

Technical Requirements for ADSL/VDSL (up to 35b profile) Broadband CPE interface for Tim copper access network

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INDEX

1	REFERENCES	3
1.1	TIM references	3
1.2	Standard references	3
2	SCOPE	5
2.1	Description of Requirements	5
3	DESCRIPTION OF THE REFERENCE SCENARIO	6
4	XDSL PHYSICAL INTERFACE REQUIREMENTS	7
4.1	xDSL interface requirements for ADSL working modality	8
4.1.1	ATM support requirements.....	8
4.1.2	Interworking with the customer premises network requirements	8
4.1.3	ADSL1/2/2+ requirements	9
4.2	xDSL interface requirements for VDSL2 working modality	13
4.2.1	VLAN support requirements.....	13
4.2.2	VDSL2 with support of 8b/17a profiles requirements.....	13
4.2.3	VDSL2 with support of 35b profiles requirements	16
4.2.4	VDSL2 Quality Management requirements.....	19

1 REFERENCES

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- [1] TIM HW/SW equipment reference for FTTx deployment in access network (last version)

1.2 Standard references

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- [3] ITU-T G.992.3: "Asymmetric digital subscriber line (ADSL) transceivers – 2 (ADSL2)", 2009
- [4] ITU-T G.992.5: "Asymmetric digital subscriber line (ADSL) transceivers – extended bandwidth adsl2 (adsl2plus)", 2009
- [5] ITU-T G.997.1: "Physical layer management for digital subscriber line (DSL) transceivers", 2009
- [6] ITU-T G.998.4: "Improved Impulse Noise Protection (INP) for DSL Transceivers", 2010
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- [10] ETSI TS 105 388 V1.1.1 Technical Specification, Transmission and Multiplex™; Access transmission systems on metallic access cables; Asymmetric Digital Subscriber Line (ADSL2plus) – European specific requirements, 2008
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- [13] Broadband Forum "ADSL2/ADSL2plus Performance Test Plan", Technical Report TR-100 Issue 3, September 2014 and amendment 1
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- [16] ITU-T Recommendation G.994.1 "Handshake procedures for digital subscriber line (DSL) transceiver – 2012 Edition ", June 2012 and Amendments
- [17] ITU-T Recommendation G.997.1 "Physical layer management for digital subscriber line (DSL) transceivers – 2012 Edition", December 2012 and Amendments
- [18] ITU-T Recommendation G.998.4 "Improved Impulse Noise Protection (INP) for DSL Transceivers ", June 2015
- [19] ITU-T Recommendation G.996.2 "Line Testing for Digital Subscriber lines (DSL) ", May 2009 and Amendments
- [20] ITU-T Recommendation G.993.5 "Self-FEXT Cancellation (Vectoring) for use with VDSL2 transceivers", apr-10 and Amendments
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- [25] Broadband Forum Technical Report TR-249 Issue 1 "Testing of Self-FEXT Cancellation (vectoring)", March 2014 and amendment 1
- [26] Broadband Forum Technical Report TR-138 "Accuracy Tests for Test Parameters", November 2009 and amendment 1 and corrigendum 1
- [27] Broadband Forum Technical Report TR-198 Issue 2 "DQS: DQM systems functional architecture and requirements Issue 2", November 2012
- [28] Broadband Forum TR-042 "ATM Transport over ADSL Recommendation" – August 2001
- [29] ITU-T I.361: "B-ISDN ATM Layer Specification"
- [30] ITU-T I.363.5: "B-ISDN ATM Adaptation Layer (AAL) Specification"

- [31] ETSI TR 102 139 V1.1.1 “Compatibility of POTS terminal equipment with xDSL systems” – June 2000
- [32] TBR 21 “Terminal Equipment (TE); Attachment requirements for pan-European approval for connection to the analogue Public Switched Telephone Networks (PSTNs) of TE (excluding TE supporting the voice telephony service) in which network addressing, if provided, is by means of Dual Tone Multi Frequency (DTMF) signalling ETSI”;
- [33] ETSI EN 301 437: “Terminal Equipment (TE); Attachment requirements for pan-European approval for connection to the analogue Public Switched Telephone Networks (PSTNs) of TE supporting the voice telephony service in which network addressing, if provided, is by means of Dual Tone Multi Frequency (DTMF) signalling”
- [34] ETSI ETS 300 001: “General technical requirements for equipment connected to analogue subscriber interface in the PSTN”
- [35] ETSI TR 101 728: “Access and Terminals (AT); Study for the specification of the low pass section of POTS/ADSL splitters”
- [36] ETSI TS 101 952-3 “Access, Terminals, Transmission and Multiplexing (ATTM); Access network xDSL splitters for European deployment; Part 3: Generic specification of static distributed filters for xDSL over POTS” v1.1.1 2012-02.
- [37] EN 60950-1: “Apparecchiature per la tecnologia dell’informazione comprese le apparecchiature elettriche per ufficio - Sicurezza”
- [38] IEEE Std. 802.1Q-2003, Virtual Bridged Local Area Networks

2 SCOPE

This document provided by TIM, defines the technical requirements that a generic CPE with an A/VDSL interface (the “xDSL interface”), MUST fulfil for guaranteeing, on the physical layer, a full level of compatibility with the TIM Broadband CO devices, in order to support the Broadband TIM services distributed via its Copper Access Network line. These services are intended for both FTTCab and FTTEx deployment scenarios.

The present document does not describe any specific terminal equipment (TE) requirements. It does not aim to derive requirements for the network of TIM.

2.1 Description of Requirements

The document is organized as a list of numbered requirements (R.#) regarding physical functionalities of the xDSL CPE interface. The vendor is required to guarantee that its own CPE, based on a device part of its product portfolio, fulfil these requirements, to be interoperable at best level with TIM Copper Access Network devices, regarding A/VDSL2 physical layer aspects.

The Requirements items (R.#) are divided in 2 different groups:

- List of items called with “MUST”: these are mandatory requirements that must be supported by the CPE xDSL interface, in order to reach the necessary level of physical layer interoperability with TIM Copper Access Network. A not compliance of the CPE xDSL interface with these requirements can lead to have severe interoperability lacks with the Access Network devices, with potential impacts on the services delivered on it.
- List of items called with “SHOULD”: these are not mandatory requirements for the CPE xDSL interface, but the fulfilment of these will enable the CPE to reach, on the physical layer, the maximum level of compatibility and performance with TIM Copper Access Network.

3 DESCRIPTION OF THE REFERENCE SCENARIO

This section describes the reference scenarios where the CPE (specified in this document) will be used to provide data and voice services via the xDSL connection.

Two different deployment models are possible with ADSL technology, with master customer splitter (scenario #1), or with distributed u-filters (scenario #2) for delivering the phone service on the customer premises plant.

With VDSL2 technology only model #3 without splitter is foreseen (VoIP service).

The “xDSL interface” to which this document refers in the requirements, is the one specified in standards documents (ITU-T), and is:

- U-R2 for model #1
- U-R for models #2 and #3

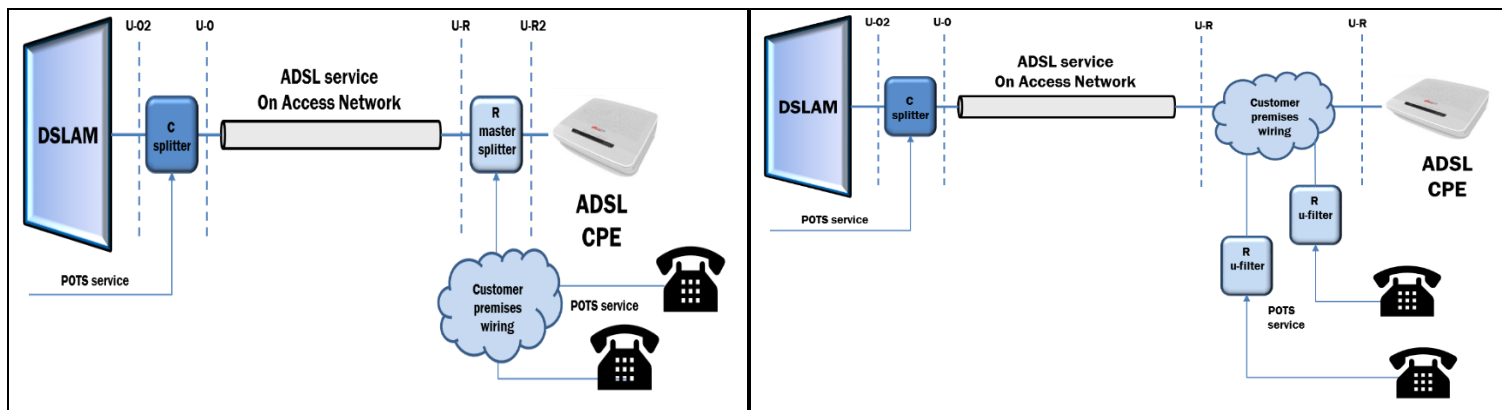


Figure 3-1 – Reference model #1 and #2 for ADSL technology with master customer splitter or distribute splitters (POTS service)

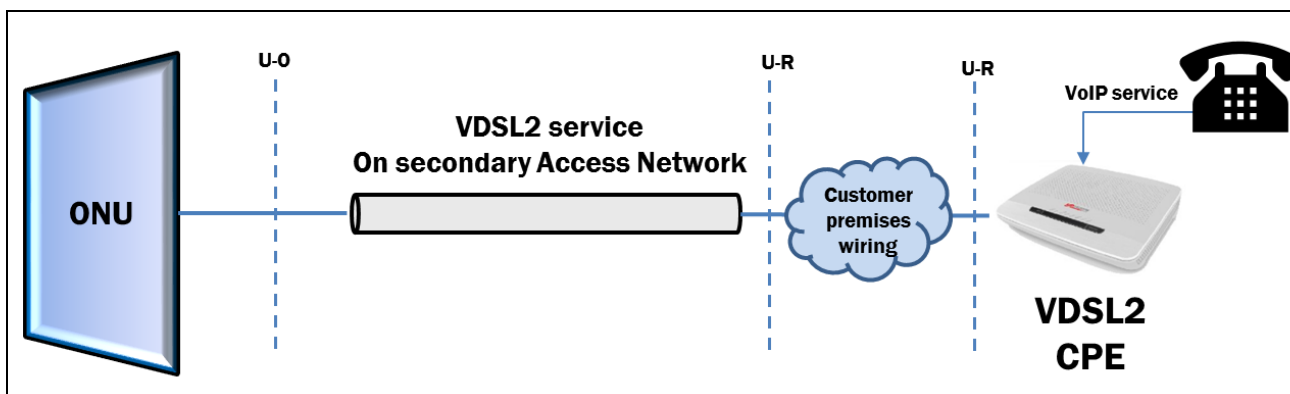


Figure 3-2 – Reference model #3 for VDSL2 technology without customer splitters (VoIP service)

4 XDSL PHYSICAL INTERFACE REQUIREMENTS

The requirements reported in the following sections have the aim to specify the xDSL interface behaviour of a generic CPE, working in ADSL only, VDSL2 only or A/VDSL2 “hybrid” modality, in order to permit a good interworking level with the TIM Copper Access Network remote devices.

The CPE xDSL interface, according to its supported Working Modalities, **MUST** support the following sections of requirements:

CPE Type	Working Modality	Requirements sections to be supported
A	ADSL1/2/2+ only	4.1.1, 4.1.2, 4.1.3
V17	VDSL2 only (up to 17a)	4.2.1, 4.2.4
V35	VDSL2 only (up to 35b)	4.2.1, 4.2.3, 4.2.4
AV17	ADSL1/2/2+ and VDSL2 (up to 17a)	4.1.1, 4.1.2, 4.1.3 4.2.1, 4.2.4
AV35	ADSL1/2/2+ and VDSL2 (up to 35b)	4.1.1, 4.1.2, 4.1.3 4.2.1, 4.2.3, 4.2.4

Table 1 – List of requirements sections to be supported of each type of CPE

- R. 1. In case of a CPE of Type AV17 or AV35, supporting both ADSL and VDSL2 services, the xDSL interface **MUST** support a multimode set allowing the synchronization in ADSL1/2/2+ or VDSL2 mode, depending on what is negotiated with the network platform DSLAM/ONU in the handshaking phase. Subsets of the above multimode set **MUST** be allowed.
- R. 2. In case of a CPE Type AV17 or AV35, supporting both ADSL and VDSL2 services, the xDSL interface **MUST** be able to trigger the right connectivity model (based on ATM or PTM) each time an ADSL or VDSL network is synchronized.
- R. 3. The xDSL interface on the network side (U-R2 for scenario #2 #3, and U-R for scenario #3) **MUST** provide a compatible mechanical connection with the RJ11 standard female plug of TIM customer master phone socket and of distributed u-filters (xDSL service delivered on the 2 central pins of the female connector).

4.1 xDSL interface requirements for ADSL working modality

4.1.1 ATM support requirements

- R. 4. The ATM/ADSL network interface MUST be based on a PVC model.
- R. 5. The ATM/ADSL network interface MUST work as a Termination function of the ATM layer transported between the CPE and the ONU, as specified in Broadband Forum recommendation TR-042 [28].
- R. 6. The ATM/ADSL network interface MUST be UNI type, in conformance with ATM Forum UNI 4.0.
- R. 7. The ATM/ADSL network interface functionalities MUST be compliant to ITU-T I.361 recommendation [29].
- R. 8. The ATM/ADSL network interface AAL5 adaptation protocol MUST be compliant to ITU-T I.365 recommendation [30].
- R. 9. The ATM/ADSL network interface MUST support the whole VPI/VCI range.
- R. 10. The ATM/ADSL network interface MUST support that the ATM PVCs be configurable with all the possible combinations, in terms of:
 - encapsulation mode: each PVC MUST be configurable with any encapsulation mode, independently by the encapsulation of other PVCs;
 - ATM Transfer Capabilities: each PVC MUST be configurable with any of the transfer capability specified in the next requirements, independently by the configuration of other PVCs
- R. 11. The ATM/ADSL network interface MUST support OAM F5 RDI, AIS and loop-back functionalities.
- R. 12. The ATM/ADSL network interface MUST support the “Multiprotocol Encapsulation over ATM Adaptation Layer 5”, in conformance with RFC 2684 (bridged) with LLC/SNAP. The CPE MUST be an end-point for this protocol, independently from connected LAN interfaces (Ethernet, WLAN).
- R. 13. The ATM/ADSL network interface MUST support “Classical IP and ARP over ATM”, in conformance with RFC 1577 with LLC/SNAP encapsulation.
- R. 14. The ATM/ADSL network interface MUST support ATM UBR transfer capability (characterised by PCR, Peak Cell Rate, parameter, configurable on single PVC basis).

4.1.2 Interworking with the customer premises network requirements

- R. 15. The correct interworking of the CPE with the network MUST be guaranteed under all circumstances. In particular, the disturbances caused by or related with other POTS services on the same network termination MUST be minimised. By following the guidelines of ETSI TR 102 139 [31], the immunity to disturbances generated by POTS terminals complying with ETSI TBR21 [32] o ETSI EN 301 437 [33] MUST be guaranteed, also with respect to loop disconnection dialling, as operated in compliance with ETSI ETS 300 001 [34]. The CPE MUST also comply with ETSI TBR21 requirements applicable to POTS terminals in quiescent state.
- R. 16. The CPE xDSL interface MUST be compatible with all the POTS splitter configurations [35], both centralised (based on one master splitter) and distributed [35] (currently adopted by TIM for offering the xDSL access to residential users).
- R. 17. In case the CPE installation kit provide a distribute filter, it MUST be an ADSL2+ filter type compliant with ETSI TS 101 952-3 v1.1.1 2012-02 [36] and CEI EN 60950-1 [37];

4.1.3 ADSL1/2/2+ requirements

- R. 18. The xDSL interface **MUST** support the automatic selection of the best ADSL operational mode, if more than 1 mode is specified in the DSLAM profile (multimode configuration). In this case, the CPE **MUST** support the selection of the working modality following this priority order:
- 1 - ADSL2+
 - 2 - ADSL2
 - 3 - ADSL1
- R. 19. The xDSL interface, when working in ADSL1 mode, **MUST** be compliant with the requirements specified in ITU-T G.992.1 Recommendation (ADSL1) Annex A [2].
- R. 20. The xDSL interface, when working in ADSL2 mode, **MUST** be compliant with the requirements specified in ITU-T G.992.3 Recommendation (ADSL2) Annex A [3].
- R. 21. The xDSL interface, when working in ADSL2+ mode, **MUST** be compliant with the requirements specified in ITU-T G.992.5 Recommendation (ADSL2+) Annex A [4].
- R. 22. The xDSL interface, when working in ADSL1/2/2+ mode, **MUST** be compliant with the ITU-T G.994.1 Recommendation [16].
- R. 23. The xDSL receiver interface **MUST** support, in ADSL1/2/2+ modality, the limits on the transmitted power in downstream direction, as required by the “ATU-C transmitter PSD mask for not overlapped spectrum operation”, with US spectrum working between 25kHz and 138 kHz.
- R. 24. The xDSL interface, when working in ADSL2/2+ mode, **SHOULD** support spectral compatibility with other services deployed from different locations, supporting Downstream Power Back Off (DPBO) functionality as described in chapter 7.3 of ITU-T G.997.1 Recommendation [17].
- R. 25. The xDSL interface, when working in ADSL1/2/2+ mode **MUST** support rate adaptation modes according MANUAL and AT INIT modality.
- R. 26. The xDSL interface, when working in ADSL2 mode, **SHOULD** support at least the framing parameters configuration as specified in Table 1 of ETSI TS 103 388 v1.1.1 [11].
- R. 27. The xDSL interface, when working in ADSL2+ mode, **SHOULD** support at least the framing parameters configuration as specified in Tables 1 and 2 of ETSI TS 105 388 v1.1.1 [10].
- R. 28. The xDSL interface, when working in ADSL2/2+ mode, **MUST** support the framing extended values, to achieve higher net data rates while satisfying a configured minimum impulse noise protection (INP_min), as specified in Table 7-8 of ITU-T G.992.3 and G.992.5 Amd 3 Recommendations [3] and [4].
- R. 29. The xDSL interface, when working in ADSL2/2+ mode **MUST** support bitrate not lower than those specified in K.3c of Annex K of ITUT-T G.992.3 (ADSL2) [3] and G.992.5 (ADSL2+) [4]. In any case the The xDSL interface **MUST** support, without connection rate limitations, the maximum rate value set of the TIM service profiles in its actual ADSL deployment.
- R. 30. The xDSL interface, when working in ADSL2/2+ mode, **SHOULD** support a DS interleaving memory amount of 24kB, as specified in Table 7-8 of ITU-T G.992.3 and G.992.5 Amd 3 Recommendation [3] and [4].
- R. 31. The xDSL interface, also when working in ADSL1/2/2+ mode, **MUST** support operativity in interleaved mode and in fast mode.
- R. 32. The xDSL interface, when working in ADSL2/2+ mode, **MUST** support the G.INP Retransmission in downstream direction, for impulsive noise protection as specified in

ITU-T G.998.4 Recommendation [6]. The ADSL interface MUST support both protection against SHINE and REIN impulsive noise types.

- R. 33. The xDSL interface, when working in ADSL2/2+ mode, MUST support the automatic downgrade to work with the standard INP/Interleaving Delay protection method, with specified settings parameters if, for any reason, the retransmission protection method is enabled but cannot be applied on the connection.
- R. 34. The xDSL interface, when working in ADSL2+ mode MUST support a DS bitrate not lower than 22240 kbps, with parameters INP/Delay =2/8 or when G.INP retransmission is enabled.
- R. 35. The xDSL interface, when working in ADSL2/2+ mode SHOULD support rate adaptation modes according DYNAMIC modality.
- R. 36. The xDSL interface, when working in ADSL2/2+ mode, SHOULD support SRA functionalities, as defined in § 10.2.1 of the ITU-T G.992.3 Recommendation [3].
- R. 37. The ADSL interface SHOULD support the compatibility between the SRA and standard G.998.4 Retransmission, as specified in ITU-T G.998.4, Amd 1 [6].
- R. 38. The xDSL interface, when working in ADSL2/2+ mode, SHOULD support Loop diagnostic (DELT). After a DELT procedure has been finished (successful or unsuccessful), the line has to fall back into the same state as before the DELT procedure was started.
- R. 39. The xDSL interface, when working in ADSL1 mode, MUST guarantee, at least, the required performances indicated in Broadband Forum TR-067 Issue 2 Annex A.2 [12]
- R. 40. The xDSL interface, when working in ADSL2/2+ mode MUST be compliant to all tests specified in Broadband Forum TR-100 Issue 2 [13] for Europe, and guarantee at least the rate reach performances indicated in Annex A.2
- R. 41. The xDSL interface, when working in ADSL2/2+ mode, MUST pass the tests specified in Broadband Forum TR-105 Issue 2 [14] for Europe and applicable to a G.992.3 and G.992.5 Annex A line.
- R. 42. The xDSL interface, when working in ADSL1/2/2+ mode MUST support the OAM “Loss of Power” autonomous message (dying gasp) towards the DSLAM, in case of interruption of power of the CPE.
- R. 43. The xDSL interface, when working in ADSL1/2/2+ mode, MUST make available to the DSLAM/ONU the Inventory Information as described in ITU-T G.997.1 Recommendation [17] section 7.4. In particular, the CPE MUST provide back to the DSLAM/ONU the correct contents specified for the following information fields, related to the identification of the system and the chipset vendor:
 - xTU-R ITU-T G.994.1 vendor ID

In this field the ITU-T G.994.1 vendor ID MUST identify the vendor of the xTU-R ITU-T G.994.1 functionality, whether implemented in hardware or software. It is not intended to indicate the system integrator but instead the **chipset** vendor. The structure of the info MUST be 8 bytes, and in particular:

 - T.35 country code (2 octets)
 - T.35 provider code (vendor identification) (4 octets)
 - T.35 provider oriented code (vendor revision number) (2 octets)
 - xTU-R system vendor ID

The xTU-R system vendor ID MUST identify the xTU-R **system** integrator. In this context, the system integrator usually refers to the vendor of the smallest field-

replaceable unit. As such, the xTU-R system vendor ID may not be the same as the xTU-R ITU-T G.994.1 vendor ID.

The structure of the info MUST be 8 bytes, and in particular:

- T.35 country code (2 octets)
- T.35 provider code (vendor identification) (4 octets)
- T.35 provider oriented code (vendor revision number) (2 octets)

- xTU-R version number

It shall contain the xTU-R firmware version and the xTU-R model. Both shall be encoded in this order and separated by a space character, i.e., "<xTU-R firmware version> <xTU-R model>". The structure MUST be 16 ASCII char.

NOTE – This field is intended to contain information about the firmware and model of the xTU-R physical layer interface (**chipset**).

- xTU-R serial number

It shall contain the following **system** indicators: the equipment serial number, the equipment model and the equipment software version. All shall be encoded in this order and separated by space characters, i.e., "<equipment serial number> <equipment model> <equipment software version>". The structure MUST be 32 ASCII char.

Note that the combination of **system** vendor ID and serial number creates a unique number for each xTU-R.

The vendor specific information in the Vendor ID information block SHOULD not be used as a mean to achieve interoperability in order to avoid workarounds and to achieve full standard compliance.

R. 44. The xDSL interface, when working in ADSL1/2/2+ mode, MUST provide to the DSLAM the following line parameters:

- scalars:
 - Actual Data Rate, Noise Margin, Attainable Data Rate, LATN, SATN, ATP
- performance monitoring counters (for 15 minutes and 24h periods):
 - ES, SES, UAS, Full Init, Failed full Init

R. 45. In addition to parameters required in R. 44, the xDSL interface, when working in ADSL2/2+ mode MUST provide to the DSLAM the following line parameters:

- Vectorial parameters
 - HLOGps, SNRps, BITSps, QLNps, PSDps

In case of Retransmission Enabled:

- Retransmission Scalar parameters:
 - Actual Net Data Rate, Attainable Net Data Rate, ActINP, ActINPrein, ActDelay;
- Retransmission performance monitoring counters (for 15 minutes and 24h periods):
 - Leftr defect, Error-free bits, MINEFTR

- R. 46. The xDSL interface MUST support the interoperability at least with the ADSL1/2/2+ DSLAMs currently in use in the Telecom Italia network specified in the TIM document [1].

4.2 xDSL interface requirements for VDSL2 working modality

4.2.1 VLAN support requirements

These requirements apply to the CPE xDSL interface independently of its VDSL2 working modality, and are necessary for guaranteeing the correct interface layer-2 connectivity

- R. 47. The xDSL interface MUST support traffic based on VLAN tags according to 802.1q [38].
- R. 48. The xDSL interface MUST support the full range of VLAN IDs (as defined in standard).
- R. 49. The xDSL interface MUST be able to add/remove VLAN tag on the transmitted/received Ethernet frames.
- R. 50. The xDSL interface MUST allow the transmission of Ethernet frames with a payload (excluded the 802.1q tag) up to 1500 bytes (as defined in standard).

4.2.2 VDSL2 with support of 8b/17a profiles requirements

- R. 51. The xDSL interface MUST be compliant with ITU-T G.993.2 “Very high speed digital subscriber line 2” Recommendation [15].
- R. 52. The xDSL interface MUST support working mode according to Annex B (tables B-1, B-3, B-6.A and B-7.A, B-6.B and B-7.B) of ITU-T G.993.2 Recommendation [15].
- R. 53. The xDSL interface MUST be compliant to ITU-T G.994.1 Recommendation [16].
- R. 54. The xDSL interface MUST support 8b profile (with +20.5 dBm of DS ATP), with 998 Band Plan as described in table B-1 of ITU-T G.993.2 Recommendation [15], fulfilling the specific parameters according to the indications reported in sec. 6.3.
- R. 55. The xDSL interface MUST implement B8-4 (998-M2x-A) limit PSD mask for 8b profiles as described in tables B-3, B-6.A and B-7.A of Annex B of ITU-T G.993.2 Recommendation [15].
- R. 56. The xDSL interface MUST support 998 Band Plan 17a profile with 998E17 Band Plan as described in table B-1 of ITU-T G.993.2 Recommendation [15].
- R. 57. The xDSL interface MUST implement B8-18 (998E17-M2x-A) limit PSD mask for 17a profile, as described in tables B-3, B-6.A and B-7.A of Annex B of ITU-T G.993.2 Recommendation [15].
- R. 58. The xDSL interface when working with 8b or 17a profile, MUST use the US0 optional band with spectrum from 25kHz to 138 kHz. The US0 is necessary for guarantying connection in case of high attenuation loops.
- R. 59. The xDSL interface SHOULD implement a dynamic smart US0 power control. For example, enabling the US0 band and/or tuning its power level depending on the Upstream attenuation on the line. In any case, US0 usage MUST not penalize the Downstream and Upstream performances.
- R. 60. The xDSL interface MUST support the full spectral compatibility with legacy ADSL1/2/2+ services coming from other remote nodes. For doing this, the VDSL2 interface MUST support “Downstream Power Back Off” shaping function (DPBO), with a shaping up to 2.2 MHz, as described in the sec. 7.3 of ITU-T G.997.1 Recommendation [17].
- R. 61. The xDSL interface MUST guarantee the full Upstream spectral compatibility with other VDSL2 interfaces in the same system. For doing this, the VDSL2 interface MUST support “Upstream Power Back Off” function (UPBO) as specified in the sec. 7.2 of ITU-T G.993.2 Recommendation [15].
- R. 62. The VDSL2 interface MUST support UPBO function applying independent parameters (a,b) for all the US used bands.

- R. 63. The xDSL interface MUST support the Default Electrical Length estimation Method (ELE-M0).
- R. 64. The xDSL interface MUST support the optional Alternative Electrical Length Estimation Method (ELE-M1), and all AELEM1/2/3 calculation methods to derive the UPBO electrical length (KL0) applied to all US used bands, except of US0, as specified in the sec. 7.2 of ITU-T G.993.2 Recommendation [15].
- R. 65. The xDSL interface MUST make available to the DSLAM/ONU, via the EOC, the VTU-R UPBO electrical length per-band estimations (KL0pb) for each supported downstream band (UPBOKLE-R-pb)
- R. 66. The xDSL interface MUST support the presence of Bridged Tap (BT) on the connection, causing “holes” on the transmission channel. In any case the existing BTs of any length on the channel MUST not prevent the VDSL2 connection. BTs can be present in the customer house in case of not sectioned plant with master splitter, or on the access network line in case of loop forks.
- R. 67. The xDSL interface MUST support the Ethernet data packets transport with EFM (64/65) encapsulation method, as specified for the PTM-TC functionalities reported in the Annex K of the ITU-T G.993.2 Recommendation [15].
- R. 68. The xDSL interface, MUST support rate adaptation modes according MANUAL, AT INIT and DYNAMIC modality.
- R. 69. The xDSL interface SHOULD support Loop diagnostic (DELT). After a DELT procedure has been finished (successful or unsuccessful), the line has to fall back into the same state as before the DELT procedure was started.
- R. 70. The xDSL interface MUST support transmission with RFI enabled as specified in §7.2.1.2 of ITU-T G.993.2 Recommendation [15].
- R. 71. The xDSL interface SHOULD support the extended values of (1/S)max as reported in table 9-7, of the ITU-T G.993.2 Recommendation [15].
- R. 72. The xDSL interface MUST support G.INP Retransmission for impulsive noise protection as specified by ITU-T G.998.4 Recommendation [18], for both Downstream and Upstream direction for all VDSL2 profiles required (8b, 17a) and limit PSD masks. The VDSL2 interface MUST support both protection against SHINE and REIN impulsive noise types.
- R. 73. The VDSL2 interface MUST support the “Intra DTU Interleaver” for operations with standard PHY Layer Retransmission, as specified in ITU-T G.998.4, Amd 2 [8], with the interleaving depth for latency path #1 greater than 1.
- R. 74. The xDSL interface MUST support G.INP Retransmission protection in DS side of at least 15 ms (ACT INP = 60) at DS Data Rate of 108Mbps.
- R. 75. The xDSL interface MUST automatically switch to work with the standard INP/Delay protection method, with the specified settings parameters if, for any reason, the Retransmission protection method is enabled but cannot be applied on the connection.
- R. 76. The xDSL interface MUST support without rate limitations a data rate of at least 108M/21.6M with 17a profile (Actual Net Data Rate DS/US with Retransmission enabled).
- R. 77. The xDSL interface SHOULD guarantee, with profile 17a, a data rate of 150/50M (Actual Net Data Rate DS/US) for permitting the deployment of future service offers.
- R. 78. The xDSL interface MUST support SRA functionalities as defined in §13.1 of the ITU-T G.993.2 Recommendation [15].
- R. 79. The xDSL interface MUST support the SOS functionality, as specified in §13.4.3 of ITU-T G.993.2 Recommendation [15].

- R. 80. The xDSL interface MUST support the compatibility between the SRA/SOS and standard G.998.4 Retransmission, as specified in ITU-T G.998.4 Recommendation [18].
- R. 81. The xDSL interface MUST support the compatibility between the SRA/SOS and a line profile with interleaving (i.e. profile with INP/Delay protection) with automatic update of framing parameters (e.g. D parameter) when an OLR event (SRA or SOS) changes the connection rate, for guaranteeing the fulfilling the INPmin and Delaymax constraints specified by the line profile.
- R. 82. The xDSL interface SHOULD support the “improved Attainable Net Data Rate” for both standard G.993.2 and with standard retransmission operation modes, as specified in ITU-T G.993.2 [15] and ITU-T G.998.4 [18] Recommendations.
- R. 83. The xDSL interface MUST support the Self-FEXT Cancellation (Vectoring) functionality on both Downstream and Upstream directions, with all profiles required (8b, 17a) and limit PSD masks, as defined in ITU-T G.993.5 Recommendation [20].
- R. 84. The xDSL interface when working with retransmission, MUST support the “Extended memory for enhanced net data rates with ITU-T G.993.5 (vectoring)” operation, with the indicated Maximum Aggregate Achievable Net Data Rate values for the 17a profile (150 Mbit/s) as specified in Annex D of ITU-T G.998.4 Recommendation [18], supporting both activation methods (with vectoring enabled and with G.998.4 Extension “G.998.4 Annex D support”).
- R. 85. The xDSL interface, when working with vectoring, MUST support Disorderly Leaving Events (line interruption) that SHOULD be detected within the period necessary for Retransmission intervention (e.g. < 10 ms), and appropriate means need to be provided to limit the impact on other lines within the same vectoring group. This can be achieved e.g. by stopping any transmit signal immediately by the CPE.
- R. 86. The xDSL interface, when working with vectoring, MUST support the support of all the previously specified functionalities (DPBO, UPBO, G.INP Retransmission, SRA, SOS) without limitations and interworking issues among them.
- R. 87. The xDSL interface MUST support the interoperability at least with VDSL2 ONUs currently in use in the Telecom Italia network specified in the TIM document [1] for 8b and 17a profiles.
- R. 88. The xDSL interface MUST be compliant to all tests specified in Broadband Forum TR-114 issue 2 [21], WT-114 issue 3 [22] and WT-114 issue 3 Amd1 [23], applicable to all required profiles and limit PSD masks. Moreover, the system MUST support at least the performances indicated in Annex B.
- R. 89. The xDSL interface MUST be compliant to the tests specified for Europe in Broadband Forum TR-115 issue 3 [24], applicable to all above required profiles (8b, 17a) and limit PSD masks.
- R. 90. The xDSL interface when working with vectoring MUST be compliant to all tests and performance requirements specified in Broadband Forum TR-249 [25] test plan, applicable to all required VDSL2 profiles and limit PSD masks.

4.2.3 VDSL2 with support of 35b profiles requirements

- R. 91. The xDSL interface MUST support working mode according to Annex Q (profile 35b) of ITU-T G.993.2 Recommendation [15].
- R. 92. The xDSL interface MUST support 35b profile, with 998E35 Band Plan as described in table B-1 of ITU-T G.993.2 Recommendation [15], fulfilling the specific parameters according to the indications reported in Annex Q.
- R. 93. The xDSL interface MUST implement B8-19 (998E35-M2x-A) limit PSD mask for 35b profile, as described in tables B-3, B-6.B and B-7.B of Annex B of ITU-T G.993.2 Recommendation [15].
- R. 94. The xDSL interface when working in 35b profile, MUST use the US0 optional band with spectrum from 25kHz to 138 KHz. The US0 is necessary for guarantying connection in case of high attenuation loops.
- R. 95. The xDSL interface SHOULD implement a dynamic smart US0 power control. For example, enabling the US0 band and/or tuning its power level depending on the Upstream attenuation on the line. In any case, US0 usage MUST not penalize the Downstream and Upstream performances.
- R. 96. The xDSL interface MUST support the full spectral compatibility with legacy ADSL/2/2+ services coming from other remote nodes. For doing this, the VDSL2 interface MUST support “Downstream Power Back Off” shaping function (DPBO) as described in the sec. 7.3 of ITU-T G.997.1 Recommendation [17].
- R. 97. The xDSL interface MUST guarantee the full Upstream spectral compatibility with other VDSL2 interfaces in the same system. For doing this, the VDSL2 interface MUST support “Upstream Power Back Off” function (UPBO) as specified in the sec. 7.2 of ITU-T G.993.2 Recommendation [15].
- R. 98. The VDSL2 interface MUST support UPBO function applied with independent parameters (a,b) for all US bands used.
- R. 99. The xDSL interface of the CPE supporting 35b profile, in case of a multi-profile setting on the ONU, MUST support the automatic selection of the VDSL2 profile with the following priority:
 - 1 - 35b profile
 - 2 - 17a profile
- R. 100. The xDSL interface MUST support the Default Electrical Length estimation Method (ELE-M0).
- R. 101. The xDSL interface MUST support the optional Alternative Electrical Length Estimation Method (ELE-M1), using all AELEM1/2/3 calculation methods to derive the UPBO electrical length (KL0) applied to all US bands, except of US0, as specified in the sec. 7.2 of ITU-T G.993.2 Recommendation [15].
- R. 102. The xDSL interface MUST make available to the DSLAM/ONU, via the EOC, the UPBO electrical length per-band (KL0pb) estimates for each supported downstream band (UPBOKLE-R-pb).
- R. 103. The xDSL interface MUST support the presence of Bridged Tap (BT) on the connection, causing “holes” on the transmission channel. In any case existing BTs of any length on the channel MUST not prevent the VDSL2 connection. BTs can be present in the customer house in case of not sectioned plant with master splitter, on the access network line in case of loop forks.

- R. 104. The xDSL interface MUST support the Ethernet data packets transport with EFM (64/65) encapsulation method, as specified for the PTM-TC functionalities reported in the Annex K of the ITU-T G.993.2 Recommendation [15].
- R. 105. The xDSL interface, MUST support rate adaptation modes according MANUAL, AT INIT and DYNAMIC modality.
- R. 106. The xDSL interface SHOULD support Loop diagnostic (DELT). After a DELT procedure has been finished (successful or unsuccessful), the line has to fall back into the same state as before the DELT procedure was started.
- R. 107. The xDSL interface MUST support transmission with RFI enabled as specified in § 7.2.1.2 of ITU-T G.993.2 Recommendation [15].
- R. 108. The xDSL interface MUST support G.INP Retransmission for impulsive noise protection as specified by ITU-T G.998.4 Recommendation [18], for both Downstream and Upstream direction for 35b profile and limit PSD mask. The VDSL2 interface MUST support both protection against SHINE and REIN impulsive noise types.
- R. 109. The VDSL2 interface MUST support the “Intra DTU Interleaver” for operations with standard PHY Layer Retransmission, as specified in ITU-T G.998.4, Amd 2 [8], with the interleaving depth for latency path #1 greater than 1.
- R. 110. The xDSL interface MUST support G.INP Retransmission protection in DS side of at least 10 ms (ACT INP = 40) at DS Data Rate of 216Mbps.
- R. 111. The xDSL interface MUST automatically switch to work with the standard INP/Delay protection method, with the specified settings parameters if, for any reason, the Retransmission protection method is enabled but cannot be applied on the connection.
- R. 112. The xDSL interface MUST support without rate limitations a data rate of at least 216M/21.6M with profile 35b (Actual Net Data Rate DS/US with Retransmission enabled).
- R. 113. The xDSL interface MUST support SRA functionalities as defined in § 13.1 of the ITU-T G.993.2 Recommendation [15].
- R. 114. The xDSL interface MUST support the SOS functionality, as specified in §13.4.3 of ITU-T G.993.2 Recommendation [15].
- R. 115. The xDSL interface MUST support the compatibility between the SRA/SOS and standard G.998.4 Retransmission, as specified in ITU-T G.998.4 Recommendation [18].
- R. 116. The xDSL interface MUST support the compatibility between the SRA/SOS and a line profile with interleaving (i.e. profile with INP/Delay protection) with automatic update of framing parameters (e.g. D parameter) when an OLR event (SRA or SOS) changes the connection rate, for guaranteeing the fulfilling the INPmin and Delaymax constraints specified by the line profile.
- R. 117. The xDSL interface SHOULD support the “improved Attainable Net Data Rate” for both standard G.993.2 and with standard retransmission operation modes, as specified in ITU-T G.993.2 [15] and ITU-T G.998.4 [18] Recommendations.
- R. 118. The xDSL interface MUST support the Self-FEXT Cancellation (Vectoring) functionality on both Downstream and Upstream directions, with 35b profile, as defined in ITU-T G.993.5 Recommendation [20].
- R. 119. The xDSL interface when working with retransmission, MUST support the “Extended memory for enhanced net data rates with ITU-T G.993.5 (vectoring)” operation, with the indicated Maximum Aggregate Achievable Net Data Rate values for the 35b profile (at least 350 Mbit/s with Upstream retransmission active) as specified in Annex Q of ITU-T G.993.2 Recommendation [15] and Annex D of ITU-T G.998.4 Recommendation [18], supporting both activation methods (with vectoring enabled and with G.998.4 Extension “G.998.4 Annex D support”).

- R. 120. The xDSL interface, when working with vectoring, MUST support Disorderly Leaving Events (line interruption) that SHOULD be detected within the period necessary for Retransmission intervention (e.g. < 10 ms), and appropriate means need to be provided to limit the impact on other lines within the same vectoring group. This can be achieved e.g. by stopping any transmit signal immediately by the CPE.
- R. 121. The xDSL interface, when working with vectoring, MUST support the support of all the previously specified functionalities (DPBO, UPBO, G.INP Retransmission, SRA, SOS), without limitations and interworking issues among them.
- R. 122. The xDSL interface MUST support the interoperability at least with VDSL2 ONUs currently in use in the Telecom Italia network specified in the TIM document [1] for 35b profile.
- R. 123. The xDSL interface MUST be compliant to all tests specified in Broadband Forum TR-114 issue 2 [21], WT-114 issue 3 [22] and WT-114 issue 3 Amd1 [23], applicable to required profile and limit PSD masks. Moreover, the system MUST support at least the performances indicated in Annex B and Annex Q.
- R. 124. The xDSL interface MUST be compliant to the tests specified for Europe in Broadband Forum TR-115 issue 3 [24], applicable to all above required profiles and limit PSD masks.
- R. 125. The xDSL interface when working with vectoring MUST be compliant to all tests and performance requirements specified in Broadband Forum TR-249 [25] test plan.

4.2.4 VDSL2 Quality Management requirements

Independently from which VDSL2 profile (8b, 17a or 35b) is applied on the connection, the xDSL interface MUST support the following VDSL2 Quality Management requirements:

- R. 126. The xDSL interface MUST be compliant to ITU-T G.997.1 Recommendation [17].
- R. 127. The xDSL interface MUST be compliant to PLOAM Accuracy Requirements, listed in ITU-T G.993.2 Recommendation [15].
- R. 128. The xDSL interface MUST be compliant to the tests specified in Broadband Forum TR-138 [26].
- R. 129. Independently of the ONU platform on the ATU-C side (Refer to [1] document), the CPE MUST make available to the ONU, via the EOC, all the parameters listed in the document Broadband Forum TR-198 issue 2 [27] applicable to a CPE:
 - Scalar parameters:
 - Actual Data Rate, Noise Margin, Attainable Data Rate, LATNpb, SATNpb, ATP, INP, Interleaving Delay
 - In case of Retransmission enabled: Actual Net Data Rate, Attainable Net Data Rate ActINP, ActINPREin, ActDelay;
 - Performance monitoring counters (15 minutes and 24h periods):
 - ES, SES, UAS, Full Init, Failed full Init, SOS-SUCCESS
 - in case of Retransmission enabled: Leftr defect, Error-free bits, MINEFTR
 - Vectorial parameters
 - HLOGps, SNRps, BITSps, QLNps, PSDps
 - In case of vectoring enabled: XLINps
- R. 130. The xDSL interface MUST support the correct generation of the “dying gasp” message via the EOC channel, as an indication of loss of power (LOP or LPR), in case of the device switch off or unplug of either side of the device power cord.
- R. 131. The xDSL interface MUST make available to the DSLAM/ONU the Inventory Information as described in ITU-T G.997.1 Recommendation [17] section 7.4. In particular, the CPE MUST provide back to the DSLAM/ONU the correct contents specified for the following information fields, related to the identification of the system and the chipset vendor:
 - xTU-R ITU-T G.994.1 vendor ID

In this field the ITU-T G.994.1 vendor ID MUST identify the vendor of the xTU-R ITU-T G.994.1 functionality, whether implemented in hardware or software. It is not intended to indicate the system integrator but instead the **chipset** vendor. The structure of the info MUST be 8 bytes, and in particular:

 - T.35 country code (2 octets)
 - T.35 provider code (vendor identification) (4 octets)
 - T.35 provider oriented code (vendor revision number) (2 octets)
 - xTU-R system vendor ID

The xTU-R system vendor ID MUST identify the xTU-R **system** integrator. In this context, the system integrator usually refers to the vendor of the smallest field-replaceable unit. As such, the xTU-R system vendor ID may not be the same as the xTU-R ITU-T G.994.1 vendor ID.

The structure of the info MUST be 8 bytes, and in particular:

 - T.35 country code (2 octets)

- T.35 provider code (vendor identification) (4 octets)
- T.35 provider oriented code (vendor revision number) (2 octets)
- xTU-R version number
It shall contain the xTU-R firmware version and the xTU-R model. Both shall be encoded in this order and separated by a space character, i.e., "<xTU-R firmware version> <xTU-R model>". The structure MUST be 16 ASCII char.

NOTE – This field is intended to contain information about the firmware and model of the xTU-R physical layer interface (**chipset**).

- xTU-R serial number
It shall contain the following **system** indicators: the equipment serial number, the equipment model and the equipment software version. All shall be encoded in this order and separated by space characters, i.e., "<equipment serial number> <equipment model> <equipment software version>". The structure MUST be 32 ASCII char.

Note that the combination of **system** vendor ID and serial number creates a unique number for each xTU-R.

The vendor specific information in the Vendor ID information block MUST not be used as a mean to achieve interoperability, in order to avoid workarounds and to achieve full standard compliance.