrier group: measurement time (HLOGMT), group size (HLOGG) and an array of real values in dB for Hlog(f) (HLOGps) apply within the specified ranges as specified in Section 7.5.1.26.4-6 and 7.5.1.26.10-12 of G.997.1.
	(7) The requirements for the Quiet line noise PSD per subcarrier group: measurement time (QLNMT), group size (QLNG) and an array of real values in dBm/Hz for QLN(f) (QLNps) apply within the specified ranges as specified in Section 7.5.1.27.1-3 and 7.5.1.27.4-6 of G.997.1.
	(8) The requirements for the Signal-to-noise ratio per subcarrier group: measurement time (SNRMT), group size (SNRG) and an array of real values in dB for SNR(f) (SNRps) apply within the specified ranges as specified in Section 7.5.1.28.1-3 and 7.5.1.28.4-6 of G.997.1.

5.6   VTU-R Inventory Test

The purpose of this test is to verify that the VTU-R inventory formatting is correct according to Section 7.4 of G.997.1 and the information contained within the fields is consistent with the equipment identification information provided by the equipment supplier to the test lab.

Table 27 - VTU-R Inventory Information Test

Test Configuration	(1) See Section 4.1 for the test configuration (2) According to the VDSL2 band-profile to be tested, configure the SUT with one of the profile line combinations associated to that band-profile (see section 4.2.3). If, for the specific band-profile, profile-line combinations are defined with DPBO and/or UPBO enabled, these SHALL be applied.
Method of Procedure	(1) Force a new initialization and wait for VTU-R to sync. (2) Wait for 1 minute after initialization for EoC data to be exchanged.

Expected Results	(1) VTU-R Vendor ID is correct as specified in Section 7.4.2/G.997.1
	    a. The T.35 country code (2 octets) is correct for the country of the vendor of the VTU-R VDSL2 Chipset.
	    b. The T.35 provider code (vendor identification) (4 octets) correctly identifies the vendor of the VDSL2 Chipset.
	
	(2) VTU-R System Vendor ID is correct as specified in Section 7.4.4/G.997.1
	    a. The T.35 country code (2 octets) is correct for the country of the system integrator (VTU-R vendor).
	    b. The T.35 provider code (vendor identification) (4 octets) correctly identifies VTU-R vendor.
	
	Note: System Vendor ID MAY be different from the Vendor ID.

	(3) VTU-R version number is correct as specified in Section 7.4.6/G.997.1
	a. It contains the VTU-R firmware version and the VTU-R model. Both SHALL be encoded in this order and separated by a space character, i.e. "\<VTU-R firmware version> \<VTU-R model>".
	(4) VTU-R serial number is correct as specified in Section 7.4.8/G.997.1
	a. It contains the equipment serial number, the equipment model and the equipment firmware version. All SHALL be encoded in this order and separated by space characters, i.e. "\<equipment serial number> \<equipment model> \<equipment firmware version>".

5.7   PSD Tests

5.7.1   PSD Mask Test

The purpose of this test is to verify that the VTU-O and VTU-R power spectral density (PSD) mask in Showtime does not exceed the mask set forth by ITU-T VDSL2 standard. This measurement SHALL include both the passband and stopband frequencies.

Table 28 - PSD Mask Test

Test Configuration	(1) The VTU modems SHALL be connected as shown in Section 4.1
	(2) The test setup SHALL support the PSD mask measurement over the entire downstream and upstream bands and SHALL provide enough dynamic range to allow the measurements be done over both the passband and stopband frequencies into a resolution bandwidth less than or equal to 10 kHz.
	(3) Configure the VTU-O with the general line setting "F-1/0" defined in Section 4.2.2.2.
	(4) According to the band-profile to be tested, configure the VTU-O with one of the profile line combinations associated with that band-profile (see 4.2.3).
	Note: this PSD test is conceived for profile-line combinations with PBO disabled.
	(5) Line simulator SHALL be set up for the straight homogeneous loop specified for the regional annex, Section 4.4. Its length SHALL be varied in 5 steps from the NULL loop to the length at which the loop is the equivalent of 20dB @ 1MHz. Alternatively, a flat attenuator MAY be used to perform the measurements, provided its value matches the attenuation of the equivalent loop at 1MHz

Method of Procedure	(1) Connect and configure the VTU-O and VTU-R as per test configuration details.
	(2) Set spectrum analyzer for the requested frequency range, resolution bandwidth and input attenuation range to prevent it from being over driven.
	(3) Force initialization and wait for modems to synchronize.
	(4) Wait 1 minute following synchronization. Disconnect the line. The VDSL2 link SHOULD stay in L0 stay long enough for the PSD to be measured. If it does not see the Note below.
	(5) PSD SHALL be measured in one of the following ways:
	a. over a resistive load of 100 ohms (the same value as the VTU termination impedance) and a high-impedance differential probe
	b. over a wideband 50:100 BALUN transformer (assumes 50ohm analyser)
	If the characteristic of the balun or resistor is not calibrated out, it SHALL have an effect of ≤ 0.5dB on the PSD measurement
	(6) Take a note of the measured downstream and upstream PSD data.
	(7) Repeat the test steps 3 through 6 for all five loop lengths (between NULL loop and the defined maximum loop) according to test configuration TC(5).
	NOTE: If the VTUs can not operate in the mode described in MOP(4), the test setup SHALL provide adequate isolation of the downstream and upstream transmit signals between the two transceivers to allow for an accurate measurement to be made, while both transceivers remain connected and in state L0. If mode described in MOP(4) is unavailable, the measurements will not be made on loops or attenuation settings not providing adequate isolation, and the measurement method used will be noted within the test report.
Expected Result	Measured PSD mask SHALL comply with the requirements from Section 7.2.3/G.993.2 [2] and SHALL not exceed the Limit PSD mask (LIMITMASK).

5.7.2   Aggregate Transmit Power Test

The purpose of this test is to verify that the VTU-O and VTU-R does not transmit the total amount of transmit power that exceeds the maximum downstream/upstream transmit power specified in G.993.2 standard for each VDSL2 profile. The aggregate transmit power SHALL be measured over the entire passband and stopband frequencies.

Table 29 - Aggregate Transmit Power Test

Test Configuration	(1) The VTU modems SHALL be connected as shown in Section 4.1
	(2) The test setup SHALL support the aggregate transmit power (ATP) measurement over the entire downstream and upstream bands and SHALL provide enough dynamic range to allow the measurements be done over both the passband and stopband frequencies into a resolution bandwidth less than or equal to 10 kHz.
	(3) Configure the VTU-O with the general line setting "F-1/0" defined in

	Section 4.2.2.2. (4) According to the band-profile to be tested, configure the VTU-O with one of the profile line combinations associated with that band-profile (see 4.2.3). Note: this ATP test is conceived for profile-line combinations with PBO disabled. (5) Line simulator SHALL be set up for the straight homogeneous loop specified for the regional annex Section 4.4. Its length SHALL be varied in 5 steps from the NULL loop to the length at which the loop is the equivalent of 20dB @ 1MHz. Alternatively, a flat attenuator MAY be used to perform the measurements, provided its value matches the attenuation of the equivalent loop at 1MHz

Method of Procedure	(1) Connect and configure the VTU-O and VTU-R as per test configuration details.
	(2) Force initialization and wait for modems to synchronize.
	(3) Wait 1 minute following synchronization. Disconnect the line. The VDSL2 link SHOULD stay in L0 stay long enough for the ATP to be measured. If it does not see the Note in Table 28.
	(4) ATP SHALL be measured in one of the following ways:
	    a. over a resistive load of 100 ohms (the same value as the VTU termination impedance) and a high-impedance differential probe
	    b. over a wideband 50:100 BALUN transformer (assumes 50ohm analyser)
	
	If the characteristic of the balun or resistor is not calibrated out, it SHALL have an effect of ≤ 0.5dB on the power measurement
	
	(5) Take a note of the measured downstream and upstream aggregate transmit power
	(6) Repeat the test steps 2 through 5 for all five loop lengths (between NULL loop and the defined maximum loop) according to the test configuration TC(5).

Expected Result	Measured aggregate transmit power SHALL not exceed the maximum aggregate downstream/upstream transmit power specified in Table 6-1/G.993.2 [2].

5.7.3   In-band Spectral Shaping Test

The purpose of this test is to verify the ability of VDSL2 transmitters to reduce the PSD of the transmitted signal to a level below -80dBm/Hz in 16 arbitrary frequency bands simultaneously. An example list of frequency bands is shown in Table 30. The data is sourced from ITU-T G.993.2 and T-Systems. First two RFI notches are in line with the specification from TR-100 (section A.1 and B.3.7).

Table 30 - List of some predefined RFI Notches
(source: Europe/Germany, incl. international amateur radio bands)

Frequency	Application	
1,800 – 2,000 MHz	amateur radio	
2,173 – 2,191 MHz	GMDSS (Global Maritime Distress and Safety Service)	
2,850 – 3,155 MHz	aeronautical communications	
3,400 – 3,500 MHz	aeronautical communications	
3,500 – 3,800 MHz	amateur radio	
3,800 – 4,000 MHz	aeronautical communications / broadcasting	
3,500 – 4,000 MHz	amateur radio	
4,200 – 4,215 MHz	GMDSS	
4,650 – 4,850 MHz	aeronautical communications	
5,450 – 5,730 MHz	aeronautical communications	
5,900 – 6,200 MHz	(future) DRM radio (broadcasting)	
6,300 – 6,320 MHz	GMDSS	
6,525 – 6,765 MHz	aeronautical communications	
7,000 – 7,300 MHz	amateur radio	
7,000 – 7,200 MHz	amateur radio	
7,200 – 7,450 MHz	(future) DRM radio (broadcasting)	
8,405 – 8,420 MHz	GMDSS	
8,815 – 9,040 MHz	aeronautical communications	
9,400 – 9,900 MHz	(future) DRM radio	
10,005 – 10,100 MHz	aeronautical communications	
10,100 – 10,150 MHz	amateur radio	
11,175 – 11,400 MHz	aeronautical communications	
11,600 – 12,100 MHz	(future) DRM radio (Broadcasting)	
12,570 – 12,585 MHz	GMDSS	
13,200 – 13,360 MHz	aeronautical communications	
13,570 – 13,870 MHz	(future) DRM radio (Broadcasting)	
14,000 – 14,350 MHz	amateur radio	
15,010 – 15,100 MHz	aeronautical communications	
15,100 – 15,800 MHz	(future) DRM radio (broadcasting)	
16,795 – 16,810 MHz	GMDSS	
17,480 – 17,900 MHz	(future) DRM radio (broadcasting)	
17,900 – 18,030 MHz	aeronautical communications	
18,068 – 18,168 MHz	amateur radio	
21,000 – 21,450 MHz	amateur radio	
24,890 – 24,990 MHz	amateur radio	
26,965 – 27,405 MHz	CB radio	
28,000 – 29,700 MHz	amateur radio	

Table 31 - In-band Spectral Shaping / RFI Notch Configuration Test

Test Configuration	(1) The VTU modems SHALL be connected as shown in Section 4.1 (2) The test setup SHALL support the PSD mask and aggregate transmit power (ATP) measurements over the entire downstream and upstream bands and SHALL provide enough dynamic range to allow the measurements be done over both the passband and stopband frequencies into a resolution bandwidth less than or equal to 10 kHz. (3) Configure the VTU-O with the general line setting "F-1/0" defined in Section 4.2.2.2. (4) According to the band-profile to be tested, configure the VTU-O with one of the profile line combinations associated with that band-profile (see 4.2.3). If, for the specific band-profile, profile-line combinations are defined with DPBO and/or UPBO enabled, these SHALL be applied. (5) Line simulator SHALL be set up for the straight homogeneous loop specified for the regional annex, Section 4.4. Its length SHALL be set to the length at which the loop is the equivalent of 20dB @ 1MHz. Alternatively, a flat attenuator MAY be used to perform the measurements, provided its value matches the attenuation of the equivalent loop at 1MHz.

Method of Procedure	(1) Set spectrum analyzer for the requested frequency range, resolution bandwidth and input attenuation range to prevent it from being overridden.
	(2) Configure 16 different RFI bands. A list of possible configuration is shown in Table 30.
	(3) Force initialization and wait for modems to synchronize.
	(4) Wait 1 minute following synchronization.
	(5) Disconnect the line. The VDSL2 link SHOULD stay in L0 stay long enough for the PSD to be measured. If it does not see the Note in Table 28.
	(6) PSD SHALL be measured, while ATP could be measured or calculated from the PSD. in one of the following ways:
	    a. over a resistive load of 100 ohms (the same value as the VTU termination impedance) and a high-impedance differential probe.
	    b. over a wideband 50:100 BALUN transformer (assumes 50 ohm analyser).
	If the characteristic of the balun or resistor is not calibrated out, it SHALL have an affect of ≤ 0.5dB on the measurement.
	(7) Take a note of the measured downstream and upstream PSD data.
	(8) Take a note of the measured or calculated downstream and upstream ATP.

Expected Result	Measured PSD mask SHALL comply with the requirements from Section 7.2.3/G.993.2 [2] and SHALL not exceed the Limit PSD mask (LIMITMASK).

5.7.4   Downstream Power Back-off Test

The purpose of this test is to verify the modified VTU-O transmit PSD mask based on the downstream power back-off configuration parameters and procedure described in section 7.3.1.2.13 in G.997.1.

Table 32 - Downstream Power Back-Off Test

Test Configuration	(1) The VTU modems SHALL be connected as shown in Section 4.1
	(2) The test setup SHALL support the PSD mask and aggregate transmit power (ATP) measurements over the entire downstream bands and SHALL provide enough dynamic range to allow the measurements be done over both the passband and stopband frequencies into a resolution bandwidth less than or equal to 10 kHz.
	(3) Configure the VTU-O with the general line setting "F-1/0" defined in Section 4.2.2.2.
	(4) According to the band-profile to be tested, configure the VTU-O with one of the profile line combinations associated with that band-profile (see 4.2.3).
	If, for the specific band-profile, profile-line combinations are defined with UPBO enabled, apply the related UPBO configuration parameters. Otherwise define one set of UPBO parameters (a, b) for each upstream band.
	(5) Line simulator SHALL be set up for the straight homogeneous loop specified for the regional annex Section 4.4. Its length SHALL be set to the length at which the loop is the equivalent of 20dB @ 1MHz. Alternatively, a flat attenuator MAY be used to perform the measurements, provided its value matches the attenuation of the equivalent loop at 1MHz.

Method of Procedure	(1) Set spectrum analyzer for the requested frequency range, resolution bandwidth and input attenuation range to prevent it from being overridden.
	 (2) Define DPBOESEL in the range of 10 dB to 60 dB, in 10 dB steps.
	 (3) Force initialization and wait for modems to synchronize.
	 (4) Wait 1 minute following synchronization.
	 (5) Disconnect the line. The VDSL2 link SHOULD stay in L0 stay long enough for the PSD to be measured. If it does not see the Note in Table 28.
	 (6) PSD SHALL be measured, while ATP could be measured or calculated from the PSD. in one of the following ways:
	
	     a. over a resistive load of 100 ohms (the same value as the VTU termination impedance) and a high-impedance differential probe
	     b. over a wideband 50:100 BALUN transformer (assumes 50ohm analyser)
	
	If the characteristic of the balun or resistor is not calibrated out, it SHALL have an affect of ≤ 0.5dB on the measurement
	
	 (7) Take a note of the measured PSD data.
	 (8) Take a note of the measured or calculated ATP.
	 (9) Repeat the test steps 3 through 8 for all DPBOESEL values (20dB, 30dB, 40dB, 50dB and 60dB) defined in step 2

Expected Result	Measured PSD mask SHALL comply with the requirements from Section 7.3.1.2.13/G.997.1 and SHALL not exceed the resultant mask (RESULTMASK).

5.7.5   Upstream Power Back-off Test

The purpose of this test is to verify that the upstream power back-off (UPBO) mechanism in the VTU-R is implemented correctly according to the directions of section 7.2.1.3 in G.993.2 standard and that the VTU-R transmit signal in Showtime is adapted to conform to the upstream power back-off mask UPBOMASK(kl_o,f) while remaining below the transmit PSD mask limit communicated to the VTU-R at the beginning of initialization and within the limit imposed by the upstream PSD ceiling. One set of configuration parameters (a,b) for the UPBO reference PSD SHALL be defined for each upstream band in the selected VDSL2 band-profile, except the US0.

Table 33 - Upstream Power Back-Off Test

Test Configuration	(1) The VTU modems SHALL be connected as shown in Section 4.1
	(2) The test setup SHALL support the PSD mask and aggregate transmit power (ATP) measurements over the entire upstream bands and SHALL provide enough dynamic range to allow the measurements be done over both the passband and stopband frequencies into a resolution bandwidth less than or equal to 10 kHz.
	(3) Configure the VTU-O with the general line setting "F-1/0" defined in Section 4.2.2.2.
	(4) According to the band-profile to be tested, configure the VTU-O with one of the profile line combinations associated with that band-profile (see 4.2.3).
	
	If, for the specific band-profile, profile-line combinations are defined with DPBO enabled, apply the related DPBO configuration parameters. Otherwise define one set of DPBO parameters.
	
	(5) Line simulator SHALL be set up for the straight homogeneous loop specified for the regional annex, Section 4.4 Its length SHALL be set to the length at which the loop is the equivalent of:
	    a. 0dB @ 1MHz;
	    b. 10dB @ 1MHz;
	    c. 20dB @ 1MHz
	Alternatively, a flat attenuator MAY be used to perform the measurements, provided its value matches the attenuation of the equivalent loop at 1MHz

Method of Procedure	(1) Set spectrum analyzer for the requested frequency range, resolution bandwidth and input attenuation range to prevent it from being overridden.
	(2) Force initialization and wait for modems to synchronize.
	(3) Wait 1 minute following synchronization.
	(4) Disconnect the line. The VDSL2 link SHOULD stay in L0 stay long enough for the PSD to be measured. If it does not see the Note in Table 28.
	(5) PSD SHALL be measured, while ATP could be measured or calculated from the PSD, in one of the following ways:
	    a. over a resistive load of 100 ohms (the same value as the VTU termination impedance) and a high-impedance differential probe
	    b. over a wideband 50:100 BALUN transformer (assumes 50ohm analyser)
	If the characteristic of the balun or resistor is not calibrated out, it SHALL have an affect of ≤ 0.5dB on the measurement
	
	(6) Take a note of the measured PSD data.
	(7) Take a note of the measured or calculated ATP.
	(8) Take a note of the estimated electrical length kl_0 (UPBOKLE).
	(9) Repeat the test steps MOP(2) through MOP(8) for all three loop lengths (between NULL loop and the defined maximum loop) according to the test configuration TC(5).
	(10) Maintaining the test loop equivalent to 20 dB @ 1MHz. Force the VTU-R to use the electrical length kl_o configured by the CO-MIB (UPBOKL) to compute the UPBO. Set the kl_o value to 15dB and repeat steps 2 through 7.

Expected Result	Measured PSD mask SHALL comply with the requirements from Section 7.2.1.3.2/G.993.2 [2] and SHALL not exceed the reference UPBO mask (UPBOMASK).

5.8   Longitudinal Conversion Loss (LCL) Test

The purpose of this test is to verify the longitudinal conversion loss (LCL) of the VDSL2 transceiver fulfills the requirement from section 7.4 in G.992.3. LCL is a measure in dB of the degree of unwanted transversal signal produced at the input of the VDSL2 transceiver (V_{diff}) due to the presence of a longitudinal signal (V_{cm}) on the connecting leads: LCL=20 log $|V_{cm}/V_{diff}|$

Table 34 - Longitudinal Conversion Loss (LCL) Test

Test Configuration	(1) See Section 4.1 for the test configuration (2) As per VDSL2 band-profile to be tested, configure the SUT in one of the profile line combinations associated to that band-profile (see Section 4.2.3) (3) During the test, the transceiver under test SHALL be powered in L3 state and not transmitting any signal.
Method of Procedure	(1) Measure the LCL as specified in ITU-T Recommendation G.117 [9] and O.9 [8]
Expected Result	(1) LCL ≥38 dB in the frequency band up to 12 MHz. (2) LCL $\geq$ 38 dB $-$ 20 $\log_{10}(f_{[MHz]}/12)$ for 12 MHz $< f <$ Fmax,

5.9   Virtual Noise Test (Optional)

The purpose of this test is to verify that the virtual noise mechanism in the VTU-R/O is implemented correctly according to the directions of section 11.4.1.1.6.1.2 in G.993.2 standard. A transmitter referred virtual noise profile will be programmed in the VTU-O. The modem SHALL be trained on a quiet line and then simulated crosstalk noise SHALL be added to the line at transmitter side, with PSD equal to the transmitter referred virtual noise profile The modem SHALL not lose synchronization and the recorded margin SHALL not drop by more than 3 dB when the external noise injection is enabled. The crosstalk noise SHALL only be injected at one end of the loop at once, in order to avoid noise from both ends of the system combining, causing deviation from the desired noise PSD.

The noise profile suggested corresponds to a crosstalk from a group of VDSL2 systems operating using band profile BA8c.

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

Table 35 - Transmitter Referred Virtual Noise VTU-O

Freq / MHz	VN PSD / dBm/Hz
0.0	-140
0.137	-140
0.138	-127.2
2.999	-100.5
3.0	-140

5.1	-135.8
5.101	-95.8
7.05	-93.0
7.051	-133
30.0	-120.5

Table 36 - Tranmitter Referred Virtual Noise Functionality Test

Test Configuration	(1) The test setup SHALL support simulated crosstalk generation over the entire VDSL active transmission band. (2) The VTU modems SHALL be connected as shown in Section 4.1 and configured in the general line-setting "F-1/0" defined in Section4.2.2.2. (3) According to the band-profile to be tested, configure the VTU-O with one of the profile line combinations associated with that band-profile". (4) The SNRMODEds SHALL be set to 2, which implies SNRM_MODE (as defined in G.993.2) is set to 2. (5) Line simulator SHALL be set up for the straight homogeneous loop specified for the regional annex in Section 4.4. Its length SHALL be varied in 3 steps from the NULL loop to the length at which the loop is the equivalent of 20dB @ 1MHz. (6) Inject −140dBm/Hz AWGN noise at both the VTU-O and VTU-R.
Method of Procedure	(1) Connect and configure the VTU-O and VTU-R as per test configuration details. (2) Define virtual noise mask for downstream direction. (3) Force initialization and wait for modems to synchronize. (4) Wait 1 minute following synchronization (5) Record the downstream SNR margin. (6) Noise injection SHALL be configured to generate simulated crosstalk noise with PSD equal to the transmitter referred virtual noise for VTU-O. This noise SHALL be injected on the loop at the VTU-O side. (7) After 1 minute, record the downstream SNR margin. (8) Repeat the test steps 3 through 7 for the 3 loop lengths.
Expected Result	(1) Link SHALL not retrain when simulated crosstalk is turned on. (2) For each loop the SNR Margin drop SHALL be ≤ 3 dB when simulated crosstalk noise is turned on.

6   System Level Tests

6.1   64/65-Octet Encapsulation Far-End PTM-TC Performance Monitoring Test (Optional)

The purpose of this test is to verify that the access node and CPE use the IEEE802.3 Clauses 30, 45 and 57 for retrieval and reporting at the access node of the 64/65-Octet Encapsulation Far-End PTM-TC Performance Monitoring counters.

The PTM-TC functionality of VDSL2 implements 64/65-octet encapsulation is defined in Annex N/G.992.3 (see K.3.8/G.993.2 [2]).

However, the far end counters are not supported by the indicator bits or EOC messages specified in the G.992.x-series of ITU-T Recommendations or in ITU-T Rec. G.993.2. They MAY be provided if the higher layer protocol running over this PTM-TC provides means (outside the scope of these Recommendations) to retrieve far end PTM-TC surveillance primitives from the far end, or through the proprietary OAM communication channel specified in clause 6 of G.997.1 (refer to the PTM data path far-end performance monitoring parameters in 7.2.5.2 /G.997.1).

If the PTM-TC carries Ethernet packets (IEEE Std 802.3ah-2005), the Ethernet management function (residing above the γ reference point) maps the near end surveillance primitives and counters (obtained over the γ interface through access to clause 45 MDIO registers) into MIB objects defined in clause 30. MIB objects are exchanged with the far end using the Ethernet OAM PDU format and protocol defined in clause 57 (7.2.5.2 /G.997.1).

For the purpose of this optional system level test, the Access Node SHALL support the following minimum functionality related to IEEE802.3:

- The AN SHALL operate in Active Mode (Clause 57.2.9).
- The AN SHALL support CPE operating in Passive Mode (Clause 57.2.9).
- The AN SHALL initiate OAM Discovery (Clause 57.3.2.1).
- The AN SHALL send and receive Information OAMPDUs (Clause 57.4.3.1).
- The AN SHALL send Variable Request OAMPDUs (Clause 57.4.3.3).
- The AN SHALL receive Variable Response OAMPDUs (Clause 57.3.2.1).
- The Clause 30 OAM counters SHALL be reported at the Q interface. The reporting format is out of the scope of this test, and MAY be one of the following examples:
  - i. Non-resettable counters (i.e., the format used in IETF EFMCu MIB [1]);
  - ii. Current/previous 15 minutes/1 day counters (i.e., the format used in ITU T G.997.1).

The CPE SHALL support the following minimum functionality related to IEEE 802.3:

- The CPE SHALL operate in Passive Mode if the OAM Discovery process cannot be successfully completed with CPE in Active Mode (Clause 57.2.9).
- The CPE SHALL react to OAM Discovery process initiation (Clause 57.3.2.1).
- The CPE SHALL receive Variable Request OAMPDUs (Clause 57.4.3.3).
- The CPE SHALL send Variable Response OAMPDUs (Clause 57.4.3.4).
- The CPE SHALL support the TCCRCErrors and TCCodingViolations counters (Clause 30.11.2.1.9&10)

▪ The Clause 30 OAM counters (as contained in Variable Response OAMPDUs received from the CPE) SHALL be non-resettable counters (see 30.11.2.1.9&10), derived from the related Clause 45 MDIO registers (see Clause 45.2.6.11 and 45.2.6.12). The Clause 30 OAM counters SHALL be cleared to all zeros at system reset (as the Clause 45 registers) and SHALL not be cleared with a link state transition or when read

Table 37 - 64/65-Octet Encapsulation Far-End PTM-TC Performance Monitoring Test (Optional)

Test Configuration	(1) See Section 4.1 for the test configuration. (2) Configure the SUT with specific line setting: FX_I_010_001 and the band-profile chosen for the test.
Method of Procedure	(1) Connect VTU-R and VTU-O with 0 length loop and no noise injected. (2) Force an initialization and wait for modem to sync. Wait 1 minute following synchronization. (3) Activate the CRC-PFE and CV-PFE performance monitoring counters on the access node. (4) Record the initial values of the CRC-PFE and CV-PFE performance monitoring counters at the access node. (5) Force a "micro-interruption" of 3ms (+ or − 0.5ms) every 10 seconds for 2.5min (for a total of 15 micro-interruptions). (6) Force performance monitoring counters update or wait for the counters to be updated at the access node. (7) Record the value of the CRC-PFE and CV-PFE performance monitoring counters at the access node.

Expected Result	(1) The VTU-R SHALL not lose sync with the VTU-O during the test.
	
	(2) The test result SHALL consist of reporting at the Q-interface (i.e., at the Access Node) the following two Clause 30 OAM counters:
	
	    a. CRC-PFE: Downstream TCCRCErrors counter (32-bit)
	    b. CV-PFE: Downstream TCCodingViolations (32-bit)
	
	(3) The Clause 30 OAM counters SHALL be observed before and after errors are induced on the loop. The test is passed if the downstream TCCodingViolations counter changes because of the errors induced. The downstream TCCRCErrors counter MAY or MAY not change, depending on the impact of the errors induced on the received 64/65-octet encapsulation syntax.

NOTE: Further information on OAMPDU is provided in Appendix I.

7   Testing G.ploam Configuration Parameters and Performance Monitoring Counters

These tests verify the G.ploam configuration parameters and performance monitoring counters.

7.1   Configuration Parameter MINSNRM

A test procedure for verification of the MINSNRM noise margin configuration parameter is shown in Table 38. The parameters MINSNRMds and MINSNRMus define the minimum noise margin the VTU-R/VTU-O receiver SHALL tolerate. This test procedure SHALL be applied to both the downstream and upstream directions.

Table 38 - MINSNRM Control Test

Test Configuration	(1) See Section 4.1 for the test configuration.
	(2) As per VDSL2 band-profile to be tested, configure the SUT in one of the profile line combinations associated to that band-profile in the rate adaptive mode (see Section 4.2.3).
	(3) Additional test conditions: MINSNRM = 1dB, 2dB and 3dB
Method of Procedure	(1) Connect VTU-R and VTU-O through the shortest loop length defined for the chosen profile-line combination in the regional annex of TR-114.
	(2) Inject -140dBm/Hz AWGN noise added at both the VTU-R and VTU-C ends. This power level is considered the 0dB noise power.
	(3) Let the modems train. Wait for 1 minute after initialization.
	(4) Record the reported SNR margin. SNRMds and SNRMus
	(5) Increase the noise power level by 1dB. Wait for 1 minute.
	(6) Record the reported SNR margin.
	(7) Repeat step 5 until the reported SNR margin becomes lower than MINSNRM.
	(8) Repeat the test for each MINSNRM.
Expected Result	For each test Modems SHALL retrain if the reported SNR margin is lower than MINSNRM.

7.2   Configuration Parameter TARSNRM

A test procedure for verification of the TARSNRM noise margin configuration parameter is shown in Table 39. The parameters TARSNRMds and TARSNRMus define the noise margin the

VTU-R/VTU-O receiver SHALL achieve to successfully complete initialization. This test procedure SHALL be applied to both the downstream and upstream directions.

Table 39 - TARSNRM Control Test

Test Configuration	(1) See Section 4.1 for the test configuration. (2) As per VDSL2 band-profile to be tested, configure the SUT in one of the profile line combinations associated to that band-profile in the rate adaptive mode (see Section 4.2.3).
Method of Procedure	(1) Connect VTU-R and VTU-O through the second loop length defined for the chosen profile-line combination in the regional annex of TR-114 (2) Inject the crosstalk noise applicable for that testloop at both the VTU-R and VTU-O ends. (3) Let the modems train. Wait for 1 minute after initialization. (4) Record the reported SNR margin, SNRMds and SNRMus. (5) Repeat the test 3 times.
Expected Result	(1) For Region A: Each reported SNR margin SHALL be $\geq$ (TARSNRM – 2 dB). (2) For Region B: Each reported SNR margin SHALL be $\geq$ (TARSNRM – 1 dB).

7.3   Configuration Parameter PSDMASK

A test procedure for verification of the PSDMASK configuration parameter is shown in Table 40. The parameters PSDMASKds and PSDMASKus define the MIB PSD mask MIBMASK and it MAY impose additional PSD restrictions for the passbands compared to the Limit PSD mask specified in the regional annexes of G.993.2.

Table 40 - PSDMASK Control Test

Test Configuration	(1) SeeSection 4.1 for the test configuration. (2) 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 4.2.3). (3) Additional test conditions: a. Set the PSDMASK for passbands only and restrict the transmit PSD to levels below those allowed by the applicable Limit PSD mask
Method of Procedure	(1) Connect VTU-R and VTU-O through the shortest loop length defined for the chosen profile-line combination in the regional annex of TR-114 (2) Wait 1 minute following synchronization

	(3) Disconnect the line. The VDSL2 link SHOULD stay in L0 stay long enough for the PSD to be measured. If it does not see the Note in Table 28
	(4) The PSD SHALL be measured in one of the following ways:
	a. over a resistive load of 100 ohms (the same value as the VTU termination impedance) and a high-impedance differential probe
	b. over a wideband 50:100 BALUN transformer (assumes 50ohm analyser)
	If the characteristic of the balun or resistor is not calibrated out, it SHALL have an effect of ≤ 0.5dB on the power measurement
Expected Result	Measured PSD SHALL NOT exceed the MIB PSD mask (MIBMASK) and Limit PSD mask (LMITMASK), and SHALL comply with the requirements from Section 7.2.3/G.993.2. [2]

7.4   Configuration Parameter VDSL2-CARMASK

A test procedure for verification of the VDSL2-CARMASK configuration parameter is shown in Table 41. This parameter defines the restrictions, additional to the band plan, to determine the set of subcarriers allowed for transmission.   Test procedure SHALL be applied to both the downstream and upstream directions.

Table 41 - VDSL2 CARMASK Control Test

Test Configuration	(1) See Section 4.1 for the test configuration.
	(2) As per VDSL2 the band-profile to be tested, configure the SUT in one of the profile-line combinations associated to that band-profile (see section 4.2.3).
Method of Procedure	(1) Configure VTU-R and VTU-O with target SNR margin set to 6dB. Set VDSL2-CARMASK to one that is associated with the used profile line combination.
	(2) Connect VTU-O and VTU-R through the shortest loop length defined for the chosen profile-line combination in the regional annex of TR-114.
	(3) Let the modems train. Wait for 1 minute after initialization.
Expected Result	The reported bits of disabled subcarriers BITSpsds and BITSpsus SHALL be set to 0.

7.5   Configuration Parameter MAXNOMATP

A test procedure for verification of the MAXNOMATP configuration parameter is shown in Table 42. This test procedure SHALL be applied to both the downstream and upstream directions.

Table 42 - MAXNOMATP Control Test

Test Configuration	(1) See Section 4.1 for the test configuration.
	(2) As per VDSL2 band-profile to be tested, configure the SUT in one of the profile-line combinations associated to that band-profile (see section 4.2.3).
Method of Procedure	(1) Connect VTU-O and VTU-R through the shortest loop length defined for the chosen profile-line combination in the regional annex of TR-114
	(2) Wait 1 minute following synchronization
	(3) Disconnect the line. The VDSL2 link SHOULD stay in L0 stay long enough for the power to be measured. If it does not see the Note in Table 28.

	(4) The power generated SHALL be measured in one of the following ways:
	
	    a. over a resistive load of 100 ohms (the same value as the VTU termination impedance) and a high-impedance differential probe
	    b. over a wideband 50:100 BALUN transformer (assumes 50ohm analyser)
	
	If the characteristic of the balun or resistor is not calibrated out, it SHALL have an effect of ≤ 0.5dB on the power measurement

Expected Result	The measured power SHALL be lower than MAXNOMATP.

7.6 Performance Monitoring Counters for Code Violations and Errored Seconds

Test procedures for verification of the channel performance monitoring parameter CV and line performance monitoring parameter ES in the fast and interleaved modes are shown in Table 43 and Table 44, respectively.

Table 43 - Code Violation and Errored Seconds Test in the Fast Mode

Test Configuration	(1) See Section 4.1 for the test configuration. (2) As per VDSL2 band-profile to be tested, configure the SUT in FX_F_003_001 specific line-setting. (3) Additional test conditions: optional OLR (SRA, SOS) shall not be used.

Method of Procedure	(1) Connect VTU-R and VTU-O with 0 length loop and no noise injected. (2) Wait 1 minute following synchronization. (3) Note down the initial value of the CV-C, CV-CFE, ES-L, ES-LFE, SES-L, SES-LFE, UAS-L and UAS-LFE performance monitoring counters at the VTU-O. (4) Note down the initial value of the CV-C, ES-L, SES-L and UAS-L at the VTU-R. (5) Force a "micro-interruption" of 3ms (+ or − 0.5ms) every 10 seconds for 2.5min (for a total of 15 micro-interruptions). (6) Force performance monitoring counters update and wait 30 seconds for the counters to be read out. (7) Note down the value of the counter CV-C, ES-L, SES-L and UAS-L at the VTU-R. (8) Note down the value of the counters CV-C and CV-CFE, ES-L and ES-LFE, SES-L and SES-LFE, and UAS-L and UAS-LFE at the VTU-O. (9) Calculate the increase of these counters between step 7 and step 4. (10) Calculate the increase of these counters between step 8 and step 3.
Expected Result	(1) No loss of synchronization shall occur during the test. (2) No increase of SES-L, SES-LFE, UAS-L and UAS-LFE at the VTU-O SHALL be reported. (3) If available, no increase of SES-L and UAS-L at the VTU-R SHALL be reported. (4) The increase of CV-C counter at the VTU-R SHALL be equal to the increase of CV-CFE counter at the VTU-O. (5) The increase of CV-C counter at the VTU-R, as well as the increase of both CV-CFE and CV-C counters at the VTU-O, SHALL be at least equal to 15 and ≤ 35 for DS and ≤ 32 for US. (6) The increase of ES-L counter at the VTU-R SHALL be equal to the increase of ES-LFE counter at the VTU-O. (7) The increase of ES-L counter at the VTU-R, as well as the increase of both ES-LFE and ES-L counters at the VTU-O, SHALL be at least equal to 15 and ≤ 35 for DS and ≤ 32 for US.

NOTE 1: The numbers in step ER(5) and ER(7) are computed taking into account up to 5 CRC in DS and 2 CRC in US due to 10^{-7} BER in the fast mode, in 3 minutes test duration.
NOTE 2: If the duration of the overhead frame is shorter than ½ of the micro-interruption length the increase of CV-C counter at the VTU-R, as well as the increase of both CV-CFE and CV-C counters at the VTU-O, SHALL be at least equal to 15 and ≤ 50 for DS and ≤ 47 for US.

Table 44 - Code Violation and Errored Seconds Test in the Interleaved Mode

Test Configuration	(1) See Section 4.1 for the test configuration (2) As per VDSL2 band-profile to be tested, configure the SUT according to section 4.2 in FX_I_010_001 specific line-setting defined in Table 11. (3) Additional test conditions: optional OLR (SRA, SOS) shall not be used.

Method of Procedure	(1) Connect VTU-R and VTU-O with 0 length loop and no noise injected. (2) Wait 1 minute following synchronization. (3) Report the actual impulse noise protection in US (ACTINPus) and DS (ACTINPds). (4) Calculate the micro-interruption duration as: [(max(ACTINPus, ACTINPds) +1) x 0.25ms] x 2 and rounded up to the nearest ms (5) Note down the initial value of the CV-C, CV-CFE, ES-L, ES-LFE, SES-L, SES-LFE, UAS-L and UAS-LFE performance monitoring counters at the VTU-O. (6) Note down the initial value the CV-C, ES-L, SES-L and UAS-L at the VTU-R. (7) Force one micro-interruption of the duration calculated in step 4 every 10 seconds for 2.5min (for a total of 15 micro-interruptions). (8) Force performance monitoring counters update and wait 30 seconds for the counters to be read out. (9) Note down the value of the counter CV-C, ES-L, SES-L and UAS-L at the VTU-R.. (10) Note down the value of the counters CV-C and CV-CFE, ES-L and ES-LFE, SES-L and SES-LFE, and UAS-L and UAS-LFE at the VTU-O. (11) Calculate the increase of these counters between step 9 and step 6. (12) Calculate the increase of these counters between step 10 and step 5.
Expected Result	(1) No loss of synchronization shall occur during the test. (2) No increase of SES-L, SES-LFE, UAS-L and UAS-LFE at the VTU-O SHALL be reported. (3) If available, no increase of SES-L and UAS-L at the VTU-R SHALL be reported. (4) The increase of CV-C counter at the VTU-R SHALL be equal to the increase of CV-CFE counter at the VTU-O. (5) The increase of CV-C counter at the VTU-R, as well as the increase of both CV-CFE and CV-C counters at the VTU-O, SHALL be at least equal to 15 and ≤ 35 for DS and ≤ 31 for US. (6) The increase of ES-L counter at the VTU-R SHALL be equal to the increase of ES-LFE counter at the VTU-O. (7) The increase of ES-L counter at the VTU-R, as well as the increase of both ES-LFE and ES-L counters at the VTU-O, SHALL be at least equal to 15 and ≤ 35 for DS and ≤ 31 for US.

NOTE 1: The numbers in step ER(5) and ER(7) are computed taking into account up to 5 CRC in DS and 1 CRC in US due to 10^{-7} BER in the interleaved mode, in 3 minutes test duration.
NOTE 2: If the duration of the overhead frame is shorter than ½ of the micro-interruption length the increase of CV-C counter at the VTU-R, as well as the increase of both CV-CFE and CV-C counters at the VTU-O, SHALL be at least equal to 15 and ≤ 50 for DS and ≤ 46 for US.

7.7   Performance Monitoring Counter for SES

A test procedure for verification of the line performance monitoring parameter SES is shown in Table 45.

Table 45 - SES counter reporting test

Test Configuration	(1) See Section 4.1 for the test configuration (2) As per VDSL2 band-profile to be tested, configure the SUT according to Section 4.2 in FX_I_010_001 specific line-setting defined in Table 11 (3) Additional test conditions: a. optional OLR (SRA, SOS) SHALL NOT be used.
Method of Procedure	(1) Connect VTU-R and VTU-O with 0 length loop and no noise injected. (2) Wait 1 minute following synchronization. (3) Note down the initial value of the SES-L, SES-LFE, UAS-L and UAS-LFE performance monitoring counters at the VTU-O and the initial value of the SES-L and UAS-L counters at the VTU-R. (4) Force one 330ms "micro-interruption" every 1s for 2 seconds (a total of 2 micro-interruptions) (5) Repeat previous event 15 times (15 x 2 micro-interruption) with 10s between each event. (6) Force performance monitoring counters update and wait 30 seconds for the counters to be read out. (7) Note down the value of the counter SES-L and UAS-L at the VTU-R. Note down the value of the counters SES-L and SES-LFE, and UAS-L and UAS-LFE at the VTU-O. (8) Calculate the increase of these counters between step 6 and step 3.
Expected Result	(1) No lost of synchronization SHALL occur during the test. (2) No increase of UAS-L and UAS-LFE at the VTU-O SHALL be reported during the test time. (3) If available, no increase of UAS-L at the VTU-R SHALL be reported. (4) The increase of SES-L counter at the VTU-R SHALL be equal to the increase of SES-LFE counter at the VTU-O. (5) The increase of SES-L counter at the VTU-R, as well as the increase of both SES-LFE and SES-L counters at the VTU-O, SHALL be at least equal to 30 and less than 45.

7.8   Performance Monitoring Counter for Unavailable Seconds (UAS)

A test procedure for verification of the line performance monitoring parameter UAS is shown in Table 46.

Table 46 - Unavailable Seconds (UAS) Reporting Test

Test Configuration	(1) See Section 4.1 for the test configuration (2) As per VDSL2 band-profile to be tested, configure the SUT according to section 4.2 in FX_I_010_001 specific line-setting defined in Table 11 (3) Additional test conditions: a. optional OLR (SRA, SOS) SHALL not be used.
Method of Procedure	(1) Connect VTU-R and VTU-O with 0 length loop and no noise injected. (2) Wait 1 minute following synchronization. (3) Note down the initial value of the UAS-L and UAS-LFE performance monitoring counters at the VTU-O and the initial value of the UAS-L counter at the VTU-R. (4) Disconnect the line, and wait for modem to transit from L0 to L3 state. Wait at least 1 minute before reconnecting the line and wait for the transition back to L0 state. (5) Measure the duration between the line disconnection and the moment that the operational state of the line at the VTU-O is reported as 'in Showtime'. (6) Force performance monitoring counters update and wait for 30 seconds for the counters to be read out (7) Note down the value of these counters (UAS-L and UAS-LFE) on the VTU-O and the value of the UAS-L counter at the VTU-R. (8) Calculate the increase of the UAS counters between MOP(7) and MOP(3).

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Expected Result	(1) The modem SHALL drop the connection after the disconnection of the line.
	(2) Δ UAS-L calculated at the VTU-O SHALL not differ from the value measured in MOP(5) by more than 10s.
	(3) If available, the Δ UAS-L calculated at the VTU-R SHALL not differ from the value measured in MOP(5) by more than 10s.
	(4) Δ UAS-LFE calculated at the VTU-O SHALL not differ from the value measured in MOP(5) by more than 14s.
	(5) If available, Δ UAS-L calculated at the VTU-R SHALL not differ from the value of Δ UAS-LFE calculated at the VTU-O by more than 13s.

7.9 Performance Monitoring Counters for Full initialization and Failed Full initialization

A test procedure for verification of the full initialization and failed full initialization performance monitoring parameter is shown in Table 47.

Table 47 - Full Initialization Count and Failed Full Initialization Count Test

Test Configuration	(1) See Section 4.1 for the test configuration
	(2) As per VDSL2 band-profile to be tested, configure the SUT according to Section 4.2 in FX_I_010_001 specific line-setting defined in Table 11 Configure the SUT with specific line setting: FX_I_010_001 and the band-profile chosen for the test
	(3) Additional test conditions: optional OLR (SRA, SOS) SHALL not be used.

Method of Procedure	(1) Connect VTU-R and VTU-O with 0 length loop and no noise injected. (2) .Wait 1 minute following synchronization. (3) Record the initial values of the Full initialization count and the Failed full initialization count at the VTU-O. (4) Disconnect the line for at least 7 seconds. (5) Wait for the modem to retrain. (6) Wait for 1 minute following synchronization. (7) Repeat steps 4 to 6 four times. (8) Record the value of Full initialization count and Failed full initialization count reported by VTU-O. (9) Calculate the increase of these performance counters (Full initialization count and Failed full initialization count) at the VTU-O as the difference between the values from step 8 and step 3.
Expected Result	(1) The increase of the Full initialization count SHALL be equal to 5 or greater. (2) The difference between the increase of Full initialization count and the increase of Failed full initialization count SHALL be equal to 5.

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Annex A Summary of Band Profiles and Profile Line Combinations

Table 48 - Band Profile and Profile Line Combination used in TR-115

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 I   Additional Information about OAM Protocol Data Unit (OAMPDU) (informative)

The Information OAMPDU at the end of the Discovery process is shown in Table 49 for both downstream (-O side transmit) and upstream (-R side transmit). In this example, the capabilities reflect the minimum functionality required in Section 6.1. However, other capabilities that are not essential to perform this test might also be indicated.

The Variable Request and Variable Response OAMPDUs to retrieve both counters are shown in Table 50 through Table 53, These examples show the basic single request/response OAMPDUs. However, a Variable Request OAMPDU MAY contain multiple Variable Descriptors, and a Variable Response OAMPDU MAY contain multiple Variable Containers, in order to retrieve multiple counter values at once.

Table 49 - Example Information OAMPDU after OAM discovery

	Octets	Downstream	Upstream
Header			
MAC destination @	6	0x0180C2000002	0x0180C2000002
MAC source @	6	MAC source @	MAC source @
Length/Type	2	0x8809	0x8809
Subtype	1	0x03	0x03
FLAGS	2	0x0050	0x0050
CODE	1	0x00	0x00
Local TLV			
Information Type	1	0x01	0x01
Information Length	1	0x10	0x10
OAM version	1	0x01	0x01
Revision	2	Counter-O	Counter-R
State	1	0x00	0x00
OAM configuration	1	0x01	0x10
OAMPDU	2	MAXPDUsize-O	MaxOAMPDUsize-R
OUI Vendor ID	3	IEEEvendorID-O	IEEEvendorID-R
Vendor specific	4	VendorSpecific-O	VendorSpecific-R
Remote TLV			
Information Type	1	0x02	0x02
Information Lenth	1	0x10	0x10
OAM version	1	0x01	0x01
Revision	2	Counter-R	Counter-O
State	1	0x00	0x00
OAM configuration	1	0x10	0x01
OAMPDU	2	MaxOAMPDUsize-R	MaxOAMPDUsize-O
OUI Vendor ID	3	IEEEvendorID-R	IEEEvendorID-O
Vendor specific	4	VendorSpecific-R	VendorSpecific-O
PAD	10	All 0x00	All 0x00
FCS	4	FCS	FCS

Table 50 - Variable Request OAMPDU to retrieve TCCRCErrors Counter

	Octets	Value
Header		
MAC destination @	6	0x0180C2000002
MAC source @	6	MAC source @
Length/Type	2	0x8809
Subtype	1	0x03
FLAGS	2	0x0050
CODE	1	0x02
Variable Descriptor for TCCRCErrors		
Branch	1	0x07
Leaf	2	0x014C
PAD	39	All 0x00
FCS	4	FCS

Table 51 - Variable Response OAMPDU to retrieve TCCRCErrors Counter

	Octets	Value
Header		
MAC destination @	6	0x0180C2000002
MAC source @	6	MAC source @
Length/Type	2	0x8809
Subtype	1	0x03
FLAGS	2	0x0050
CODE	1	0x03
Variable Container for TCCRCErrors		
Branch	1	0x07
Leaf	2	0x014C
Width	1	0x04
Value	4	counter
PAD	34	All 0x00
FCS	4	FCS

Table 52 - Variable Request OAMPDU to retrieve TCCodingViolations Counter

	Octets	Value
Header		
MAC destination @	6	0x0180C2000002
MAC source @	6	MAC source @
Length/Type	2	0x8809
Subtype	1	0x03
FLAGS	2	0x0050
CODE	1	0x02
Variable Descriptor for TCCodingViolations		
Branch	1	0x07
Leaf	2	0x0160
PAD	39	All 0x00
FCS	4	FCS

Table 53 - Variable Response OAMPDU to retrieve TCCodingViolations counter

	Octets	Value
Header		
MAC destination @	6	0x0180C2000002
MAC source @	6	MAC source @
Length/Type	2	0x8809
Subtype	1	0x03
FLAGS	2	0x0050
CODE	1	0x03
Variable Container for TCCodingViolations		
Branch	1	0x07
Leaf	2	0x0160
Width	1	0x04
Value	4	counter
PAD	34	All 0x00
FCS	4	FCS

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