TECHNICAL REPORT

TR-115
VDSL2 Functionality Test Plan

Issue: 2
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Issue History

Issue Number	Approval Date	Publication Date	Issue Editor	Changes
1	23 November 2009		Michael Hanrahan, Huawei Technologies Zhang Yongjun, Huawei Technologies	Original
Corrigendum 1	3 March 2010		Michael Hanrahan, Huawei Technologies	Corrections summarized in Executive Summary
Corrigendum 2	22 February 2011		Michael Hanrahan, Huawei Technologies	Corrections summarized in Executive Summary
2	2 July 2012	9 July 2012	Michael Hanrahan, Huawei Technologies	Updates summarized in Executive Summary

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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.

Updates for Issue 1 Corrigendum 1 include corrections to:

- Section 2, *Definitions*
- Table 5, *Common Lines Settings for BA8c_D&UPBO Band Profile*
- Table 16, *Capabilities of Impulse Noise Protection*
- Table 17, *Verification of the Function of Dual Latency*
- Table 18, *Bitswap Test*
- Table 34, *Longitudinal Conversion Loss (LCL) Test*
- Table 45, *SES counter reporting test*

Updates for Issue 1 Corrigendum 2 include corrections to:

- Table 18, *Bitswap Test*
- Table 23, *SOS Test In The Downstream*
- Table 24, *SOS Test In The Upstream*
- Table 32, *Downstream Power Back-Off Test*
- Table 33, *Upstream Power Back-Off Test*
- Table 38, *MINSNRM Control Test*
- Table 45, *SES counter reporting test*

Updates for Issue 2 include:

- Added Annex B 30a band profiles in Wideband Bitswap test
- SOS extended to all band-profiles
- PEIN test sequence included in TR-115_Issue-2.xls

The following tests were updated:

- Table 18, *Bitswap Test* (now Table 20)
- Table 22, *Functional SRA Test*
    - Test expanded to
      Table 25, *Functional SRA Test – Downstream*
      Table 26, *Functional SRA test – Upstream*
      Table 27, *Functional SRA Test with DCID – Downstream*
      Table 28, *Functional SRA Test with DCID – Upstream*
- Table 23, *SOS Test In The Downstream* (now Table 29)
- Table 24, *SOS Test In The Upstream* (now Table 30)
- Table 32, *Downstream Power Back-Off Test (now Table 38)*
- Table 33, *Upstream Power Back-Off Test (now Table 39)*
- Table 38, MINSNRM Control Test (Now Table 44)
- Table 42, MAXNOMATP Control Test (now Table 48)

The following tests were added:

- Table 41, VTU-R INM Tests
- Table 42, VTU-R INM Capability

The following was removed:

- Section 5.9, *Virtual Noise Test*
    - Includes Table 36, *Tranmitter Referred Virtual Noise Functionality Test*
    - At the time of publication it was agreed to include the test in the next issue of TR-114, *VDSL2 Performance Test Plan*

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 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 [14].

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

2.2 References

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

Document	Title	Source	Year
[1] TR-100	*ADSL2/ADSL2plus Performance Test Plan*	BBF	2007
[2] TR-114	*VDSL2 Performance Test Plan*	BBF	2009
[3] G.117	*Transmission aspects of unbalance about earth*	ITU-T	1996
[4] G.992.3	*Asymmetric digital subscriber line transceivers 2 (ADSL2)*	ITU-T	2009
[5] G.992.5	*Asymmetric Digital Subscriber Line (ADSL) transceivers - Extended bandwidth ADSL2 (ADSL2plus)*	ITU-T	2009
[6] G.993.2	*Very high speed subscriber line transceivers 2 (VDSL2)*	ITU-T	2006
[7] G.993.2 Amendment 1	*Very high speed digital subscriber line transceivers 2 (VDSL2)*	ITU-T	2007
[8] G.997.1	*Physical Layer Management for Digital Subscriber Line (DSL) Transceivers.*	ITU-T	2009
[9] O.9	*Measuring arrangements to assess the degree of unbalance about earth*	ITU-T	1999
[10] T1.417 Issue 2	*Spectrum Management for Loop Transmission System*	ANSI Standard	2003
[11] 802.3	*CSMA/CD access method and physical layer specifications*	IEEE	2005
[12] 802.3ah	*Ethernet in the First Mile*	IEEE	2005
[13] RFC 1242	*Benchmarking terminology for network interconnection devices.*	IETF	1991
[14] RFC 2119	*Key words for use in RFCs to Indicate Requirement Levels*	IETF	1997
[15] RFC 2544	*Benchmarking terminology for network interconnection devices (Test methodology).*	IETF	1999

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 or ISDN
Ethernet Frame Size	Size of the Ethernet frame including the CRC Checksum. See Section 3.5/RFC 1242.
F_{max}	The higher of the highest passband frequency in the upstream and downstream directions for the Limit PSD masks selected.
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
Net Data Rate	Sum of net data rates of all bearer channels
Null Loop	VTU-O/VTU-R wired "back to back" i.e. a zero length loop
Showtime	VTU-O and VTU-R trained up to the point of passing data.

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
INM	Impulse Noise Monitoring
INP	Impulse Noise Protection
INPMIN	Minimum impulse noise protection (Section 7.3.2.3/G.997.1
INPMIN8	Minimum impulse noise protection for system using 8.625 kHz subcarrier spacing (Section 7.3.2.4/G.997.1)
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
MIN_NDR	Minimum Net Data Rate
MIN-SOS-BR	Minimum SOS Bit Rate
MINSNRM	Minimum Signal to Noise Ratio Margin
MOP(n)	Method of Procedure step n
NDR_REINIT	Reinitialized Net Data Rate
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

2.5.1 Far-end INM performance monitoring parameters

Parameter	Section in G.997.1
INM INPEQ histogram 1..17 (INMINPEQ$_{1..17}$-LFE)	7.2.1.5.1
INM total measurement (INMME-LFE)	7.2.1.5.2
INM IAT histogram 0..7 (INMIAT$_{0..7}$-LFE)	7.2.1.5.3

2.5.2 INM configuration parameters (downstream, upstream)

Parameter	Section in G.997.1
INM Inter Arrival Time Offset (INMIATOds, INMIATOus)	7.3.1.9.1
INM Inter Arrival Time Step (INMIATSds, INMIATSus)	7.3.1.9.2
INM Cluster Continuation value (INMCCds, INMCCus)	7.3.1.9.3
INM Equivalent INP Mode (INM_INPEQ_MODEds, INM_INPEQ_MODEds)	7.3.1.9.4

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.

3.4 Privacy

Any issues regarding privacy are not affected by TR-115.

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.

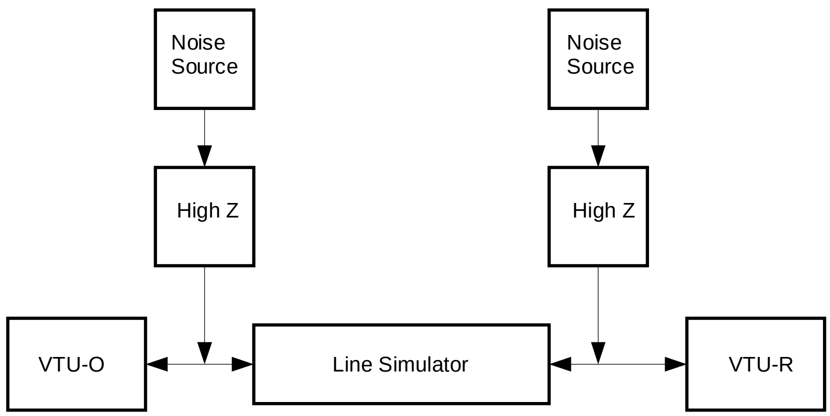

Figure 1 - Generic Test Configuration

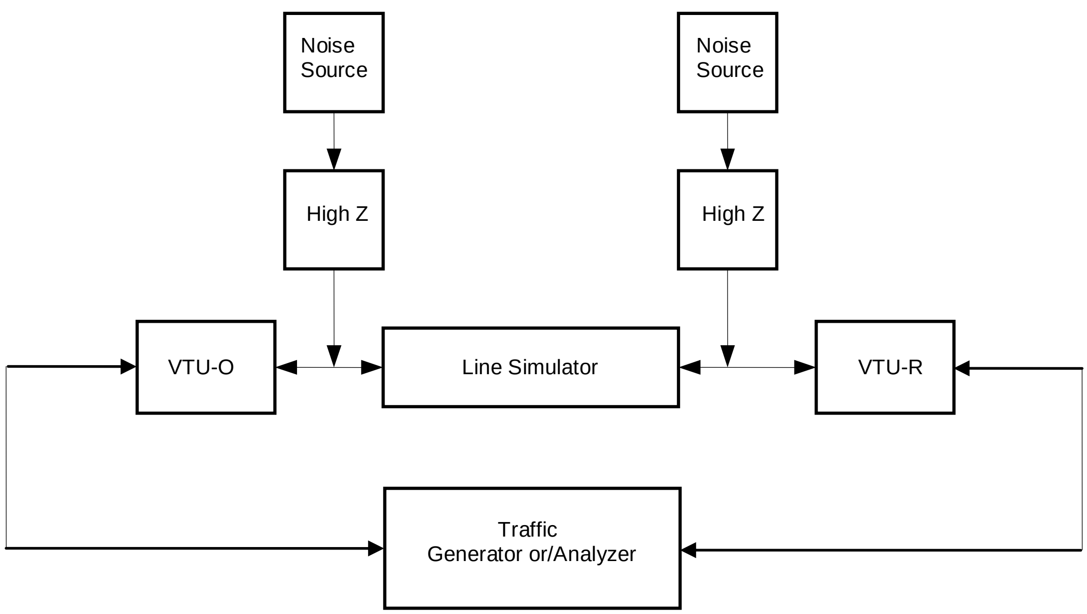

Figure 2 - Test Setup For Configurations Using Data Layer

Note 1 - The modem SHALL be set to a bridged configuration.

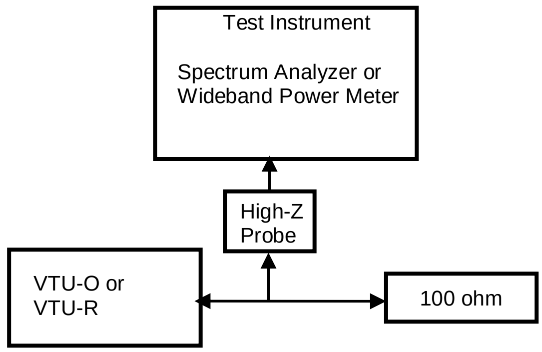

Figure 3 - Test Configuration for PSD Measurement Tests

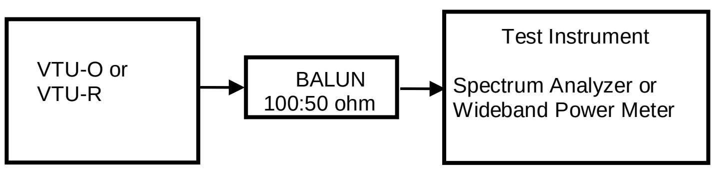

Figure 4 - Alternative Test Configuration for PSD Measurement Tests

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 [6]				
VDSL2 band profile	AA8d			
Profile	8d			
Annex	A			
Limit PSD Mask	Table A.7/G.993.2 Amd1 + Table A.8/G.993.2 Amd1 [7] downstream mask D-32			
US0 type	Table A.2/G.993.2 Amd1 upstream mask EU-32			
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
VDSL2 Band-profile	BA30a			
Profile	30a			
Annex	B			
Limit PSD Mask (short name)	998E30-M2x-NUS0 (B8-13)			
US0 type	Not applicable			
MAXNOMATPds	+14.5 dBm			
Annex B/G.993.2				
VDSL2 Band-profile	BB8b	BB12a	BB17a	BB30a
Profile	8b	12a	17a	30a
Annex	B	B	B	B
Limit PSD Mask (short name)	998-M2x-B (B8-6)	998-M2x-B (B8-6)	998ADE17-M2x-B (B8-12)	998ADE30-M2x-NUS0-M (B8-15)
US0 type	B	B	B	N/A
MAXNOMATPds	+20.5 dBm	+14.5 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 BA30a_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	72dB@1MHz	E-side electrical length
DPBOESCMA	0.1924	Model of the frequency dependent loss of E-side cable: scalars DPBOESCMA (NOTE)
DPBOESCMB	0.5960	Model of the frequency dependent loss of E-side cable: scalars DPBOESCMB (NOTE)
DPBOESCMC	0.2086	Model of the frequency dependent loss of E-side cable: scalars DPBOESCMC (NOTE)
DPBOMUS	-95 dBm/Hz	Minimum usable receive signal PSD mask
DPBOFMIN	138 kHz	Minimum frequency from which on the DPBO SHALL be applied
DPBOFMAX	2208 kHz	Maximum frequency up to which the DPBO SHALL be applied
UPBOKLF	0	Force CO-MIB electrical loop length (means that kl_0 is estimated during training)
UPBOKL	estimated during training	Upstream electrical loop length (kl_0)
UPBOA US0	40.00	A and B values US band 0 (these values imply no UPBO)
UPBOB US0	0	
UPBOA US1	47.30	A value US band 1
UPBOB US1	21.14	B value US band 1
UPBOA US2	54.00	A value US band 2
UPBOB US2	16.29	B value US band 2
UPBOA US3	54.00	A value US band 3
UPBOB US3	16.29	B value US band 3
UPBOA US4	40.00	A and B values US band 4 (these values imply no UPBO)
UPBOB US4	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 - Common Line Settings for BB30a_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	72dB@1MHz	E-side electrical length
DPBOESCMA	0.1924	Model of the frequency dependent loss of E-side cable: scalars DPBOESCMA (NOTE)
DPBOESCMB	0.5960	Model of the frequency dependent loss of E-side cable: scalars DPBOESCMB (NOTE)
DPBOESCMC	0.2086	Model of the frequency dependent loss of E-side cable: scalars DPBOESCMC (NOTE)
DPBOMUS	-95 dBm/Hz	Minimum usable receive signal PSD mask
DPBOFMIN	254 kHz	Minimum frequency from which on the DPBO SHALL be applied
DPBOFMAX	2208 kHz	Maximum frequency up to which the DPBO SHALL be applied
UPBOKLF	0	Force CO-MIB electrical loop length (means that kl_0 is estimated during training)
UPBOKL	estimated during training	Upstream electrical loop length (kl_0)
UPBOA US0	40.00	A and B values US band 0 (these values imply no UPBO)
UPBOB US0	0	
UPBOA US1	47.30	A value US band 1
UPBOB US1	21.14	B value US band 1
UPBOA US2	54.00	A value US band 2
UPBOB US2	16.29	B value US band 2
UPBOA US3	40.00	A and B values US band 3 (these values imply no UPBO)
UPBOB US3	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 7 - 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	0.1719	Model of the frequency dependent loss of E-side cable: scalars DPBOESCMA (NOTE)
DPBOESCMB	0.644453	Model of the frequency dependent loss of E-side cable: scalars DPBOESCMB (NOTE)
DPBOESCMC	0.18359	Model of the frequency dependent loss of E-side cable: scalars DPBOESCMC (NOTE)
DPBOMUS	-101.5 dBm/Hz	Minimum usable receive signal PSD mask
DPBOFMIN	138 kHz	Minimum frequency from which on the DPBO SHALL be applied
DPBOFMAX	2208 kHz	Maximum frequency up to which the DPBO SHALL be applied
UPBOKLF	0	Force CO-MIB electrical loop length (means that kl_0 is estimated during training)
UPBOKL	estimated during training	Upstream electrical loop length (kl_0)
NOTE: the values of DPBOESCMA, B and C are referred to a PE 0.4mm loop @ 1 MHz. Values that are configured according to G.997.1 SHALL be rounded to the nearest scalar value.		

Table 8 - 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 9 - 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 10 - 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 11 - 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 12.

Table 12 - General Line Settings

General line-setting	Parameter	Setting	Description
F-1/0	$delay\_max_n$ ds	S1	Special value S1 as defined in section 7.3.2.2/ G.997.1 indicating that S and D SHALL be selected such that S ≤ 1 and D=1
	$delay\_max_n$ us	S1	Special value S1 as defined in section 7.3.2.2/ G.997.1 indicating that S and D SHALL be selected such that S ≤ 1 and D=1
	INPMINds	0 symbols	
	INPMIN 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.
	INPMIN ds	0 symbols	
	INPMIN us	0 symbols	
I-8/2	$delay\_max_n$ ds	8 ms	
	$delay\_max_n$ us	8 ms	
	INPMIN ds	2 symbols	
	INPMIN us	2 symbols	
I-16/2	$delay\_max_n$ ds	16 ms	
	$delay\_max_n$ us	16 ms	
	INPMIN ds	2 symbols	
	INPMIN us	2 symbols	
I-32/16 *(Not applicable for 30 Mhz profiles)*	$delay\_max_n$ ds	32 ms	
	$delay\_max_n$ us	32 ms	
	INPMIN ds	16 symbols	
	INPMIN us	16 symbols	
Note: For 30 MHz profiles the value of the INPMIN8 parameter SHALL be set to the double of INPMIN.			

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 13 (Fast or Interleaved).
- The following two numbers are the upper limits of the downstream and upstream rates rounded and expressed in Mbps.

Table 13 - Specific line settings

Specific line-setting	General line-setting	RA-Mode	DS net 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 14 provides a few examples of these combinations without a complete listing of all of the expected combinations.

Table 14 - Concatenated common settings, testing combination description

Band-profile	Specific line-setting	Profile-line combination
AA8d	RA_ I_096_056	AA8d_RA_ I_096_056
BA12a	RA_I_150_150	BA12a_RA_I_150_150
BB17a	RA_F_150_150	BB17a_RA_F_150_150
BA8c_ D&UPBO	FX_HI_010_004	BA8c_ D&UPBO_FX_HI_010_004
etc.	etc.	etc.

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

Loop models are specified in Section 6.3.2/TR-114 [1].

The following noise models are also specified in TR-114:

- Section 6.3.3.1/TR-114 for Region A VDSL2 profiles
- Section 6.3.3.2/TR-114 for Region B VDSL2 profiles up to 17MHz
    - Note: Annex A specifies the noise model for Region B VDSL2 profiles 30MHz
- Section 6.3.3.3/TR-114 for Region C VDSL2 profiles

Information on noise injection is specified in Section 6.3.4/TR-114.

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 15 - VTU-O Feature Table

Feature	Specification
System Vendor ID	
G.994.1 Vendor ID	
Version Number	
Serial Number	
VDSL2 Band-Profiles supported: - AA8d - BA8b,BA8c,BA12a,BA17a,BA30a - BB8b,BB12a,BB17a,BB30a - CG8d,CG12a,CG17a,CG30a	
VDSL2 Band-Profiles tested	
VDSL2 optional features supported: - Dual Latency - Seamless Rate Adaptation - SOS - Virtual Noise	
VDSL2 optional features tested	
TPS-TC encapsulation supported: - ATM - PTM	
TPS-TC encapsulation tested (ATM, PTM)	

Table 16 - VTU-R Feature Table

Feature	Specification
System Vendor ID	
G.994.1 Vendor ID	
Version Number	
Serial Number	
VDSL2 Band-Profiles supported: - AA8d - BA8b,BA8c,BA12a,BA17a,BA30a - BB8b,BB12a,BB17a,BB30a - CG8d,CG12a,CG17a,CG30a	
VDSL2 Band-Profiles tested	
VDSL2 optional features supported: - Dual Latency - Seamless Rate Adaptation - SOS - Virtual Noise - INM	
VDSL2 optional features tested	
TPS-TC encapsulation supported: - ATM - PTM	
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 17 - 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 18 - 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 profile line combinations using the general line setting I-8/2 or I-16/2 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) Connect VTU-O and VTU-R to: a. 2700 ft 26AWG for profiles up to 17MHz or 900 ft 26AWG for 30MHz profiles or b. 900 m PE 0.4mm for profiles up to 17MHz or 300 m PE 0.4mm for 30MHz profiles
Method of Procedure	(1) Inject white noise of -140dBm/Hz at the VTU-R end of the loop and -110 dBm/Hz at the VTU-O end of the loop. (2) Force initialization and wait for the modems to sync (3) Wait for 1 minute after initialization. (4) Inject 15 impulses spaced at least 1 second apart into the circuit at the VTU-O end of the loop 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. (5) Test the VTU-R modem by repeating the steps above, injecting the -140dBm/Hz white noise at the VTU-O end of the loop and -110dBm/Hz white noise and impulses at the VTU-R end of the loop.
Expected Result	(1) 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 19 - 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 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 to: a. 2400 ft 26AWG for profiles up to 17MHz or 800 ft 26AWG for 30MHz profiles or b. 750 m PE 0.4mm for profiles up to 17MHz or 250m PE 0.4mm for 30MHz profiles.
Method of Procedure	(1) Inject white noise of -140dBm/Hz at the VTU-R end of the loop and -110dBm/Hz 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 Ethernet frame size of 1518 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 -140dBm/Hz white noise at the VTU-O end of the loop and -110dBm/Hz white noise and impulses at the VTU-R end of the loop
Expected Result	(1) The measured delay on the low latency channel (Delay1) SHALL be < the one of the higher latency (Delay2). (2) The number of reported code violations in channel_2 SHALL be < channel_1.

5.4 On-Line Reconfiguration Tests

5.4.1 Bitswap Test

The purpose of this test is to verify that the VTU-O and VTU-R support bit swapping per the Type 1 OLR on-line reconfiguration operation as defined in Section 13/G.993.2 [6].

Table 20 - Bitswap Test

Test Configuration	(1) See Section 4.1 for the test configuration. (2) Connect VTU-O and VTU-R to: a. 1350 ft 26AWG for profiles up to 17MHz or 450ft 26AWG for 30MHz profiles or b. 450 m PE 0.4mm for profiles up to 17MHz or 150 m PE 0.4mm for 30MHz profiles (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 done for both the F-1/0 and I-8/2 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 SHALL be 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. (5) Set the noise generator to -140 dBm/Hz AWGN noise at both VTU-O and VTU-R.
Method of Procedure	(1) Force initialization and wait for the modems to sync. (2) Wait for 1 minute after initialization. (3) Record the bit 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, also after the injection of the RFI in MOP(5). The frequency of the interfering tone SHALL be set to n x 4.3125 kHz for profiles up to 17MHz or n x 8.625 kHz for 30MHz profiles. (5) The interfering tone SHALL be applied at the VTU-R side in the downstream bit swap test and at the VTU-O side in the upstream bit swap test. Its power SHALL be -110 dBm or less. Wait 60 seconds. (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 and record the Transmitted_Bits_US_Old:

	$\sum_i BITSpsus_i - \left\lceil \frac{NCUSEDus - \frac{NCONEBITus}{2}}{2} \right\rceil - 4$ and the Transmitted_Bits_DS_Old: $\sum_i BITSpsds_i - \left\lceil \frac{NCUSEDds - \frac{NCONEBITds}{2}}{2} \right\rceil - 4$ where the ┌ x ┐ notation represents rounding to the next higher integer, the index 'i' denotes the carrier number, NCUSED represents the number of loaded sub-carriers and NCONEBIT is the number of sub-carriers with 1 bit. Transmitted_Bits_US_Old and Transmitted_Bits_DS_Old refer to the information bits from the PMS-TC. (See Figure 9-1/G.993.2).. (9) Increase the power of the interfering tone to -50 dBm. (10) 2 minutes after increasing the tone power, record BITSpsus and BITSpsds, and document them as BITSpsus_New and BITSpsds_New respectively. (11) Calculate and record values of Transmitted_Bits_US_New and Transmitted_Bits_DS_New by using the formulas in (8). Transmitted_Bits_US_New and Transmitted_Bits_DS_New refer to the information bits from the PMS-TC. (See Figure 9-1/G.993.2). (12) Execute a BER test for 2 minutes. (13) 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. (14) Record the estimated BER (see Section 4.6) (15) Repeat MOP(1) to MOP(14) 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(10), 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(10), SHALL differ from BITSpsds_Old in step MOP(7), if tone n is in the bands of downstream direction. (4) Transmitted _Bits_US_Old SHALL equal Transmitted _Bits_US_New (5) Transmitted _Bits_DS_Old SHALL equal Transmitted _Bits_DS_New (6) SES (as recorded in step MOP(13)) SHALL NOT increase (7) The estimated BER SHALL NOT exceed $1e^{-7}$.

5.4.2 Wideband Bitswap Test

The purpose of this test is to verify that the VTU-O and VTU-R correctly perform bit swapping per Type 1 of OLR on-line reconfiguration operation when applying a wideband noise.

The noise defined in Table 21 forces the bit swapping between bands DS1 and DS2, and bands US1 and US2 of a 998 bandplan.

The noise to be used for the wideband bitswap test is defined in Table 21.
The test procedure for the DS wideband bitswap test is defined in Table 22.
The test procedure for the US wideband bitswap test is defined in Table 23.

Table 21 - 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 22 - 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 PE 0.4mm 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: a. For European VDSL2overPOTS: BA12a_RA_I_150_150 BA17a_RA_I_150_150 BA30a _RA_I_150_150 or b. For European VDSL2overISDN: BB12a _RA_I_150_150 BB17a_RA_I_150_150 BB30a_RA_I_150_150 (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 23 - 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 PE 0.4mm 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: a. For European VDSL2overPOTS BA12a_RA_I_150_150 BA17a_RA_I_150_150 BA30a _RA_I_150_150 or b. For European VDSL2overISDN BB12a _RA_I_150_150 BB17a_RA_I_150_150 BB30a_RA_I_150_150 (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. It includes fast mode test and interleaved mode test. Interleaved mode test will verify the operation of Dynamic Change of Interleaver Depth (DCID) function. Fast mode test is designed for transceivers not supporting DCID, and interleaved mode test is designed for transceivers supporting DCID.

This test is divided into 4 sub-tests:

1. Functional SRA test fast mode – Downstream
2. Functional SRA test fast mode – Upstream
3. Functional SRA test interleaved mode with DCID – Downstream
4. Functional SRA test interleaved mode with DCID – Upstream

Pair 1,2 is REQUIRED for the SUT not supporting DCID to pass the SRA test. Pair 3,4 is REQUIRED for the SUT supporting DCID to pass the SRA test.
Note: Pair 1,2 may also be run with a system that supports DCID

This test SHALL be performed with the following parameter set:

Table 24 - SRA Configuration

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)	10sec
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)	10sec
Upstream Upshift Noise Margin(RA-USNRMus)	9dB
Upstream Minimum Upshift Rate Adaptation Upstream (RA-UTIMEus)	30sec

Table 25 - Functional SRA Test - Downstream

Test Configuration	(1) See Section 4.1 for the test configuration (2) As per VDSL2 band-profile to be tested, configure the SUT in RA_F_150_150 specific line-setting (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) Configure the SRA settings as indicated in Table 24 (4) Connect VTU-O and VTU-R to a. 1350ft 26AWG for profiles up to 17MHz or 450ft 26AWG for 30MHz profiles or b. 450m PE 0.4mm for profiles up to 17MHz or 150m PE 0.4mm for 30MHz profiles (5) Inject -110dBm/Hz AWGN noise at both the VTU-O and VTU-R side.
Method of Procedure	(1) Force a new initialization and wait for modems to sync. (2) Wait for 1 minute for bitswaps to settle. (3) Check reported margin. Document DS net data rate as rate_ds. ***Downshift functionality sub-test*** (4) Increase the noise power level by 1 dB at VTU-R side only. (5) Wait for 1 minute, then check reported DS margin. (6) Repeat MOP(4) and MOP(5) until: RA-DSNRMds < DS reported margin ≤ RA-DSNRMds + 1.5dB. (7) Increase the noise power level by 3 dB at VTU-R side only. (8) Wait for (RA-DTIMEds + 30) seconds for SRA to settle (9) Check reported DS margin, and document as SRA_reported_margin_ downshift_ds. Document DS net data rate as SRA_downshift_rate_ds. (10) Execute a DS BER test for 2 minutes. Record the DS CRC and DS 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. (See Section 4.6 on BER). ***Upshift functionality sub-test*** (11) Decrease the noise power level by 1 dB at VTU-R side only. (12) Wait for 1 minute, then check the reported margin. (13) Repeat MOP(11) and MOP(12) until: RA-USNRMds - 1.5dB ≤ reported DS margin < RA-USNRMds. (14) Decrease the noise power level by 3 dB at VTU-R side only. (15) Wait for (RA-UTIMEds + 30) seconds for SRA to settle. (16) Check reported DS margin, and document as SRA_reported_margin_upshift_ds. Document DS net data rate as SRA_upshift_rate_ds. (17) Execute a DS BER test for 2 minutes. (18) Record the DS CRC and DS 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. (See Section 4.6 on BER).
Expected Result	(1) No retrain SHALL occur during the test. (2) SRA_reported_margin_downshift_ds ≥RA-DSNRMds + 1 dB; (3) SRA_reported_margin_upshift_ds≤RA-USNRMds - 1dB. (4) SRA_downshift_rate_ds < rate_ds; (5) SRA_upshift_rate_ds > SRA_downshift_rate_ds. (6) Estimated BER SHALL NOT exceed $1e^{-7}$. (7) No DS SES SHALL be reported.

Table 26 - Functional SRA test - Upstream

Test Configuration	(1) See Section 4.1 for the test configuration. (2) As per VDSL2 band-profile to be tested, configure the SUT in RA_F_150_150 specific line-setting (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) Configure the SRA settings as indicated in Table 24 (4) Connect VTU-O and VTU-R to a. 1350ft 26AWG for profiles up to 17MHz or 450ft 26AWG for 30MHz profiles or 450m PE 0.4mm for profiles up to 17MHz or 150m PE 0.4mm for 30MHz profiles (5) Inject -110dBm/Hz AWGN noise at both the VTU-O and VTU-R side.

Method of Procedure	(1) Force a new initialization and wait for modems to sync. (2) Wait for 1 minute for bitswaps to settle. (3) Check the reported margin. Document US net data rate as rate_us. ***Downshift functionality sub-test*** (4) Increase the noise power level by 1 dB at VTU-O side only. (5) Wait for 1 minute, then check reported US margin. (6) Repeat MOP(4) and MOP(5) until: RA-DSNRMus < reported US margin ≤ RA-DSNRMus + 1.5dB. (7) Increase the noise power level by 3 dB at VTU-O side only. (8) Wait for (RA-DTIMEus + 30) seconds for SRA to settle. (9) Check reported US margin, and document as SRA_reported_margin_downshift_us. Document US net data rate as SRA_downshift_rate_us. (10) Execute a US BER test for 2 minutes. Record the US CRC and US 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. (See Section 4.6 on BER). ***Upshift functionality sub-test*** (11) Decrease the noise power level by 1 dB at VTU-O side only. (12) Wait for 1 minute, then check the reported margin. (13) Repeat MOP(11) and MOP(12) until: RA-USNRMus - 1.5dB ≤ reported US margin < RA-USNRMus. (14) Decrease the noise power level by 3 dB at VTU-O side only. (15) Wait for (RA-UTIMEus + 30) seconds for SRA to settle. (16) Check reported US margin, and document as SRA_reported_ margin_upshift_us. Document US net data rate as SRA_upshift_rate_us. (17) Execute a BER test for 2 minutes. (18) Record the US CRC and US 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. (See Section 4.6 on BER).
Expected Result	(1) No retrain SHALL occur during the test. (2) SRA_reported_margin_downshift_us ≥ RA-DSNRMus + 1dB. (3) SRA_reported_margin_upshift_us ≤ RA-USNRMus - 1dB. (4) SRA_downshift_rate_us < rate_us. (5) SRA_upshift_rate_us > SRA_downshift_rate_us. (6) The estimated BER SHALL NOT exceed $1e^{-7}$. (7) No US SES SHALL be reported.

Table 27 - Functional SRA Test with DCID – Downstream

Test Configuration	(1) See Section 4.1 for the test configuration. (2) As per VDSL2 band-profile to be tested, configure the SUT in RA_I_150_150 specific line-setting (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) Configure the SRA settings as indicated in Table 24. (4) Connect VTU-O and VTU-R to a. 1350ft 26AWG for profiles up to 17MHz or 450ft 26AWG for 30MHz profiles or b. 450m PE 0.4mm for profiles up to 17MHz or 150m PE 0.4mm for 30MHz profiles (5) Inject -110dBm/Hz AWGN noise at both the VTU-O and VTU-R side.
Method of Procedure	(1) Force a new initialization and wait for modems to sync. (2) Wait for 1 minute for bitswaps to settle. (3) Check reported margin. Document DS net data rate as downshift_rate_ds. (4) Record the DS interleaver depth as downshift_ID_ds_init. ***SRA Downshift functionality sub-test*** (5) Increase the noise power level by 1 dB at VTU-R side only. (6) Wait for 1 minute, then check reported DS margin. (7) Repeat MOP(5) and MOP(6) until: RA-DSNRMds < DS reported margin ≤ RA-DSNRMds + 1.5dB. (8) Increase the noise power level by 3 dB at VTU-R side only. (9) Wait for (RA-DTIMEds + 30) seconds for SRA to settle. (10) Document the reported DS margin as SRA_reported_margin_downshift_ds, the DS net data rate as SRA_downshift_rate_ds, the DS interleaver depth as downshift_ID_ds, the actual reported delay as downshift_delay_ds, and the actual INP as downshift_INP_ds. (11) If the downshift_ID_ds is equal to the downshift_ID_ds_init, repeat MOP(5) to MOP(10). (12) Execute a DS BER test for 2 minutes. (13) Record the DS CRC and DS 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 downshift_BER_ds. (See Section 4.6 on BER). ***SRA Upshift functionality sub-test*** (14) Decrease the noise power level by 1 dB at VTU-R side only. (15) Wait for 1 minute, then check the reported margin (16) Repeat MOP(14) and MOP(15) until: RA-USNRMds - 1.5dB ≤ DS reported margin < RA-USNRMds. (17) Decrease the noise power level by 3 dB at VTU-R side only. (18) Wait for (RA-UTIMEds + 30) seconds for SRA to settle. (19) Document the reported DS margin as SRA_reported_margin_upshift_ds, the DS net data rate as SRA_upshift_rate_ds, the DS interleaver depth as upshift_ID_ds,

	the actual reported delay as upshift_delay_ds, and the actual INP as upshift_INP_ds. (20) If the upshift_ID_ds is equal to downshift_ID_ds, repeat MOP(14) to MOP(19). (21) Execute a DS BER test for 2 minutes. (22) Record the DS CRC and DS SES counts at the start and the end of the BER test. (23) Actual number of CRCs and SESs is the difference between these two counts. Document the estimated upshift_BER_ds. (See Section 4.6 on BER).
Expected Result	(1) No retrain SHALL occur during the test. (2) SRA_reported_margin_downshift_ds ≥RA-DSNRMds + 1 dB. (3) SRA_reported_margin_upshift_ds≤RA-USNRMds - 1dB. (4) SRA_downshift_rate_ds < downshift_rate_ds. (5) SRA_upshift_rate_ds > SRA_downshift_rate_ds. (6) The downshift_ID_ds SHALL differ from downshift_ID_ds_init. (7) The upshift_ID_ds SHALL differ from downshift_ID_ds. (8) Estimated downshift_BER_ds and upshift_BER_ds SHALL NOT exceed $1e^{-7}$. (9) No DS SES SHALL be reported. (10) downshift_delay_ds ≤ Maximum Interleaving Delay of the profile. (11) upshift_delay_ds ≤ Maximum Interleaving Delay of the profile. (12) downshift_INP_ds ≥ INPMIN (INPMIN8 for 30MHz profiles). (13) upshift_INP_ds ≥ INPMIN (INPMIN8 for 30MHz profiles).

Table 28 - Functional SRA Test with DCID – Upstream

Test Configuration	(1) See Section 4.1 for the test configuration. (2) As per VDSL2 band-profile to be tested, configure the SUT in RA_I_150_150 specific line-setting (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) Configure the SRA settings as indicated in Table 24. (4) Connect VTU-O and VTU-R to a. 1350ft 26AWG for profiles up to 17MHz or 450ft 26AWG for 30MHz profiles or b. 450m PE 0.4mm for profiles up to 17MHz or 150m PE 0.4mm for 30MHz profiles (5) Inject -110dBm/Hz AWGN noise at both the VTU-O and VTU-R side.
Method of Procedure	(1) Force a new initialization and wait for modems to sync. (2) Wait for 1 minute for bitswaps to settle. (3) Check reported margin. Document US net data rate as downshift_rate_us. (4) Record the US interleaver depth as downshift_ID_us_init. ***SRA Downshift functionality sub-test*** (5) Increase the noise power level by 1 dB at VTU-O side only. (6) Wait for 1 minute, then check reported US margin. (7) Repeat MOP(5) and MOP(6) until: RA-DSNRMus < US reported margin ≤ RA-DSNRMus + 1.5dB. (8) Increase the noise power level by 3 dB at VTU-O side only. (9) Wait for (RA-DTIMEus + 30) seconds for SRA to settle. (10) Document the reported US margin as SRA_reported_margin_downshift_us, the US net data rate as SRA_downshift_rate_us, the US interleaver depth as downshift_ID_us, the actual reported delay as downshift_delay_us, and the actual INP as downshift_INP_us. (11) If the downshift_ID_us is equal to the downshift_ID_us_init, repeat MOP(5) to MOP(10). (12) Execute a US BER test for 2 minutes. (13) Record the US CRC and US 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 downshift_BER_us. (See Section 4.6 on BER). ***SRA Upshift functionality sub-test*** (14) Decrease the noise power level by 1 dB at VTU-O side only. (15) Wait for 1 minute, then check the reported margin (16) Repeat MOP(14) and MOP(15) until: RA-USNRMus - 1.5dB ≤ US reported margin < RA-USNRMus. (17) Decrease the noise power level by 3 dB at VTU-O side only. (18) Wait for (RA-UTIMEus + 30) seconds for SRA to settle.

	(19) Document the reported US margin as SRA_reported_margin_upshift_us, the US net data rate as SRA_upshift_rate_us, the US interleaver depth as upshift_ID_us, the actual reported delay as upshift_delay_us, and the actual INP as upshift_INP_us. (20) If the upshift_ID_us is equal to downshift_ID_us, repeat MOP(14) to MOP(19). (21) Execute a US BER test for 2 minutes. (22) Record the US CRC and US SES counts at the start and the end of the BER test. (23) Actual number of CRCs and SESs is the difference between these two counts. (24) Document the estimated upshift_BER_us.
Expected Result	(1) No retrain SHALL occur during the test. (2) SRA_reported_margin_downshift_us ≥RA-DSNRMus + 1 dB. (3) SRA_reported_margin_upshift_us≤RA-USNRMus - 1dB. (4) SRA_downshift_rate_us < downshift_rate_us. (5) SRA_upshift_rate_us > SRA_downshift_rate_us. (6) The downshift_ID_us SHALL differ from downshift_ID_us_init. (7) The upshift_ID_us SHALL differ from downshift_ID_us. (8) Estimated downshift_BER_us and upshift_BER_us SHALL NOT exceed $1e^{-7}$. (9) No US SES SHALL be reported. (10) downshift_delay_us ≤ Maximum Interleaving Delay of the profile. (11) upshift_delay_us ≤ Maximum Interleaving Delay of the profile. (12) downshift_INP_us ≥ INPMIN (INPMIN8 for 30MHz profiles). (13) upshift_INP_us ≥ INPMIN (INPMIN8 for 30MHz profiles).

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).

NOTE – For the following test configuration, the MIN-SOS-BR is configured to be greater than Min-NDR.

Table 29 – SOS Test In The Downstream

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 combination is defined with DPBO and/or UPBO enabled, these SHALL be applied. (3) Configure 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 f. DS SNRM offset for the ROC (SNRMOFFSET-ROC-ds): 6dB g. DS INPMIN for ROC (INPMIN-ROC-ds): 8 symbols NOTE: SOS triggering condition specified by parameter SOS-NTONES is superseded with the number of degraded tones ≥129 (Section 13.4.3.2/G.993.2). (4) Inject -140 dBm/Hz AWGN noise at both VTU-O and VTU-R. (5) Specific settings: SRA settings from Table 24
Method of Procedure	(1) Connect the VTU-O and VTU-R. Wait for the modems to sync. Note: The SOS capability SHOULD be disabled in this phase. (2) Add the crosstalk noise defined in TR-114 [2] for the band-profile under test at the VTU-R side only, and ensure the link breaks down before Downstream Minimum Downshift Rate Adaptation time. If not, deactivate the line and then enhance the noise power level by 1 dB per step and re-inject to the link, which is established under the noise of AWGN-140dBm/Hz only, at the VTU-R side. The Upper-limit of noise power level increase is 6dB above the initial noise level. Repeat the procedure above until the link breaks down once the noise is injected or the 6 dB noise increase limit is reached. Record the final noise value, as Noise_SOS-ds. (3) Force a new initialization. (4) Wait for 1 minute after initialization and record the downstream net data rate NDR_REINIT_DS NOTE: this is the downstream data rate that would be obtained if the VTU were to (re-)initialize in the crosstalk noise condition using the same Transmit PSD level. (5) Deactivate the line. (6) Remove the crosstalk noise. (7) Enable SOS function by setting RA-MODE to 4 (DYNAMIC with SOS rate adaptation mode).. (8) Force a new initialization. (9) Wait for 1 minute after initialization. (10) Inject the Noise_SOS-ds at the VTU-R side only.

	(11) Record the net data rate NDR_SOS_BEG_DS one second after the crosstalk is injected. NOTE: this is the downstream data rate in the crosstalk noise condition at the end of SOS procedure. (12) Record the data rate NDR_SOS_END_DS three minutes after the crosstalk is injected. NOTE: this is the downstream data rate in the crosstalk noise condition at the end of SRA procedure.
Expected Result	(1) No retrain SHALL occur during the test, after enabling SOS function (2) NDR_SOS_BEG_DS > MIN-SOS-BR-ds (3) NDR_SOS_END_DS > 0.8*NDR_REINIT_DS

Table 30 - SOS Test In The Upstream

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 combination is defined with DPBO and/or UPBO enabled, these SHALL be applied. (3) Configure 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 f. US SNRM offset for the ROC (SNRMOFFSET-ROC-us): 6dB g. US INPMIN for ROC (INPMIN-ROC-us): 8 symbols NOTE: SOS triggering condition specified by parameter SOS-NTONES is superseded with the number of degraded tones $\geq$129 (Section 13.4.3.2/G.993.2). (4) Set the noise generator to -140 dBm/Hz AWGN noise at both VTU-O and VTU-R. (5) Specific settings: SRA settings from Table 24
Method of Procedure	(1) Connect the VTU-O and VTU-R. Wait for the modems to sync. Note: The SOS capability SHOULD be disabled in this phase. (2) Add the crosstalk noise defined in TR-114 for the band-profile under test at the VTU-O side only, and ensures the link is breaks down before Upstream Minimum Downshift Rate Adaptation time. If not, deactivate the line, then enhance the noise power level by 1 dB per step and re-inject to the link, which is established under the noise of AWGN -140dBm/Hz only, at VTU-O side. The Upper-limit of noise power level is 6dB above the initial noise level. Repeat the procedure above until the link breaks down once the noise is injected or the 6 dB noise increase limit is reached. Record the final noise value, as Noise_SOS-us. (3) Force a new initialization. (4) Wait for 1 minute after initialization and record the upstream net data rate NDR_REINIT_US. NOTE: this is the upstream data rate that would be obtained if the VTU were to (re-)initialize in the crosstalk noise condition using the same Transmit PSD level. (5) Deactivate the line. (6) Remove the crosstalk noise. (7) Enable SOS function by setting RA-MODE to 4 (DYNAMIC with SOS rate adaptation mode). (8) Force a new initialization. (9) Wait for 1 minute after initialization. (10) Inject the Noise_SOS-us at the VTU-O side only.

	(11) Record the net data rate NDR_SOS_BEG_US one second after the crosstalk is injected. NOTE: this is the upstream data rate in the crosstalk noise condition at the end of SOS procedure. (12) Record the data rate NDR_SOS_END_US three minutes after the crosstalk is injected. NOTE: this is the upstream data rate in the crosstalk noise condition at the end of SRA procedure.
Expected Result	(1) No retrain SHALL occur during the test, after enabling SOS function. (2) NDR_SOS_BEG_US > MIN-SOS-BR-us (3) 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/G.993.2 and Section 7.5.1/G.997.1.

Table 31 - 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) Connect VTU-O and VTU-R to: a. 1350 ft 26AWG for profiles up to 17MHz or 450 ft 26AWG for 30MHz profiles or b. 450m PE 0.4mm for profiles up to 17MHz or 150m PE 0.4mm for 30MHz profiles or c. 450m TP100 for profiles up to 17MHz or 150m TP100 for 30MHz profiles (5) Inject -120 dBm/Hz AWGN noise at both the VTU-O and VTU-R ends.
Method of Procedure	(1) Force the line at the VTU-O side to the L3 state. (2) Force the VTU-O to perform the loop diagnostic mode. (3) Collect and record the following "per band" test parameters: LATN, SATN, SNRM, in both downstream and upstream. (4) Collect and record the following test parameters: ATTNDR and ACTATP, in both downstream and upstream. (5) Collect and record the following parameters for the linear channel characteristics function per subcarrier group: HLINSC, HLING, HLINps, in both downstream and upstream. (6) Collect and record the following parameters for the logarithmic channel characteristics function per subcarrier group: HLOGMT, HLOGG, HLOGps, in both downstream and upstream. (7) Collect and record the following parameters for the Quiet line noise PSD per subcarrier group: QLNMT, QLNG, QLNps, in both downstream and upstream. (8) 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 32 - 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) Connect VTU-O and VTU-R to: a. 1350 ft 26AWG for profiles up to 17MHz or 450 ft 26AWG for 30MHz profiles or b. 450 m PE 0.4mm for profiles up to 17MHz or 150 m PE 0.4mm for 30MHz profiles or c. 450m TP100 for profiles up to 17MHz or 150m TP100 for 30MHz profiles (5) Inject -120 dBm/Hz AWGN noise at both the VTU-O and VTU-R ends.
Method of Procedure	(1) Force the line at the VTU-R side to the L3 state. (2) Force the VTU-R to perform the loop diagnostic mode. (3) Collect and record the following “per band” test parameters: LATN, SATN, SNRM, in both downstream and upstream. (4) Collect and record the following test parameters: ATTNDR and ACTATP, in both downstream and upstream. (5) Collect and record the following parameters for the linear channel characteristics function per subcarrier group: HLINSC, HLING, HLINps, in both downstream and upstream. (6) Collect and record the following parameters for the logarithmic channel characteristics function per subcarrier group: HLOGMT, HLOGG, HLOGps, in both downstream and upstream. (7) Collect and record the following parameters for the Quiet line noise PSD per subcarrier group: QLNMT, QLNG, QLNps, in both downstream and upstream. (8) 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/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 33 - 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 G.993.2. This measurement SHALL include both the passband and stopband frequencies.

Table 34 - 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 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 MOP(3) through MOP(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	(1) Measured PSD mask SHALL comply with the requirements from Section 7.2.3/G.993.2 [6] (2) Measured PSD mask SHALL be $\leq$ 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 for each VDSL2 profile. The aggregate transmit power SHALL be measured over the entire passband and stopband frequencies.

Table 35 - 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 long enough for the ATP to be measured. If it does not see the Note in Table 34. (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 MOP(2) through MOP(5) for all five loop lengths (between NULL loop and the defined maximum loop) according to the test configuration TC(5).
Expected Result	(1) Measured aggregate transmit power SHALL be ≤ the maximum aggregate downstream/upstream transmit power specified in Table 6-1/G.993.2 [6].

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 36. 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 36 - 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	

Frequency	Application	
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 37 - 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 36. (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 long enough for the PSD to be measured. If it does not, see the Note in Table 34. (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	(1) Measured PSD mask SHALL comply with the requirements from Section 7.2.3/G.993.2 [6] (2) Measured PSD mask SHALL be ≤ 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/G.997.1.

Table 38 - 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 optionally 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. 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 (DPBOEPSD, DPBOESCMA, -B, -C, DPBOMUS, DPBOFMIN, DPBOFMAX). (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. (6) Set DPBOESEL to 10 dB.
Method of Procedure	(1) Set spectrum analyzer for the requested frequency range, resolution bandwidth and input attenuation range to prevent it from beingover driven. (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 long enough for the PSD to be measured. If it does not see the Note in Table 34. (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 effect of ≤ 0.5dB on the measurement (6) Record the measured PSD data. (7) Optionally record the measured or calculated ATP. (8) Repeat MOP(2) through MOP(7) for the following DPBOESEL values: 20dB, 30dB, 40dB, 50dB and 60dB.

Expected Result	(1) VTU-O and VTU-R SHALL synchronize in all tested configurations. (2) Measured PSD mask SHALL comply with the requirements from Section 7.3.1.2.13/G.997.1 (3) Measured PSD mask SHALL be ≤ the resultant mask (RESULTMASK ds).

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/G.993.2 and that the VTU-R transmit signal in Showtime is adapted to conform to the upstream power back-off mask UPBOMASK(kl_0,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 39 - 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 optionally 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. 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, as referenced in 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 overdriven. (2) Force initialization and wait for modems to synchronize. (3) Wait 1 minute following synchronization. (4) Record the estimated electrical length kl_0 (UPBOKLE). (5) Disconnect the line. The VDSL2 link SHOULD stay in L0 long enough for the PSD to be measured. If it does not see the Note in Table 34. (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 effect of $\leq$ 0.5dB on the measurement (7) Record the measured PSD data. (8) Optionally record the measured or calculated ATP. (9) Repeat 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) Deactivate the line. (11) Maintain the test loop equivalent to 20 dB @ 1MHz. (12) Configure the parameter UPBOKLF to 1 to force the VTU-R to use the electrical length kl_0 configured by the CO-MIB (UPBOKL) to compute the UPBO. Set the kl_0 value UPBOKL to 15dB and repeat MOP(2) through MOP(8).
Expected Result	(1) VTU-O and VTU-R SHALL synchronize in all tested configurations. (2) Measured PSD mask SHALL comply with the requirements from Section 7.2.1.3.2/G.993.2 [6] (3) Measured PSD mask SHALL be ≤ the reference UPBO mask (UPBOMASK(kl_0, f)) calculated with kl_0 value=1.8 for 0dB loop, or estimated kl_0 value for non-0dB loop, or with UPBOKL for the case with forced kl_0.

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 40 - 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 G.117 [3] and O.9 [9]
Expected Result	(1) LCL ≥38 dB in the frequency band up to 12 MHz. (2) LCL ≥ 38 dB – 20 $\log_{10}(f_{[MHz]}/12)$ for 12 MHz < f < Fmax.

5.9 VTU-R INM

The purpose of this test is to verify that the impulse noise monitoring (INM) function and associated control and configuration INM parameters are implemented correctly according to the directions of the G.993.2 (clauses 11.2.3.13, 11.3.4.3, 11.4.2.2) and G.997.1 standard (clauses 7.2.1.5, 7.3.1.9).

The INPEQ histogram corresponds to the calculated equivalent INP, and it is defined as integer number of DMT symbols between 1 and 16. A special value of 17 represents the equivalent INP of more than 16 DMT symbols. The IAT histogram is generated for several ranges of the inter-arrival time, which is representing a number of data symbols between the start of two neighboring clusters.

INMIATO and INMIATS define the INM inter-arrival time offset and time step for generation of the IAT histogram, while parameter INMCC is used in the noise bursts indication process. Finally, configuration parameter INPEQ_MODE defines the way of computation of equivalent INP.

INM configuration parameters are defined in Table 41 and they apply to the downstream direction.

Note: Tests with the parameter INM_INPEQ_MODE set to 1 are optional.

Table 41 - VTU-R INM Tests

Test	**INM_INPEQ _MODE**	**INMIATO**	**INMIATS**	**INMCC**	**PEIN Test Sequence** (See section 5.10.9)
1	0	3 (default)	0(default)	0	#1
2	0	3 (default)	0(default)	0	#2
3	0	3	2	0	#3
4	0	3	2	0	#4
5	0	27	4	0	#5
6	0	27	4	0	#6
7	0	123	6	0	#7
8	0	123	6	0	#8
9	0	511	7	0	#9
10	0	511	7	0	#10
11	1	3	2	2	#11
12	1	27	4	64	#12

Table 42 - VTU-R INM Capability

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) The INM control parameters and PEIN test sequence for each test are defined in Table 41. (4) Connect VTU-R and VTU-O to: a. 1350 ft 26AWG (profiles up to 17MHz) or 450ft 26AWG for 30MHz profiles or b. 450 m PE 0.4mm (profiles up to 17MHz) or 150 m PE 0.4mm for 30MHz profiles (5) Inject -130dBm/Hz AWGN noise at both the VTU-O and VTU-R ends (6) Additional test conditions: • The PEIN impulses SHALL be injected at the VTU-R end. • The interval borders of the INM counters SHALL be considered
Method of Procedure	(1) Power-cycle VTU-R. (2) Deactivate the line and configure the VTU-O as per Test 1/Table 41. (3) Activate the line and wait 1 minute following synchronization. (4) Force performance counters update and wait 30 seconds. Record the values of the $INMINPEQ_{1..17}$-LFE, INMME-LFE and $INMIAT_{0..7}$-LFE counters at the VTU-O side. (5) Inject PEIN Test sequence #1. (6) Force performance counters update and wait 30 seconds. Record values of $INMINPEQ_{1..17}$-LFE, INMME-LFE and $INMIAT_{0..7}$-LFE counters at the VTU-O side. (7) For test sequence #1 only force initialization without powering down the VTU-R and wait for modems to synchronize. (8) For test sequence #1 only record values of $INMINPEQ_{1..17}$-LFE, INMME-LFE and $INMIAT_{0..7}$-LFE counters at the VTU-O side. (9) Repeat MOP(2) through MOP(6) for the next test sequence as defined per Table 41.

Expected Result	(1) No loss of synchronization SHALL occur during the application of the test impulses. (2) For Test sequence#3, the initial histograms $INMINPEQ_{1..17}$-LFE and $INMIAT_{0..7}$-LFE SHALL contain <= 2 events. The INMME-LFE counter SHALL be > 200000 and < 400000. (3) The increase of the the INMME-LFE counter between MOP(4) and MOP(6) SHALL be in the range of the expected result in Sections 5.9.1 to 5.9.7 for each test. (4) The increase of the event count in the $INMINPEQ_{1..17}$-LFE histogram between MOP(4) and MOP(6) SHALL be equal to the expected result in Sections 5.9.1 to 5.9.7 for each test. A tolerance of +1/-0 on one of the bins SHALL be permitted to allow for unexpected impulse events occurring in the test environment during the test. sequence. (5) The increase of the event count in the $INMIAT_{0..7}$-LFE histogram between MOP(4) and MOP(6) for each test SHALL equal to the expected result defined in Sections 5.9.1 to 5.9.7. A tolerance of +1/-0 on one of the bins SHALL be permitted to allow for unexpected impulse events occurring in the test environment during the test. (7) For Test sequence#1, the recorded values of $INMIAT_{0..7}$-LFE and $INMINPEQ_{1..17}$-LFE in MOP(8) SHALL be equal to the values recorded in MOP(6). A tolerance of +1/-0 on one of the bins SHALL be permitted to allow for unexpected impulse events occurring in the test environment during this step.The INMME-LFE count SHALL be ≥ INMME-LFE count recorded in MOP(6).

5.9.1 Expected Results for Test 1

INMME: [482000 ....761000]

INMINPEQ Histogram

<table>
<tr><th>Bin</th><th>1</th><th>2</th><th>3</th><th>4</th><th>5</th><th>6</th><th>7</th><th>8</th><th>9</th><th>10</th><th>11</th><th>12</th><th>13</th><th>14</th><th>15</th><th>16</th><th>17</th></tr>
<tr><td>Event Count</td><td colspan="3">25</td><td colspan="3">25</td><td>0</td><td colspan="3">25</td><td>0</td><td colspan="3">25</td><td>0</td><td>0</td><td>25</td></tr>
</table>

INMIAT Histogram

Bin	0	1	2	3	4	5	6	7
Event Count	0	0	0	0	0	0	0	125

5.9.2 Expected Results for Test 2

INMME: [462000... 741000]

INMINPEQ Histogram

<table>
<tr><th>Bin</th><th>1</th><th>2</th><th>3</th><th>4</th><th>5</th><th>6</th><th>7</th><th>8</th><th>9</th><th>10</th><th>11</th><th>12</th><th>13</th><th>14</th><th>15</th><th>16</th><th>17</th></tr>
<tr><td>Event Count</td><td>0</td><td colspan="3">30</td><td>0</td><td colspan="3">30</td><td>0</td><td colspan="3">30</td><td>0</td><td colspan="3">30</td><td>0</td></tr>
</table>

INMIAT Histogram

Bin	0	1	2	3	4	5	6	7
Event Count	0	0	0	0	0	0	0	120

5.9.3 Expected Results for Test 3

INMME: [462000... 741000]

INMINPEQ Histogram

<table>
<tr><th>Bin</th><th>1</th><th>2</th><th>3</th><th>4</th><th>5</th><th>6</th><th>7</th><th>8</th><th>9</th><th>10</th><th>11</th><th>12</th><th>13</th><th>14</th><th>15</th><th>16</th><th>17</th></tr>
<tr><td>Event Count</td><td colspan="3">240-2*q</td><td colspan="3">q (q<=30)</td><td>0</td><td>0</td><td>0</td><td>0</td><td>0</td><td>0</td><td>0</td><td>0</td><td>0</td><td>0</td><td>0</td></tr>
</table>

INMIAT Histogram

<table>
<tr><th>Bin</th><th>0</th><th>1</th><th>2</th><th>3</th><th>4</th><th>5</th><th>6</th><th>7</th></tr>
<tr><td>Event</td><td colspan="2">30-q</td><td>30</td><td>0</td><td>30</td><td>0</td><td>30</td><td>120</td></tr>
</table>

Count							

5.9.4 Expected Results for Test 5, 7 and 9

INMME: [462000... 741000]

INMINPEQ Histogram

Bin	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**	**14**	**15**	**16**	**17**
Event Count	240			0	0	0	0	0	0	0	0	0	0	0	0	0	0

INMIAT Histogram

Bin	**0**	**1**	**2**	**3**	**4**	**5**	**6**	**7**
Event Count	30	0	30	0	30	0	30	120

5.9.5 Expected results for Test 4, 6, 8 and 10

INMME: [462000... 741000]

INMINPEQ Histogram

Bin	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**	**14**	**15**	**16**	**17**
Event Count	240			0	0	0	0	0	0	0	0	0	0	0	0	0	0

INMIAT Histogram

Bin	**0**	**1**	**2**	**3**	**4**	**5**	**6**	**7**
Event Count	0	30	0	30	0	30	0	150

5.9.6 Expected Results for Test 11

INMME: [462000... 741000]

INMINPEQ Histogram

Bin	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**	**14**	**15**	**16**	**17**
Event Count	0	0	120			0	0	60			0	0	0	0	0	0	0

INMIAT Histogram

Bin	**0**	**1**	**2**	**3**	**4**	**5**	**6**	**7**
Event Count	0	0	60	0	0	0	0	120

5.9.7 Expected Results for Test 12

INMME: [462000... 741000]

INMINPEQ Histogram

Bin	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**	**14**	**15**	**16**	**17**
Event Count		120		0	0	0	0	0	0	0	0	0	0	0	0	0	60

INMIAT Histogram

Bin	**0**	**1**	**2**	**3**	**4**	**5**	**6**	**7**
Event Count	0	0	0	60	0	0	0	120

5.9.8 PEIN Test Sequence Definition

The PEIN test sequences, as defined in Annex B SHALL be used to generate the necessary number of impulses in order to perform the tests and populate the INMINPEQ and INMAIAT histograms.
The PEIN pulse SHALL be AWGN and have a bandwidth from 1MHz to 30MHz, with a pulse PSD of -90dBm/Hz.

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 Clauses 30, 45 and 57/IEEE 802.3 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 as defined in Annex N/G.992.3 (see K.3.8/G.993.2 [6]).
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 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 (802.3ah [12]), 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 IEEE 802.3 [11]:

- 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 43 - 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 might or might 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.997.1 Configuration Parameters and Performance Monitoring Counters

These tests verify the G.997.1 [8] 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 44. 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 44 - MINSNRM Control 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 in one of the profile line combinations associated to that band-profile in the rate adaptive mode (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) SNRM test configurations: a. MINSNRM = 5dB and TARSNRM=9dB b. MINSNRM = 8dB and TARSNRM=12dB (4) Connect VTU-R and VTU-O through the 300m PE04 or 1kft 26AWG (5) Additional test configurations: OPTIONAL OLR (SRA, SOS) SHALL NOT be used.
Method of Procedure	(1) Inject -120dBm/Hz AWGN noise added at both the VTU-R and VTU-C ends. This power level is considered the 0dB noise power. (2) Let the modems train. Wait for 1 minute after initialization. (3) Increase the noise power level by 6dB. (4) Wait not more than 90 seconds for modem to retrain. (5) Repeat the test for each all SNRM test configurations.
Expected Result	(1) For all SNRM test configurations modems SHALL retrain.

7.2 Configuration Parameter TARSNRM

A test procedure for verification of the TARSNRM noise margin configuration parameter is shown in Table 45. 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 45 - 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 TR-114 crosstalk noise applicable for that testloop at both the VTU-R and VTU-O ends. Note: The alien noise for 30a profiles, is provided in Annex A (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 ≥ (TARSNRM – 2 dB). (2) For Region B: Each reported SNR margin SHALL be ≥ (TARSNRM – 1 dB).

7.3 Configuration Parameter PSDMASK

A test procedure for verification of the PSDMASK configuration parameter is shown in Table 46. 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 46 - 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 long enough for the PSD to be measured. If it does not see the Note in Table 34 (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	(1) Measured PSD SHALL NOT exceed the MIB PSD mask (MIBMASK) (2) Measured PSD SHALL NOT exceed the Limit PSD mask (LMITMASK) (3) Measured PSD SHALL comply with the requirements from Section 7.2.3/G.993.2. [6]

7.4 Configuration Parameter VDSL2-CARMASK

A test procedure for verification of the VDSL2-CARMASK configuration parameter is shown in Table 47. 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 47 - 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	(1) 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 48. This test procedure SHALL be applied to both the downstream and upstream directions.

Table 48 - 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). (3) Additional test conditions for downstream test: a. MAXNOMATPds = 6.7dBm b. MAXNOMATPds = 0dBm NOTE: MAXNOMATPus=14.5dBm (Table 6-1/G.993.2). (4) Additional test conditions for upstream test (optional): a. MAXNOMATPus = 3.3dBm b. MAXNOMATPus = 0dBm NOTE: MAXNOMATPds is defined in Table 1.
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) Record the reported values of ACTATPds and ACTATPus (4) Disconnect the line. The VDSL2 link SHOULD stay in L0 long enough for the power to be measured. If it does not see the Note in Table 34. (5) 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. (6) Repeat the test for each MAXNOMATPds from TC(3). (7) Repeat the test for each MAXNOMATPus from TC(4)
Expected Result	(1) For each test the reported actual power SHALL be ≤ the configured MAXNOMATP (2) For each test the measured power SHALL be ≤ the configured 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 49 and Table 50, respectively.

Table 49 - 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 MOP(7) and MOP(4). (10) Calculate the increase of these counters between MOP(8) and MOP(3).
Expected Result	(1) No loss of synchronization SHALL occur during the test. (2) At the VTU-O. no increase of SES-L, SES-LFE, UAS-L and UAS-LFE SHALL be reported. (3) At the VTU-O, the increase of the ES-L, ES-LFE, CV-C and CV-CFE counters SHALL be ≥ 15 and ≤ 35 for DS and ≤ 32 for US (4) At the VTU-R. no increase of SES-L and UAS-L, if available, SHALL be reported. (5) At the VTU-R, the increase of CV-C and ES-L counters SHALL be at least equal to 15 and ≤ 35 for DS and ≤ 32 for US. (6) The increase of CV-C counter at the VTU-R SHALL be equal to the increase of CV-CFE counter at the VTU-O. (7) The increase of ES-L counter at the VTU-R SHALL be equal to the increase of ES-LFE counter at the VTU-O.

NOTE 1: The numbers in step ER(3) and ER(5) 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 ≥ 15 and ≤ 50 for DS and ≤ 47 for US.

Table 50 - 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 13. (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 MOP(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 MOP(9) and MOP(6). (12) Calculate the increase of these counters between MOP(10) and MOP(5).
Expected Result	(1) No loss of synchronization SHALL occur during the test. (2) At the VTU-O no increase of SES-L, SES-LFE, UAS-L and UAS-LFE SHALL be reported. (3) At the VTU-O, the increase of the ES-L, ES-LFE, CV-C and CV-CFE counters SHALL be ≥ 15 and ≤ 35 for DS and ≤ 31 for US (4) At the VTU-R no increase of SES-L and UAS-L, if available, SHALL be reported. (5) At the VTU-R, the increase of CV-C and ES-L counters SHALL be ≥ 15 and ≤ 35 for DS and ≤ 31 for US (6) The increase of CV-C counter at the VTU-R SHALL be equal to the increase of CV-CFE counter at the VTU-O.. (7) The increase of ES-L counter at the VTU-R SHALL be equal to the increase of ES-LFE counter at the VTU-O..

NOTE 1: The numbers in step ER(3) and ER(5) 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 ≥ 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 51.

Table 51 - 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 RA_F_150_150 and RA_I_150_150 specific line-setting defined in Table 13 (3) Additional test conditions: OPTIONAL OLR (SRA, SOS) SHALL NOT be used.
Method of Procedure	(1) Connect VTU-R and VTU-O through 1350 feet 26AWG or 450 m PE04. (2) Set the noise generator to -120dBm/Hz AWGN at the VTU-R and at the VTU-O side of the loop. (3) Force an initialization and wait for modem to sync. Wait 1 minute following synchronization. (4) 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. (5) Inject the noise impulse, -110dBm/Hz AWGN, with duration of 590 ± 10 milliseconds at the VTU-R side of the loop. (6) Repeat MOP(5) 14 times (for a total of 15 impulse events) with 10s between each event. (7) Force performance monitoring counters update and wait 30 seconds for the counters to be read out. (8) 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. (9) Calculate the increase of these counters between MOP(8) and MOP(4). (10) Repeat MOP(5) to MOP(9), but inject the noise impulse at the VTU-O side of the loop.
Expected Result	(1) No loss 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) For injecting the impulse noise at the VTU-R, the increase of SES-L counter at the VTU-R and SES-LFE counter at the VTU-O, SHALL be at least equal to 15 and ≤ 30. (6) For injecting the impulse noise at the VTU-O, the increase of SES-L counter at the VTU-O SHALL be ≥ 15 and ≤ 30.

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 52.

Table 52 - 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 13 (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).
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 53.

Table 53 - 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_040_006 specific line-setting defined in Table 13 (3) Additional test conditions: optional OLR (SRA, SOS) SHALL NOT be used. (4) Connect VTU-R and VTU-O with 0 length loop and no noise injected
Method of Procedure	(1) Wait 1 minute following synchronization. (2) Record the initial values of the Full initialization count and the Failed full initialization count at the VTU-O. (3) Disconnect the line for at least 7 seconds. (4) Wait for the modem to retrain. (5) Wait for 1 minute following synchronization. (6) Reconnect the line but with 900m length loop. (7) Wait for 90s. (8) Reconnect the line with 0 length loop and repeat MOP(1) and MOP(3) to MOP(7) four times. (9) Record the value of Full initialization count and Failed full initialization count reported by VTU-O. (10) 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 MOP(9) and MOP(2).
Expected Result	(1) The increase of the Full initialization count SHALL be ≥ 5. (2) The difference between the increase of Full initialization count and the increase of Failed full initialization count SHALL = 5. (3) The increase of the Failed full initialization count SHALL be ≥ 5.

Annex A Noise Model for Region B VDSL2 profile 30MHz

The noise model for Annex B/G.993.2 testing of the 30a VDSL2 over POTS (n_BA30a) and VDSL2 over ISDN (n_BB30a) systems consists of two components, self crosstalk and alien crosstalk, as defined in Section B.1.3.1/TR-114. The noise models represent the medium density scenario MD_CAB72 where the SUT is deployed from a street cabinet located at 72 dB attenuation (at 1 MHz) from the local exchange. The number of self disturbers equals 15. The equivalent alien noise PSD profiles are specified in Table 54. Noise models for the band-profiles with the activated DPBO and UPBO are defined in Table 55.

Table 54 - XA.LT and XA.NT component for MD_CAB72 noise scenario

Alien LT component for MD_CAB72 scenario		**Alien NT component for MD_CAB72 scenario**	
[Hz]	**[dBm/Hz]**	**[Hz]**	**[dBm/Hz]**
0.01	-30.2	0.01	-30.2
6500	-30.3	9100	-30.2
15000	-30.7	16000	-30.5
30000	-32.4	24000	-31
55000	-39.4	26000	-31
71000	-50.4	28000	-30.8
79000	-65	55000	-33.1
81000	-65	70000	-33.4
89000	-54.6	129000	-33.8
102000	-50.1	136000	-33.4
110000	-50.1	138000	-34.3
133000	-55.1	140000	-33.7
157000	-68.2	142000	-33.9
163000	-68.7	175000	-34.3
177000	-64.8	216000	-34.4
187000	-63.3	274000	-34.4
193000	-63.3	291000	-51.4
208000	-65.3	292000	-51.4
234000	-73	321000	-56.4
247000	-73.6	322000	-56.4
272000	-71.7	338000	-79.1
273000	-71.1	352000	-79.1
336000	-76.6	516000	-88.4
349000	-76.5	676000	-93.3
682000	-92.8	838000	-94.4
915000	-101.8	1112000	-94.6

1157000	-109.4	1411000	-94.6
1570000	-118.2	1630000	-104.5
30000000	-118.2	5274000	-106.5
		30000000	-106.5

Table 55 - Noise models for the 30a profiles with activated D&UPBO

Noise model	Associated band-profile	Self noise disturbers	Alien noise disturbers
n_BA30a_D&UPBO	Table 5	15	Table 54
n_BB30a_D&UPBO	Table 6	15	Table 54

Annex B Annex B PEIN Test Sequence

PEIN Test Sequence is contained in *TR-115_Issue-2.xls*, which can be found on the Technical Reports page at www.broadband-forum.org.

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 56 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 57 through Table 60, 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 56 - 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 57 - 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 58 - 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 59 - 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 60 - 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

End of Broadband Forum Technical Report TR-115