Technical Specification of the Broadband-Access-Interfaces in the network of Deutsche Telekom

1 TR 112

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Content

Foreword

This Technical Specification (Technische Richtlinie; TR) has been produced by Deutsche Telekom AG, (in the following named as Deutsche Telekom) and contains the interface description of the U-Interfaces between a Home Gateway (HG) and xDSL systems and the U-Interfaces between a Home Gateway (HG) and an Optical Network Termination (ONT) within a Gigabit-capable Passive Optical Network (GPON) systems in the network of Deutsche Telekom.

Compatibility of DSL modems with this Technical Specification provides full functionality with the xDSL transmission technologies, described in the present document.

> Note: A description of the IFPON-Interface (R/S-Reference point) between Optical Line Termination (OLT) and Optical Network Termination (ONT) within a Gigabit-capable Passive Optical Network (GPON) system in the network of Deutsche Telekom is in preparation and will be published in a separate Amendment.

1 Scope

The present Technical Specification (TR) is applicable to different kind of broadband access interfaces (xDSL, ETH-interface at GPON ONT) of Deutsche Telekom on the customer side behind the network termination point (NTP) of Deutsche Telekom according to the AGB [1] of Deutsche Telekom.

The present document defines the physical characteristics and transmission requirements for the broadband access interfaces provided by Deutsche Telekom via the subscriber line (xDSL, ETH-interface at GPON ONT). It provides the relevant parameters and functions descriptions to enable general compatibility to the Deutsche Telekom access network interfaces.

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

The reference points of the different interfaces are defined in clause 4.

2 References

The following documents contain provisions which, through reference in this text, constitute provisions of the present document.

- References are either specific (identified by date of publication and/or edition number or version number) or non specific.
- For a specific reference, subsequent revisions do not apply.
- For a non-specific reference, the latest version including amendments, errata and corrigenda applies.
- Date of publication in square brackets [ ] refer just to the last known version while this document was in revision.

[1] AGB: Allgemeine Geschäftsbedingungen der Deutsche Telekom
(siehe: www.telekom.de/agb)

[2] T-Com 1TR110-1 [08/2007]: Technische Beschreibung der Analogen Wählanschlüsse am T Net/ISDN der T-Com; Telefonanschlüsse ohne Durchwahl (Technical description of switched analogue accesses in the T-Net/ISDN of T-Com)

[3] ETSI ETR 328 (November 1996): Transmission and Multiplexing (TM); Asymmetric Digital Subscriber Line (ADSL); Requirements and Performance

[4] ETSI TS 101 270-1 V1.4.1 (2005-10): Transmission and Multiplexing (TM); Access transmission systems on metallic access cables; Very high speed Digital Subscriber Line (VDSL); Part 1: Functional requirements

[5] ETSI TS 101 388 V1.4.1 (2007-08): Access Terminals Transmission and Multiplexing (ATTM); Access transmission systems on metallic access cables; Asymmetric Digital Subscriber Line (ADSL) - European specific requirements [ITU-T Recommendation G.992.1 modified]

[6] ETSI TS 101 524 V1.4.1 (2006-02): Transmission and Multiplexing (TM); Access transmission system on metallic access cables; Symmetric single pair high bitrate Digital Subscriber Line (SDSL) [ITU-T Recommendation G.991.2 (2005) modified]

[7] ETSI TS 101 952-1-4 V1.1.1 (2002-11): Access network xDSL transmission filters; Part 1: ADSL splitters for European deployment; Sub-part 4: Specification of ADSL over "ISDN or POTS" universal splitters

[8] ETSI TS 102 080 V1.4.1 (2003-07): Transmission and Multiplexing (TM); Integrated Services Digital Network (ISDN) basic rate access; Digital transmission system on metallic local lines

[9] ITU-T G.117 (02/96): TRANSMISSION SYSTEMS AND MEDIA; GENERAL CHARACTERISTICS OF INTERNATIONAL TELEPHONE CONNECTIONS AND INTERNATIONAL TELEPHONE CIRCUITS; Transmission aspects of unbalance about earth

[10] ITU-T G.991.2: TRANSMISSION SYSTEMS AND MEDIA, DIGITAL SYSTEMS AND NETWORKS; Digital sections and digital line system – Access networks; Single-pair high-speed digital subscriber line (SHDSL) transceivers

[11] ITU-T G.992.1 (06/99): TRANSMISSION SYSTEMS AND MEDIA, DIGITAL SYSTEMS AND NETWORKS; Digital transmission systems – Digital sections and digital line system – Access networks; Asymmetrical digital subscriber line (ADSL) transceivers

[12] ITU-T G.992.3: TRANSMISSION SYSTEMS AND MEDIA, DIGITAL SYSTEMS AND NETWORKS; Digital sections and digital line system – Access networks; Asymmetric digital subscriber line transceivers 2 (ADSL2)

[13] ITU-T G.992.5: TRANSMISSION SYSTEMS AND MEDIA, DIGITAL SYSTEMS AND NETWORKS; Digital sections and digital line system – Access networks; Asymmetric digital subscriber line (ADSL) transceivers – Extended bandwidth ADSL2 (ADSL2plus)

[14] ITU-T G.993.2: TRANSMISSION SYSTEMS AND MEDIA, DIGITAL SYSTEMS AND NETWORKS; Digital sections and digital line system – Access networks; Very high speed digital subscriber line transceivers 2 (VDSL2)

[15] ITU-T G.994.1: TRANSMISSION SYSTEMS AND MEDIA, DIGITAL SYSTEMS AND NETWORKS; Digital sections and digital line system – Access networks; Handshake procedures for digital subscriber line (DSL) transceivers

[16] ITU-T G.997.1: TRANSMISSION SYSTEMS AND MEDIA, DIGITAL SYSTEMS AND NETWORKS; Digital sections and digital line system – Access networks; Physical layer management for digital subscriber line (DSL) transceivers

[17] ITU-T I.361 (02/99): INTEGRATED SERVICES DIGITAL NETWORK; Overall network aspects and functions – Protocol layer requirements; B-ISDN ATM layer specification

[18] ITU-T I.363.5 (08/96): INTEGRATED SERVICES DIGITAL NETWORK; Overall network aspects and functions – Protocol layer requirements; B-ISDN ATM Adaptation Layer specification : Type 5 AAL

[19] ITU-T I.432.1 (02/99): INTEGRATED SERVICES DIGITAL NETWORK; ISDN user-network interfaces – Layer 1 Recommendations; B-ISDN user-network interface - Physical layer specification: General characteristics

[20] ITU-T I.610: INTEGRATED SERVICES DIGITAL NETWORK; Maintenance principles; B-ISDN operation and maintenance principles and functions

[21] ITU-T I.732 (10/2000): INTEGRATED SERVICES DIGITAL NETWORK; B-ISDN equipment aspects – ATM equipment; Functional characteristics of ATM equipment

[22] ITU-T I.751 (03/96): INTEGRATED SERVICES DIGITAL NETWORK (ISDN); B-ISDN equipment aspects, Asynchronous transfer mode management of the network element view

[23] IETF RFC 1144: Compressing TCP/IP Headers

[24] IETF RFC 1332: The PPP Internet Protocol Control Protocol (IPCP)

[25] IETF RFC 1483: Multiprotocol Encapsulation over ATM Adaptation Layer 5

[26] IETF RFC 1570: PPP LCP Extensions

[27] IETF RFC 1661: The Point-to-Point Protocol (PPP)

[28] IETF RFC 1994: PPP Challenge Handshake Authentication Protocol (CHAP)

[29] IETF RFC 2516: A Method for Transmitting PPP Over Ethernet (PPPoE)

[30] IETF RFC 2684: Multiprotocol Encapsulation over ATM Adaptation Layer 5

[31] IEEE802.1ag: Connectivity Fault Management

[32] IEEE802.3: CSMA/CD (ETHERNET)

[33] IEEE802.3-2008: Ethernet in the First Mile

[34] Broadband Forum TR-067: ADSL Interoperability Test Plan

[35] Broadband Forum TR-100: Performance Test Plan for ADSL2/2plus

[36] Broadband Forum TR-105: Functionality Test Plan for ADSL2/2plus

[37] Broadband Forum TR-114: VDSL2 Performance Test Plan

[38] DIN EN 41003 [August 1999]: Besondere Sicherheitsanforderungen an Geräte zum Anschluß an Telekommunikationsnetze; Deutsche Fassung EN 41003 : 1998 VDE: Klassifikation VDE 0804 Teil 100

[39] DIN EN 60950-1 (VDE 0805-1) [November 2006]: Einrichtungen der Informationstechnik – Sicherheit – Teil 1: Allgemeine Anforderungen (IEC 60950-1: 2005, modifiziert); Deutsche Fassung EN 60950-1:2006EMVG

[40] DIN VDE 0228 (Normen-Reihe): Maßnahmen bei Beeinflussung von Fernmeldeanlagen durch Starkstromanlagen

[41] ITU-T Rec. K.11 : Principles of protection against overvoltages and overcurrents

[42] DIN VDE 0845 Teil 4-2 [Juli 2002]: Blitzschutz – Telekommunikationsleitungen Teil 2: Leitungen mit metallischen Leitern

[43] DIN 41 715 Teil 3 [Mai 1991): Elektrische Nachrichtentechnik; Steckverbinder für Telekommunikations-Anschluss-Einheiten (TAE); Bauformen A, B, C und R

[44] EMVG vom 18.09.98: Gesetz über die elektromagnetische Verträglichkeit von Geräten (EMVG); [Titel und Referenzen von DIN-VDE-Normen siehe Amtsblatt des Reg TP Nr. 6/2000 S. 1015 ..., Vfg 38/2000]

[45] IEEE 802.1Q - IEEE Standard for Local and Metropolitan Area Networks Virtual Bridged Local Area Networks

[46] IEEE802.3 – 2008 (Local Area Networks Standard, 802.3 Carrier Sense Multiple Access with Collision Detection)

[47] IEEE 802.1D-2004 - IEEE Standard for Local and Metropolitan Area Networks Media Access Control (MAC) Bridges

[48] IEEE 802.2 - Local Area Networks Standard, 802.2 Logical Link Control

[49] BBF TR-101 - Migration to Ethernet-Based DSL Aggregation (April 2006)

[50] BBF TR-156 - Using GPON Access in the context of TR-101 (September 2010)

[51] see [31]

[52] Technical Specification MEF 11
User Network Interface (UNI) Requirements and Framework

[53] ISO/IEC 7498-1: Information technology - Open Systems Interconnection - Basic Reference Model: The Basic Model

[54] ITU-T Y.1731: OAM functions and mechanisms for Ethernet based networks

[55] ITU-T G.998.4 : Improved Impulse Noise Protection (INP) for DSL Transceivers

[56] AGB: Allgemeine Geschäftsbedingungen der Deutschen Telekom
(see: www.telekom.de/agb)

[57] IEEE802.3 – 2008 (Local Area Networks Standard, 802.3 Carrier Sense Multiple Access with Collision Detection)

[58] IEEE 802.1D-2004 - IEEE Standard for Local and Metropolitan Area Networks Media Access Control (MAC) Bridges

[59] IEEE 802.2 - Local Area Networks Standard, 802.2 Logical Link Control

[60] IEEE 802.1Q - IEEE Standard for Local and Metropolitan Area Networks Virtual Bridged Local Area Networks

[61] BBF TR-101 - Migration to Ethernet-Based DSL Aggregation (April 2006)

[62] BBF TR-156 - Using GPON Access in the context of TR-101 (September 2010)

[63] IEEE802.1ag: Connectivity Fault Management

[64] Technical Specification MEF 11
User Network Interface (UNI) Requirements and Framework

[65] ITU-T G.993.5: Self-FEXT cancellation (vectoring) for use with VDSL2 transceivers

[66] EN 55022: Information technology equipment - Radio disturbance characteristics - Limits and methods of measurement

[67] IEC 61000-4-6: Electromagnetic compatibility (EMC)Part 4-6: Testing and measurement techniques - Immunity to conducted disturbances, induced by radio-frequency fields

[68] CISPR22: Information technology equipment –Radio disturbance characteristics – Limits and methods of measurement

[69] BBF TR-124 Functional Requirements for Broadband Residential Gateway Devices Issue: 5 (July 2016)

[70] ITU-T G.995.2: Enhanced common mode limits and measurement methods for customer premises equipment operating on copper pairs

3 Abbreviations, Definitions and Symbols

Abbreviations, definitions and symbols, not listed hereafter, are defined in the reference documents [1] to [[45]] in clause 2.

3.1 Abbreviations

For the purposes of the present document, the following abbreviations apply:

-1-	
3GPP	Third Generation Partnership Project
-A-	
AAL	ATM Adaptation Layer
AC	Alternating Current
ADSL	Asymmetrical Bit rate Digital Subscriber Line
AGB	Allgemeine Geschäftsbedingungen (der Deutschen Telekom)
AsL	Anschlussleitung (access line)
ASP	Application Service Provider
ATC	ATM Transfer Capability
ATM	Asynchronous Transfer Mode
ATPR	Aggregate Transmit Power Reduction per power trim
ATPRT	Total Aggregate Transmit Power Reduction
ATU-C	ADSL Transmission Unit Central
ATU-R	ADSL Transmission Unit Remote
-B-	
BBA	Breitbandige Anschlüsse (broadband access)
BBAE	Breitband-Anschluss-Einheit (broadband access unit)
BBF	Broadband Forum
BER	Bit Error Ratio
BNG	Broadband Network Gateway
BRAS	Broadband Remote Access Server
-C-	
C	Capacitor
C	Central Office End (in connection with "splitter")
CDN	Coupling Decoupling Network
CLIP	Calling Line Identity Presentation
CLP	Cell Loss Priority
C-MSG1	CO-Message
C-MSG-RA	CO-Message
CO	Central Office
CPE	Customer Premises Equipment
C-VLAN	Customer-Virtual Local Area Network l
-D-	
DC	Direct Current
DIN	Deutsches Institut für Normung
DELT	Dual-Ended Line Testing
DHCP	Dynamic Host Configuration Protocol
DPBO	Downstream Power Back Off
DPBOESCMA, DPBOESCMB, DPBOESCMC	Downstream Power Back Off Cable Model Parameters
DPBOESEL	Downstream Power Back Off Exchange Side Electrical Length
DPBOESEL	Minimal Downstream Power Back Off Exchange Side Electrical Length

DPBOEPSD	Downstream Power Back Off Estimated Power Spectrum Density
DPBOMUF	Downstream Power Back Off Maximum Usable Frequency
DPBOMUS	Downstream Power Back Off Minimum Usable Signal
DS	Downstream
DSLAM	Digital Subscriber Line Access Multiplexer
DSS1	Digital Subscriber System No 1
DT	Deutsche Telekom
-E-	
EFM	Ethernet First Mile
EMC	ElectroMagnetic Compatibility
EMS	Element Management System
EMVG	Gesetz über die elektromagnetische Verträglichkeit von Geräten
EN	European Standard
EOC	Embedded Operations Channel
ETR	ETSI Technical Recommendation
ET	Exchange Termination
ETSI	European Telecommunications Standards Institute
-F-	
FB	Full Service Access Network (FSAN) Noise Model "B"
FDD	Frequency Division Duplex
FTTH	Fiber to the Home
FSAN	Full Service Access Network
-G-	
GE	Gigabit Ethernet
GFC	Generic Flow Control
GPON	Gigabit-capable Passive Optical Network
-H-	
HEC	Header Error Correction
HPF	High Pass Filter
-I-	
IAD	Integrated Access Device
ID	Identification
IDFT	Inverse Discrete Fourier Transformation
IEC	International Electrotechnical Commission
IEEE	Institute of Electrical and Electronic Engineers
IETF	Internet Engineering Task Force
INP	Impulse Noise Protection
IP	Internet Protocol
ISDN	Integrated Services Digital Network
ISN	Impedance Stabilization Network
ITU-T	International Telecommunication Union, Telecommunication Branch
-J-	
-K-	
-L-	
LAN	Local Area Network
LB	Loop Back
LB	Leistungsbeschreibung
LCL	Longitudinal Conversion Loss
LPF	Low Pass Filter
LT	Line Termination
-M-	
MAC	Media Access Control
MDIX	Medium-Dependent Interface Crossover
MEF	Metro Ethernet Forum
MIB	Management Information Base

MSAN	Multi-Service Acces Multiplexer
MpoA	Multiprotocol Encapsulation over ATM
MSTV	Microsoft TV
MTU	Maximum Transmission Unit
-N-	
NSP	Network Service Provider
NT1	Network Termination 1 (Network Termination Basic Access)
NTBBA	Network Termination Broadband Access
NTP	Network Termination Point
-O-	
OAM	Operation, Administration and Maintenance
OLT	Optical Line Termination
ONT	Optical Network Termination
ONU	Optical Network Unit
-P-	
PADI	PPPoE Active Discovery Initiation
PADO	PPPoE Active Discovery Offer
PEPSDMUF	Power Back Off Estimated Power Spectrum Density Maximum Usable Frequency
PMMS	Power Measurement Modulation Session (Line Probe)
POTS	Plain Old Telephony Service (analogue telephony)
PPP	Point to Point Protocol
PPPoE	Point to Point Protocol over Ethernet
PSD	Power Spectral Density
PTI	Payload Type Identifier
PVC	Permanent Virtual Channel
-Q-	
QoS	Quality of Service
R	Remote End (in connection with splitter)
-R-	
R	Resistor
R	Remote end (in connection with “splitter”)
RBN	Regional Broadband Network
RFC	Request for Comments
RFI	Radio Frequency Interference
RG	Residential Gateway
-S-	
SDSL	Single Pair symmetrical Bit rate Digital Subscriber Line
SIP	Session Initiation Protocol
SNR	Signal to Noise Ratio
SOL	Strategic Outdoor Location
SVC	Switched virtual Connection
-T-	
TAE	Telekommunikations-Anschluss-Einheit (phone socket)
TE	Terminal Equipment
TLS	Transparent LAN Service
TR	Technical Recommendation
TR	Technical Report [ETSI]
TR	Technische Richtlinie [DT]
TS	Technical Specification
TS	Technical Specification [ETSI]
-U-	
UAE RJ45	Universelle Anschluss-Einheit RJ45 (Universal connector socket RJ45)
Ueff	Effective voltage
UNI	User Network Interface

UPBO	Upstream Power Back Off
UPBOMASK	Upstream Power Back Off resulting PSD mask
UPBOPSD	Upstream Power Back Off Reference PSD
US	Upstream
US0	VDSL2 Upstreamband 0
-V-	
VC	Virtual Channel
VCC	Virtual Channel Connection
VCI	Virtual Channel Identifier
VC-AIS	Virtual Channel Alarm Indication Signal
VC-RDI	Virtual Channel Remote Defect Indication
VDE	Verband der Elektrotechnik Elektronik Informationstechnik e.V.
VDSL	Very High Speed Digital Subscriber Line
VGW	VoIP Gateway (e.g. HG or IAD)
VLAN	Virtual Local Area Network
VoIP	Voice over IP
VP	Virtual Path
VPC	Virtual Path Connection
VPI	Virtual Path Identifier
-W-	
WAN	Wide Area Network
-X-	
xDSL	x Digital Subscriber Line (x stands for various DSL variants)
-Y-	
-Z-	
Z	Zener diode

3.2 Definitions

For the purposes of the present document, the following terms and definitions apply:

Term	Definition / Remark
NTP	Network Termination Point (termination point of a communication network and transition to the customer responsibility.
User Equipment	Any device (terminal) at the subscriber premises used by an end user to communicate. It can be e.g. an IAD or telephone set, or any other telecommunication device.
Terminal Equipment	Any device (terminal) at the subscriber premises used by an end user to communicate. It can be e.g. a telephone set, fax machine or any other telecommunication device.
HG (RG, IAD, CPE)	A user equipment at the subscriber premises which provides different kinds of interfaces (e.g. analogue ports (POTS) and/or ISDN ports, Ethernet interfaces, etc.) for VoIP and Data services. It handles the interworking between those interfaces and the SIP interface. The HG includes the function of a voice gateway (VGW).
Wholesale/Wholebuy	Wholesale means to sell large quantities of a product (in our context a telecommunication service) to a company in order to be redistributed to end customers. Wholebuy in turn means that DT buys wholesale products from a competitor in order to serve customers in places DT is not capable to provide a service or product using DT network.

3.3 Symbols

For the purposes of the present document, the following symbols apply:

Symbol	Definition
A	Attenuation
dB	Decibel
dBm	Absolute level in dB related to 1 mW
f	Frequency
P	Power Level
s	Second(s)

4 General

4.1 Purpose of this Document

This document describes the requirements for broadband access interfaces on the customer side of the Deutsche Telekom AG (in the following referred to as Deutsche Telekom) access network.
The present document incorporates interface descriptions for the following xDSL transmission technologies:

- ADSL, ADSL2 and ADSL2plus ⇨ U-R / U-R2
- SDSL ⇨ U-RS
- VDSL2 ⇨ U-RV / U-RV2
- GPON ⇨ Gigabit-Ethernet UNI (see Annex A6)
  ⇨ IF_{PON}-Interface (R/S-Reference point) specification is in preparation and will be published in a separate Amendment.

NOTE: In this document different modes of ADSL (ADSL, ADSL2, ADSL2plus) are described. In case it is not explicitly distinguished between these three ADSL modes, all modes are referenced by using the term "ADSL".

This interface description is not a specification for terminal devices. It simply presents the parameters that have been made available, and that are expected for the described interface. The first chapter in every subsection describes general functionalities and characteristics of the corresponding U-Interface. The product specific chapter outlines differences between varying Deutsche Telekom products (services) implemented via the Access Network.

4.2 Reference Models

4.2.1 ADSL Technologies

4.2.1.1 U-R Interface

If no HG splitter is present, the ADSL interface is described as U-R to be in line with the reference model defined in [11], [12] and [13]. This interface represents the connection between the line and the ADSL modem on the customer side (see Figure 4-1).

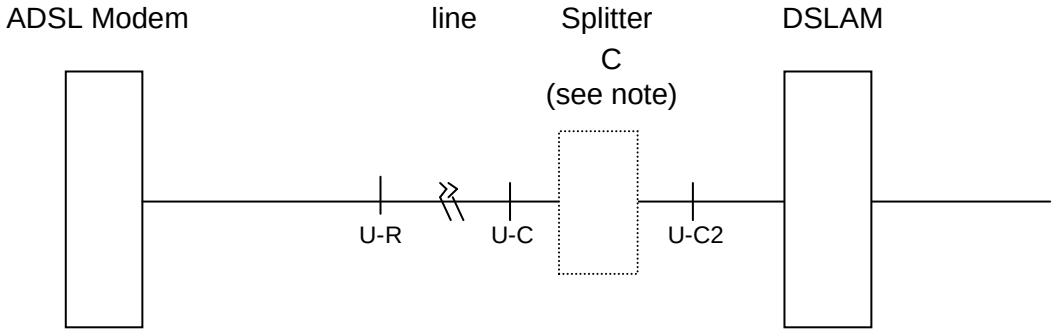

Figure 4-1: Reference Model U-R for ADSL Technologies

Note: The splitter C may not be present. This has no impact on the interface description.

4.2.1.2 U-R2 Interface

The ADSL interface at the Splitter R is described as U-R2 to be in line with the reference model defined in [11], [12] and [13]. This interface represents the connection between the splitter and the ADSL modem on the customer side (see Figure 4-2).

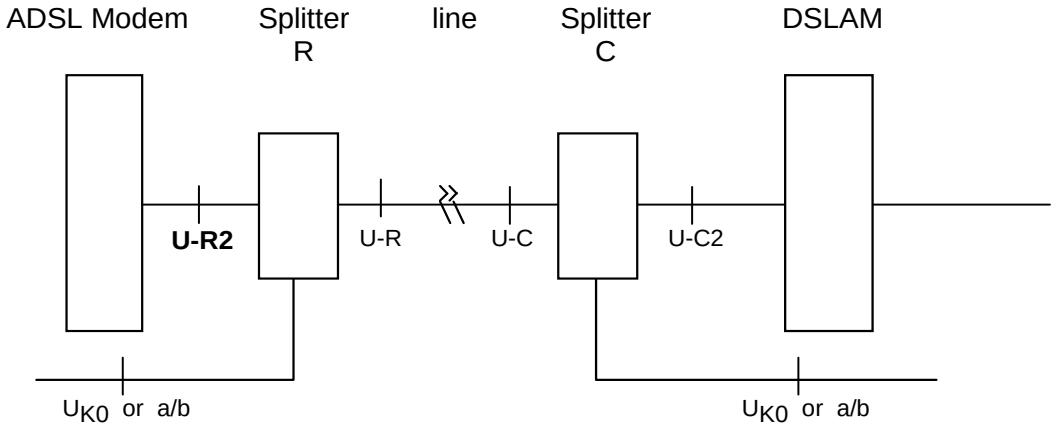

Figure 4-2: Reference Model U-R2 for ADSL Technologies

4.2.2 SDSL technologies

4.2.2.1 U-RS interface

The SDSL interface is described as U-RS to be in line with the reference model defined in [6]. This interface represents the connection between the line and the SDSL modem on the customer side (see Figure 4-3). Optional regenerators are for future use.

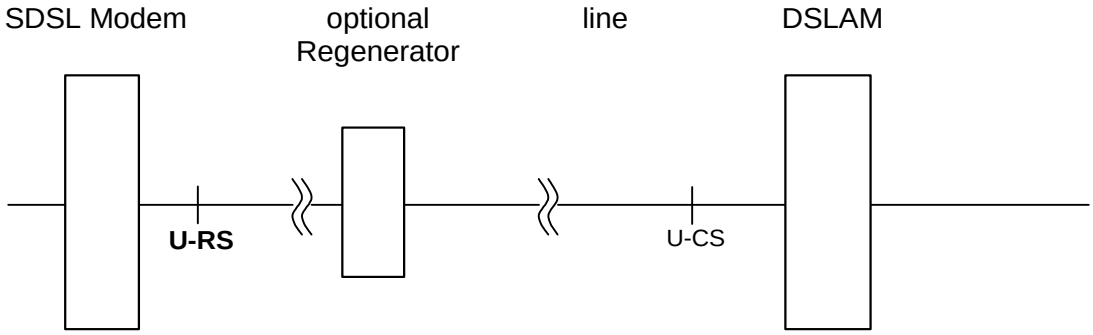

Figure 4-3: Reference Model U-RS for SDSL Technology

4.2.3 VDSL2 technologies

4.2.3.1 U-RV Interface

If no HG splitter is present, the VDSL2 interface is described as U-RV to be in line with the reference model defined in [14]. This interface represents the connection between the line and the VDSL2 modem on the customer side (see Figure 4-4).

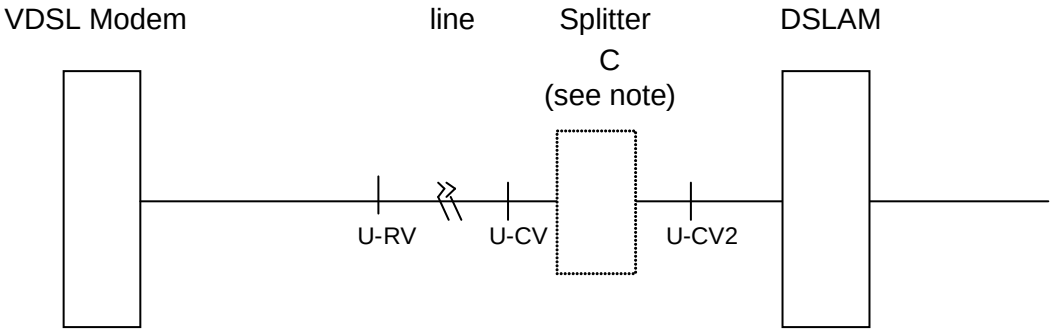

Figure 4-4: Reference Model U-RV for VDSL2 Technologies
Note: The splitter C may not be present. This has no impact on the interface description.

4.2.3.2 U-RV2 Interface

The VDSL2 interface is described as U-RV2 to be in line with the reference model defined in [14]. This interface represents the connection between the splitter and the VDSL2 modem on the customer side (see Figure 4-5).

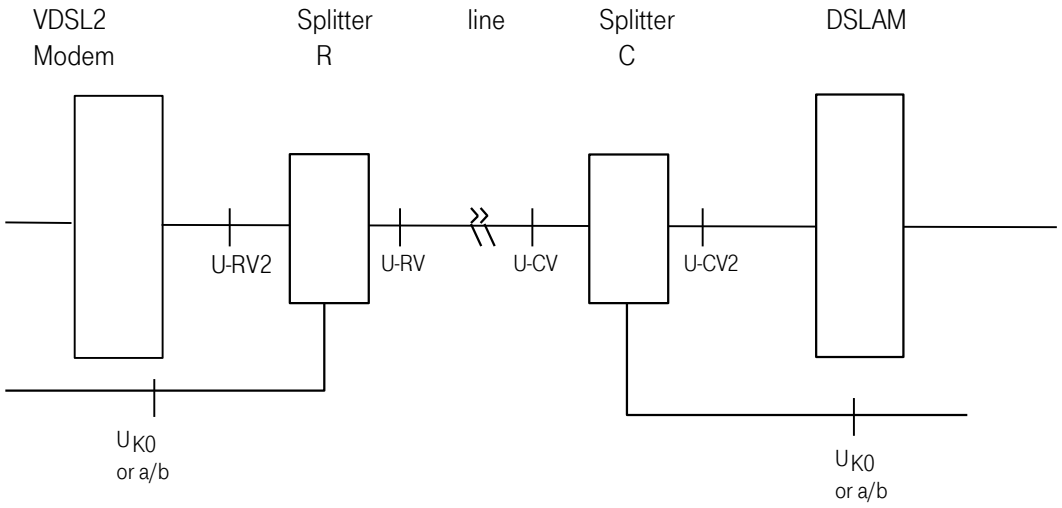

Figure 4-5: Reference Model U-RV2 for VDSL2 Technology

4.2.4 GPON ONT and the Home Gateway (HG)

The interface between a GPON ONT and the Home Gateway is described in Annex A6.

5 Technical description of ADSL

In the following sections the different general requirements for ADSL technologies are described separately for every ADSL transmission mode.

5.1 ADSL Requirements

5.1.1 U-R Interface

5.1.1.1 Multi-Mode Operation

The DSLAM is the master for selecting the active ADSL operational mode during the handshake procedure according to [15]. If both the DSLAM and the modem support more than one ADSL operational mode and the DSLAM allows this, the mode with the highest priority shall be selected. These priorities are defined as follows (1 = highest priority, 2 = lowest priority):

Priority	Mode
1	ADSL2plus Annex B
2	ADSL Annex B

Table A: Priority of ADSL Modes

Depending on the selected mode the corresponding chapter in this document applies.

5.1.1.2 Multi-Mode Operation ADSL2plus Annex B and ADSL2plus Annex J

If the HG supports both Annex B and Annex J operation, the upstream carrier set J43 according to [15] shall not be transmitted as it can interfere with ISDN present on the same line. In this case the carrier sets B43 and B43c shall be transmitted only.

Note: In previous versions of [15], the J43 carrier set was always mandatory. In May 2009 it was agreed in ITU-T to change [15] in order to protect possibly underlying ISDN services when operating together with multi mode DSL equipment.

5.1.1.3 Applied Recommendations for ADSL Annex B

At the U-R interface, ADSL signals are provided or expected, as defined in [11], Annex B, and in [5] - "ADSL over ISDN".
The guidelines cited in [11], [15] and [16] apply.
The operation according to [5], Annex C (ADSL over ISDN configuration of T1.413 based modems) is not allowed for the mentioned U-R interface.
For interoperability tests between ADSL Modems and ADSL DSLAMs [34] applies. All tests shall be executed without the use of splitters and same pair ISDN transmission.

5.1.1.3.1 Specific Requirements for ADSL Annex B

a) For upstream direction all possible data rates in steps of 32 kbit/s in the range 64 kbit/s to at least 640 kbit/s shall be supported.
b) For downstream direction all possible data rates in steps of 32 kbit/s in the range 128 kbit/s to at least 6720 kbit/s shall be supported.
c) Duplex procedure: FDD non overlapped spectrum.
d) PSD for FDD conform to [5]; this shall comply within all operational states.

e) Use of the "interleaved channel" with support of the interleave depths which can be adjusted on the standard basis according to [11] and use of the "fast channel".
f) Power cut back, conform to [11] Annex B, Section B.3.3, is allowed only for downstream direction.
g) For the Upstream power cut back is not allowed.
h) The ADSL modem has to support Trellis coding.
i) The target noise margin (minimum required downstream SNR margin at initialization, C-MSG1) has to be considered from the ADSL modem according to [11]. For the configuration the DSLAM is the master.
j) The retrain margin (margin where a resynchronization is forced, minimum required downstream ATU-R noise margin in steady state, C-MSG-RA) has to be considered from the ADSL modem according to [11]. Default value is 0 dB. For the configuration the DSLAM is the master.
k) Layer 1 OAM (configuration, fault and performance monitoring data) shall conform to [11], including dying gasp (loss of power).
l) IDFT has to be realized according to [11], B2.6.
m) The Vendor ID to be exchanged between ADSL modem and DSLAM during the handshake procedure, conveyed in the „Vendor ID information block“ of the „Identification field“ according to [15], represents the chipset manufacturer. 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.

5.1.1.4 ADSL2plus

5.1.1.4.1 Applied Recommendations for ADSL2plus Annex B

At the U-R interface, ADSL2plus signals are provided or expected, as defined in [13], Annex B "ADSL2plus over ISDN".
The guidelines cited in [13], [15] and [16] apply.
For interoperability tests between ADSL2plus Modems and ADSL2plus DSLAMs [35] and [36] apply. All tests shall be executed without the use of splitters and same pair ISDN transmission.

5.1.1.4.2 Specific Requirements for ADSL2plus Annex B

a) The ADSL2plus modem has to support all mandatory functionalities of [13].
b) For upstream direction all possible data rates in steps of < 32 kbit/s in the range 64 kbit/s to at least 1 200 kbit/s shall be supported.
c) For downstream direction all possible data rates in steps of < 32 kbit/s in the range 128 kbit/s to at least 24 000 kbit/s shall be supported.
d) All rate adaptation modes according to [16] (MANUAL, AT INIT, DYNAMIC) have to be supported.
e) Use of the "interleaved channel" with support of the interleave depths / delay which can be adjusted according to [16] and use of the "fast channel" has to be supported.
f) Support of different delay- and INP settings per transmission direction is mandatory.
g) The optional „extended Framing Mode“ according to [13], Annex K for transmission of higher data rates when using INP_min > 0 has to be supported. (For example DS rates of more than 16 Mbit/s with INP_min = 1 / maxDELAY = 8 ms).
h) Duplex procedure: FDD non overlapped spectrum.
i) PSD for FDD conform to [5]; this shall comply within all operational states.
j) Only power management with automatic transition to L2 is used, L3 in power management mode is not used (L0-time, L2-time, L2-ATPR and L2-ATPRT are to be expected in the ranges as defined in [16]). Any transition to L2 state or any performed power trim must not cause a synchronization loss. The sum of the successfully performed power trims must not cause a resulting noise margin lower than the target margin.
The following enhancements shall be supported (see also ITU-T G.992.3 Amendment 4):

- removal of the Lp ≤ 1024 constraint, which allows for higher L2 min rates and restricts the delay increments
- allow gi shaping during the L2 state by the ATU-R in order to allow increased power savings in L2 mode

k) Loop diagnostic mode has to be supported (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.
l) The ADSL2plus modem shall support the shaping of the Downstream transmit PSD.
m) In case of Cabinet Operation Mode (Downstream PSD located above ADSL spectrum, beginning at 1,1 MHz), tone set B43c has to be used during handshake.
n) In case of Cabinet Operation Mode, transmit signals must not exceed the specified levels according the following breakpoints and corresponding PSD slope as defined in [13]:

- t(1)= 233 (1004,8125 kHz), PSD1= -95 dBm/Hz,
- t(2)= 260 (1121,25 kHz), PSD2= -36,5 dBm/Hz

These apply to all operational states (e.g. training, show time, DELT).

o) The ADSL2plus modem shall support transmission with configured downstream RFI bands. The following bands are defined:

- RFI band 1: from 1 800 kHz up to 2 000 kHz, Level < -80 dBm/Hz
- RFI band 2: from 2 173,5 kHz up to 2 190,5 kHz, Level < -80 dBm/Hz

p) In case of configured RFI bands, transmit signals must not exceed the specified levels inside the RFI bands. These apply to all operational states (e.g. training, show time, DELT).
q) Layer 1 OAM (configuration, fault and performance monitoring data) shall conform to [13], including dying gasp (loss of power).
r) IDFT has to be realized according to [12], B2.4.

5.1.1.4.3 Applied Recommendations for ADSL2plus Annex J

At the U-R interface, ADSL2plus signals are provided or expected, as defined in [13], Annex J "All Digital Mode ADSL with improved spectral compatibility with ADSL over ISDN".
The guidelines cited in [13], [15] and [16] apply.
For interoperability tests between ADSL2plus Modems and ADSL2plus DSLAMs [35] and [36] apply accordingly, if necessary modified for Annex J as outlined in chapter 5.1.1.6.3. All tests shall be executed without the use of splitters and same pair ISDN transmission.

5.1.1.4.4 Specific Requirements for ADSL2plus Annex J

a) The ADSL2plus modem has to support all mandatory functionalities of [13].
b) For upstream direction all possible data rates in steps of < 32 kbit/s in the range 64 kbit/s to at least 3 000 kbit/s shall be supported.
c) For downstream direction all possible data rates in steps of < 32 kbit/s in the range 128 kbit/s to at least 24 000 kbit/s shall be supported.
d) All rate adaptation modes according to [16] (MANUAL, AT INIT, DYNAMIC) have to be supported.
e) Use of the "interleaved channel" with support of the interleave depths / delay which can be adjusted according to [16] and use of the "fast channel" has to be supported.
f) Support of different delay- and INP settings per transmission direction is mandatory.
g) The optional „extended Framing Mode“ according to [13], Annex K for transmission of higher data rates when using INP_min > 0 has to be supported. (For example DS rates of more than 16 Mbit/s with INP_min = 1 / maxDELAY = 8 ms).
h) Duplex procedure: FDD non overlapped spectrum.
i) PSD for FDD conform to [5]; this shall comply within all operational states.
j) The following Upstream Mask variants have to be supported:

   Mask no. 1 (ADLU32)
   Mask no. 5 (ADLU48)
   Mask no. 8 (ADLU60)
   Mask no. 9 (ADLU64)

k) Only power management with automatic transition to L2 is used, L3 in power management mode is not used (L0-time, L2-time, L2-ATPR and L2-ATPRT are to be expected in the ranges as defined in [16]). Any transition to L2 state or any performed power trim must not cause a synchronization loss. The sum of the successfully performed power trims must not cause a resulting noise margin lower than the target margin.
   The following enhancements shall be supported (see also ITU-T G.992.3 Amendment 4):

   - removal of the Lp ≤ 1024 constraint, which allows for higher L2 min rates and restricts the delay increments
   - allow gi shaping during the L2 state by the ATU-R in order to allow increased power savings in L2 mode

l) Loop diagnostic mode has to be supported (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.
m) The ADSL2plus modem shall support the shaping of the Downstream transmit PSD.
n) In case of Cabinet Operation Mode (Downstream PSD located above ADSL spectrum, beginning at 1,1 MHz), tone set B43c has to be used during handshake.
o) In case of Cabinet Operation Mode, transmit signals must not exceed the specified levels according the following breakpoints and corresponding PSD slope as defined in [13]:

   - t(1)= 233 (1004,8125 kHz), PSD1= -95 dBm/Hz,
   - t(2)= 260 (1121,25 kHz), PSD2= -36,5 dBm/Hz

   These apply to all operational states (e.g. training, show time, DELT).

p) The ADSL2plus modem shall support transmission with configured downstream RFI bands. The following bands are defined:

   - RFI band 1: from 1 800 kHz up to 2 000 kHz, Level < -80 dBm/Hz

- RFI band 2: from 2 173,5 kHz up to 2 190,5 kHz, Level < -80 dBm/Hz

q) In case of configured RFI bands, transmit signals must not exceed the specified levels inside the RFI bands. These apply to all operational states (e.g. training, show time, DELT).
r) Layer 1 OAM (configuration, fault and performance monitoring data) shall conform to [13], including dying gasp (loss of power).

5.1.1.4.5 Retransmission

The support of retransmission according ITU-T G.998.4 (ex G.inp) [55] is required in order to improve the DSL line stability under impulse noise conditions.

Specific requirements for retransmission:

- Both impulse noise characteristics SHINE and REIN are to be considered.
- For ADSL2plus the ATM TPS-TC specific requirements are valid.
- All mandatory control parameters acc. [55] and [16] are to be supported
- For ADSL2plus, support of Retransmission is mandatory only in Downstream direction (i.e., Downstream DTUs can be retransmitted upon request, the Retransmission Request Channel has to be implemented in Upstream Direction). Support of Retransmission in Upstream direction is optional.
- All mandatory OAM parameters (performance counter implementations) acc. [55] and [16] are to be supported.
- All mandatory channel initialization modes and parameters acc. [55] and [16] are to be supported.
- The full compatibility to an operation without retransmission support is mandatory.

5.1.1.4.6 Requirements for ADSL2plus Annex B / Annex J Downstream Power back Off (DPBO)

a) DPBO has to be supported

b) DPBO is used by the DSLAM to protect DSL connections, which are distributed from the central office in a common distribution cable together with DSL connections which are operated from the cabinet according to [13] (Amendment 2) and [16].

c) The reduced downstream PSD (PEPSD(f)) has to be calculated as follows:

$$PEPSD(f) = DPBOEPSD(f) - \left(DPBOESCMA + DPBOESCMB \cdot \sqrt{f} + DPBOESCMC.f\right) \cdot DPBOESEL + 10 \cdot \log_{10}\left(1 + \frac{DPBOESEL}{6.65dB}\right)$$

in [dBm/Hz] with f in [MHz].

d) The following definitions apply:

- DPBOEPSD(f): PSD [dBm/Hz] of the DSL type operated from the central office that has to be protected, in this case: VDSL2 Annex B, Limit PSD Mask 998ADE17-M2x-B according to [14].
- DPBOESCMA, DPBOESCMB, DPBOESCMC: cable model parameters. These parameters are configured at the DSLAM and are taking into account the standard granularity according to [16]. Since the following values do not match the standard granularity, always the nearest value, matching the granularity (lower or higher), is configured.

	Value according to G.997.1
DPBOESCMA	0,0546875
DPBOESCMB	0,9140625 [1/√Hz]
DPBOESCMC	0,03125 [1/Hz]

Table B: DPBO Cable Model Parameters

- DPBOESEL: Main cable insertion loss [dB] @ 1 MHz. If ADSL2plus is operated from the CO then DPBOESEL = 0 applies.
- The Maximum Usable Frequency (DPBOMUF), for which DPBO is active, is calculated according to [16]. The necessary level DPBOMUS for calculating MUF may vary within the specified limits according to [16].

e) In addition to the automatic DPBO configuration an individual configuration of PSD masks (MIB PSD Mask Construction) according to [13] is supported by using breakpoints.

5.1.1.5 Electrical Characteristics of the U-R Interface

5.1.1.5.1 Safety

The relevant safety regulations are met at the U-R interface of the Deutsche Telekom Network [DIN EN 41003 [38], DIN EN 60950-1[39] (as applicable)].

5.1.1.5.2 Electromagnetic Compatibility

5.1.1.5.2.1 Basic Conditions

Equipment deployed within the area of responsibility of Deutsche Telekom as Network Operator complies with the "Gesetz über die elektromagnetische Verträglichkeit von Geräten” (EMVG [44]).

5.1.1.5.2.2 Non-DSL Signals at the U-R Interface

Due to the fact that ISDN or POTS ports may be connected to the U_{k0} / a/b-interface of splitter C (see figure 4-1 and 4-2) the following voltages and signals are to be expected at the U-R interface, parallel to ADSL/ADSL2plus signals.

DC Voltages

At the U-R interface DC voltages of up to 105 V in any polarity between tip and ring (a and b) in open loop state may occur.

POTS Signals

Ringing and Calling Line Identity Presentation (CLIP) signals according [2] may occur at the U-R interface.

5.1.1.5.2.3 Interference with External Voltages

Longitudinal Voltages

Due to interference from adjacent electric power lines (power supply, railway) into the local loop longitudinal voltages may be induced. The access interface is designed such that induced longitudinal voltages of

a) Ueff = 60 V during long term interference and
b) Ueff = 430 V during short term interference or
c) Ueff = 650 V during short term interference from power systems with high reliability

are not exceeded (DIN VDE 0228 [40]).

Atmospherical Discharges

Due to atmospherical discharges (lightning) short-time voltages may occur. Deutsche Telekom does not provide any protection measures against such voltages in most cases. Only in local areas with high lightning risk protection measures may be provided (e. g. insertion of over-voltage protection).

Protection measures of terminal equipment connected at the U-R interface require a potential equalization.

NOTE: The function of terminal equipment may be disturbed during the ignition of over-voltage protection elements.

The U-R interface is designed such that the probability of exceeding longitudinal voltages of 1500 V, induced due to atmospherical discharges, is low (ITU-T recommendation K.11 [41]; DIN EN 41003 [38]; DIN VDE 0845 part 4-2 [42]).

5.1.1.5.3 Signature

The following scheme represents a signature network which is expected to be present at the U-R-Interface, independent from the xTU-R state (e.g. switched off, training, show time, low power mode, etc.).
The signature network shall be designed in a way that all applicable requirements of this specification (e.g. performance, safety, LCL) are fulfilled.

Note: The purpose is to enable a test system, connected to the line at the far end, to recognize the modem at the U-R interface.

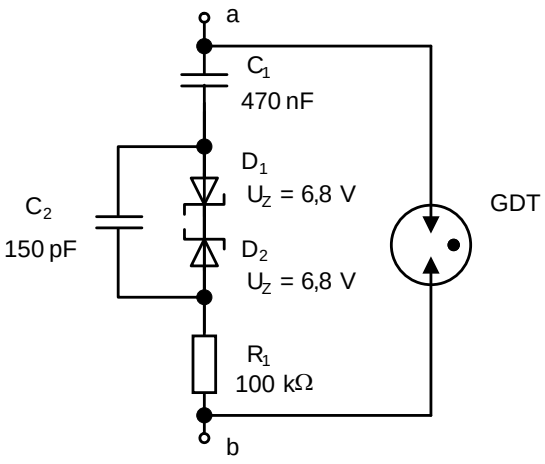

Figure 5-1: Signature Network at the U-R interface

5.1.1.5.4 Longitudinal Conversion Loss (LCL)

The LCL values of the ADSL modem, conform to [9], section 4.1.3 shall comply with the following levels:

Frequency (kHz)	LCL (dB)
0,3 – 30	> 40
30 – 1 104	> 50
1 104 – 6 000	> 40

Table C: ADSL Requirements for LCL

Frequency (kHz)	LCL (dB)
0,3 – 30	> 40
30 – 2 208	> 50
2 208 – 6 000	> 40

Table D: ADSL2plus Requirements for LCL

5.1.1.5.5 Common Mode Voltage Limits and Measurement Methods

The HG shall comply with recommendation ITU-T G.995.2 [70].

5.1.1.6 Performance Requirements

5.1.1.6.1 ADSL Annex B Performance Tests

The performance requirements shall be proved according to [34], Annex B. For the tests the setup and the settings of the mentioned section apply with the exception that splitters and same pair ISDN transmission shall not be used. All tests regarding noise margin verification (B.2.1, B.2.2), verification of downstream fine gain values (B.2.3), performance with rate adaptive configuration (B.2.4) and performance with fixed rate configuration (B.2.5) have to be performed. The pass/fail criteria of [34] apply.

NOTE: The network of Deutsche Telekom is designed for an impedance of 135 Ω +/-20 Ω in the ADSL frequency range. The modems have to meet the performance objectives in an impedance range of 100 Ω up to 150 Ω.

5.1.1.6.1.1 Tests with Rate Adaptive Configuration

Rate adaptive configuration enables an automatic data rate adaptation on the attenuation and noise conditions of a particular loop, independent for upstream and downstream. For the rate adaptive configuration minimum and maximum data rate limits (ranges) are configured in the DSLAM independently in both transmission directions in the range of the absolute ADSL data rate limits (32 kbit/s – 768 kbit/s in upstream direction and 32 kbit/s – 7 616 kbit/s in downstream direction).

For rate adaptive operation with white noise impairment and European FB noise impairment the requirements of [34], section B.2.4 apply. The herein given sync rates are boundary values. The ADSL Modem shall support all sync rates in between these values with a granularity of 32 kbit/s with a minimum performance assuming a linear interpolation of corner values.

5.1.1.6.1.2 Tests with Fixed Rate Configuration

5.1.1.6.1.2.1 White Noise Impairment

For fixed rate operation with white noise impairment the requirements of [34], section B.2.5.1, apply.
Additionally the following performance requirement has to be met:

data rates [kbps]		loop attenuation [dB @ 300 kHz]	actual margin	
DS	**US**	**Interleaver High**	**down [dB]**	**up [dB]**
448	96	3 900 m (55,3 dB)	≥ 3	≥ 3

Table E: Additional ADSL Performance Requirement for Long Loops

5.1.1.6.1.2.2 European Noise FB Impairment

Since different data rate combinations for the T-DSL service are used the following tables have to be regarded as performance requirements for the tests with fixed data rates and noise FB impairments (section B.2.5.2 of [34]). In these tables the loop attenuation measured in dB @ 300 kHz is given as performance requirement (named max. loop length requirement in [34]); where in [34] cable lengths are mentioned. If a loop simulator is used for the tests, the used loop should be adjusted in a way that the below mentioned values are met. For example the loop attenuation for ETSI loop #1 is approx. 14,2 dB per km @ 300 kHz.
As required in [34], it has also to be verified that the data rate combinations are also supported for lower loop attenuation (shorter loop lengths) than the required minimum loop attenuation (max. loop length), particularly in the region where power cut back functionality is active.
For the data rate combinations with a downstream rate > 5 000 kbps, it is necessary to switch off the noise at the DSLAM side for loop lengths below 750 m. With this set up, one can check the interoperability also on short loop lengths.

data rates [kbps]		loop attenuation [dB @ 300 kHz]		actual margin	
DS	**US**	**Fast Channel**	**Interleaver High**	**down [dB]**	**up [dB]**
448	96	2 900 m (41,3 dB)	3 000 m (42,7 dB)	≥ 3	≥ 3
1 184	160	2 800 m (39,8 dB)	2 900 m (41,3 dB)	≥ 3	≥ 3
1 728	224	2 650 m (37,7 dB)	2 750 m (39,1 dB)	≥ 3	≥ 3
2 304	224	2 550 m (36,3 dB)	2 650 m (37,7 dB)	≥ 3	≥ 3
3 456	448	2 200 m (31,2 dB)	2 300 m (32,7 dB)	≥ 3	≥ 3
3 456	576	1 900 m (26,6 dB)	2 000 m (28,1 dB)	≥ 3	≥ 3
6 656	640	1 600 m (22,7 dB)	1 650 m (23,4 dB)	≥ 3	≥ 3

Table F: ADSL Performance Requirements for Fixed Data Rates with 3 dB Noise Margin

data rates [kbps]	loop attenuation [dB @ 300 kHz]			actual margin	
DS	US	Fast Channel	Interleaver High	down [dB]	up [dB]
448	96	2 800 m (39,8 dB)	2 900 m (41,2 dB)	≥ 6	≥ 6
1 184	160	2 700 m (38,3 dB)	2 800 m (39,8 dB)	≥ 6	≥ 6
1 728	224	2 550 m (36,2 dB)	2 650 m (37,6 dB)	≥ 6	≥ 6
2 304	224	2 450 m (34,8 dB)	2 550 m (36,2 dB)	≥ 6	≥ 6
3 456	448	2 050 m (29,1 dB)	2 150 m (30,5 dB)	≥ 6	≥ 6
3 456	576	1 700 m (24,1 dB)	1 800 m (25,6 dB)	≥ 6	≥ 6
6 656	640	1 400 m (19,9 dB)	1 450 m (20,6 dB)	≥ 6	≥ 6

Table G: ADSL Performance Requirements for Fixed Data Rates with 6 dB Noise Margin

5.1.1.6.2 ADSL2plus Annex B Performance Tests

The performance requirements shall be proved according to [35], Annex B. For the tests the setup and the settings of the mentioned section apply with the exception that splitters and same pair ISDN transmission shall not be used. All tests regarding noise margin verification, verification of downstream fine gain values, performance with rate adaptive configuration, performance with fixed rate configuration, performance in L2 mode and performance with configured RFI bands and operation above ADSL (cabinet operation) have to be performed.
The pass/fail criteria of [35] according performance Class A (The DSLAM – modem combination does support the optional extended framing parameters according [12] and [13]) apply.

NOTE: The network of Deutsche Telekom is designed for an impedance of 135 Ω +/-20 Ω in the ADSL2plus frequency range. The modems have to meet the performance objectives in an impedance range of 100 Ω up to 150 Ω.

5.1.1.6.2.1 Tests with Rate Adaptive Configuration

Rate adaptive configuration enables an automatic data rate adaptation on the attenuation and noise conditions of a particular loop, independent for upstream and downstream. For the rate adaptive configuration minimum and maximum data rate limits (ranges) are configured independently in the DSLAM in both transmission directions in the range of the absolute ADSL2plus data rate limits (32 kbit/s – 1 200 kbit/s in upstream direction and 32 kbit/s – 24 000 kbit/s in downstream direction).
For rate adaptive operation with white noise impairment and European FB noise impairment the requirements of [35] apply. The herein given sync rates are boundary values. The ADSL2plus Modem shall support all sync rates in between these values with a granularity of < 32 kbit/s with a minimum performance assuming a linear interpolation of corner values.

5.1.1.6.2.2 Tests with Fixed Rate Configuration

5.1.1.6.2.2.1 White Noise Impairment

For fixed rate operation with white noise impairment the requirements of [35] apply.
Additionally the following performance requirement has to be met:

data rates [kbps]		loop attenuation [dB @ 300 kHz]	actual margin	
DS	**US**	**Interleaver High**	**down [dB]**	**up [dB]**
448	96	3 900 m (55,3 dB)	≥ 3	≥ 3

Table H: Additional ADSL2plus Performance Requirement for Long Loops

5.1.1.6.2.2.2 European Noise FB Impairment

For fixed rate operation with noise FB impairment the requirements of [35] apply.
As required in [35], it has also to be verified that the data rate combinations are also supported for lower loop attenuation (shorter loop lengths) than the required minimum loop attenuation (max. loop length).

5.1.1.6.3 ADSL2plus Annex J Performance Tests

The performance requirements shall be proved according to [35], Annex B. For the tests the setup and the settings of the mentioned section apply with the exception that splitters and same pair ISDN transmission shall not be used. All tests regarding noise margin verification, verification of downstream fine gain values, performance with rate adaptive configuration, performance with fixed rate configuration, performance in L2 mode and performance with configured RFI bands and operation above ADSL (cabinet operation) have to be performed.
The pass/fail criteria of [35] according performance Class A (The DSLAM – modem combination does support the optional extended framing parameters according [12] and [13]) apply.
The Upstream performance tests according to [35], Annex B incl. the pass/fail criteria (performance data) are TBD.

NOTE: The network of Deutsche Telekom is designed for an impedance of 135 Ω +/-20 Ω in the ADSL2plus frequency range. The modems have to meet the performance objectives in an impedance range of 100 Ω up to 150 Ω.

5.1.1.6.3.1 Tests with Rate Adaptive Configuration

Rate adaptive configuration enables an automatic data rate adaptation on the attenuation and noise conditions of a particular loop, independent for upstream and downstream. For the rate adaptive configuration minimum and maximum data rate limits (ranges) are configured independently in the DSLAM in both transmission directions in the range of the absolute ADSL2plus data rate limits (32 kbit/s – 3 000 kbit/s in upstream direction and 32 kbit/s – 24 000 kbit/s in downstream direction).
For rate adaptive operation with white noise impairment and European FB noise impairment the requirements of [35] apply for the downstream direction only. The herein given sync rates are boundary values. The ADSL2plus Modem shall support all sync rates in between these values with a granularity of < 32 kbit/s with a minimum performance assuming a linear interpolation of corner values.

Note: There are no requirements yet published within [35] for the upstream direction when operating according ADSL2plus Annex J. For actual performance requirements of this specification refer to section 5.1.1.6.3.2.

5.1.1.6.3.2 Specific Tests for ADSL2plus Annex J Upstream

The tests shall be done using the Telekom - specific upstream noise as given in the attached noise files (see Annex 4).
The noise shall be calibrated according [35] but for an impedance of 135 Ohm instead of the complex Z_{CAL}.

5.1.1.6.3.2.1 Tests for long loops

a) 3 dB Target Noise Margin
b) Mask ADLU48, INP = 1, Max Delay = 8 ms
c) Noise-Injection LT-side (upstream): Telekom-specific noise
d) Noise-Injection NT-side (downstream): White Noise -140 dBm/Hz

data rates [kbps]	loop attenuation [dB @ 300 kHz]	actual margin
US	mask ADLU48, INP = 1, Max Delay = 8 ms	up [dB]
272	55 dB (3900 m PE04)	≥ 3
320	54 dB (3800 m PE04)	≥ 3
464	50 dB (3500 m PE04)	≥ 3

Table I: Performance Requirements for ADSL2plus Annex J, ADLU-48 and 3 dB target noise margin using Telekom specific noise

5.1.1.6.3.2.2 Tests for short loops

a) Mask ADLU60, INP = 0, Max Delay = 1
b) Noise-Injection LT-side (upstream): Telekom-specific noise
c) Noise-Injection NT-side (downstream): White Noise -140 dBm/Hz

data rates [kbps]	loop attenuation [dB @ 300 kHz]	actual margin
US	Maske ADLU60, INP = 0, Max Delay = 1	up [dB]
2496	7,1 dB (500 m PE04)	≥ 6
2112	14,2 dB (1000 m PE04)	≥ 6
1344	28,8 dB (2000 m PE04)	≥ 6
608	42,6 dB (3000 m PE04)	≥ 6
256	50 dB (3500 m PE04)	≥ 6

Table J: Performance Requirements for ADSL2plus Annex J, ADLU 60 and 6 dB target noise margin using Telekom specific noise

5.1.1.6.3.3 Tests with Fixed Rate Configuration

5.1.1.6.3.3.1 White Noise Impairment

For fixed rate operation with white noise impairment the requirements of [35] apply, except for the upstream direction.

Note: There are no requirements yet published within [35] for the upstream direction when operating according ADSL2plus Annex J. For actual performance requirements of this specification refer to section 5.1.1.6.3.2.

5.1.1.6.3.3.2 European Noise FB Impairment

For fixed rate operation with noise FB impairment the requirements of [35] apply, except for the upstream direction.
As required in [35], it has also to be verified that the data rate combinations are also supported for lower loop attenuation (shorter loop lengths) than the required minimum loop attenuation (max. loop length).

Note: There are no requirements yet published within [35] for the upstream direction when operating according ADSL2plus Annex J. For actual performance requirements of this specification refer to section 5.1.1.6.3.2.

5.1.1.7 Mechanical Properties of U-R Interface

The network terminal adapter for the U-R interface (Telekommunikations-Anschluss-Einheit [TAE]), provided by Deutsche Telekom, meets the requirements of DIN 41 715 Part 3, model “NFN” or model "F" (according [43]). For operation the connection points “1” and “2” respectively “a” and “b” are used.

5.1.2 U-R2 Interface

The transmission mode "ADSL over ISDN" is used in case of base band voice transmission. The same technique is used even when analogue telephony (POTS) is used in the base band. The different parameters for POTS and ISDN can be adjusted, if necessary, by switching a filter inside the splitter. This does not influence the spectrum used for ADSL transmission.
ADSL modems compatible to this interface description shall comply with [11], [12] and [13] (Annex B in each case).
The DSLAM is the master for selecting the active operational mode during the handshake procedure according to [15]. If both the DSLAM and the modem support more than one mentioned operational mode and the DSLAM allows this, the mode with the highest priority shall be selected. These priorities are defined as follows (1 = highest priority, 3 = lowest priority):

Priority	Mode
1	ADSL2plus
2	ADSL

Table K: Priority of ADSL Modes

Depending on the selected mode the corresponding chapter in this document applies.

5.1.2.1 Applied Recommendations for ADSL Annex B

At the U-R2 interface, ADSL signals are provided or expected, as defined in [11], Annex B, and in [5] - "ADSL over ISDN". The ISDN transmission systems correspond to Annex 6.

The guidelines cited in [11], [15] and [16] apply.
The operation according to [5], Annex C (ADSL over ISDN configuration of T1.413 based modems) is not allowed for the mentioned U-R2 interface.
For interoperability tests between ADSL Modems and ADSL DSLAMs [34] applies.

5.1.2.1.1 Specific Requirements for ADSL Annex B

a) For upstream direction all possible data rates in steps of 32 kbit/s in the range 64 kbit/s to at least 640 kbit/s shall be supported.
b) For downstream direction all possible data rates in steps of 32 kbit/s in the range 128 kbit/s to at least 6720 kbit/s shall be supported.
c) Duplex procedure: FDD non overlapped spectrum.
d) PSD for FDD conform to [5]; this shall comply within all operational states.
e) The use of carriers #1 through #32 during show time is not allowed in order to avoid interoperability problems with ISDN 4B3T. In addition to c), the PSD below 138 kHz shall not exceed – 80 dBm/Hz.
f) Use of the "interleaved channel" with support of the interleave depths which can be adjusted on the standard basis according to [11] and use of the "fast channel".
g) Power cut back, conform to [11] Annex B, Section B.3.3, is only for downstream direction.
h) For the Upstream power cut back is not allowed.
i) The ADSL modem has to support Trellis coding.
j) The target noise margin (minimum required downstream SNR margin at initialization, C-MSG1) has to be considered from the ADSL modem according to [11]. For the configuration the DSLAM is the master.
k) The retrain margin (margin where a resynchronization is forced, minimum required downstream ATU-R noise margin in steady state, C-MSG-RA) has to be considered from the ADSL modem according to [11]. Default value is 0 dB. For the configuration the DSLAM is the master.
l) Layer 1 OAM (configuration, fault and performance monitoring data) shall conform to [11], including dying gasp (loss of power).
m) IDFT has to be realized according to [11], B2.6.
n) The Vendor ID to be exchanged between ADSL modem and DSLAM during the handshake procedure, conveyed in the „Vendor ID information block“ of the „Identification field“ according to [15], represents the chipset manufacturer. 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.

5.1.2.2 Applied Recommendations for ADSL2plus Annex B

At the U-R2 interface, ADSL2plus signals are provided or expected, as defined in [13], Annex B "ADSL2plus over ISDN". The ISDN transmission systems correspond to Annex 6 (4B3T line code).
The guidelines cited in [13], [15] and [16] apply.
For interoperability tests between ADSL2plus Modems and ADSL2plus DSLAMs [35] and [36] apply.

5.1.2.2.1 Specific Requirements for ADSL2plus

a) The ADSL2plus modem has to support all mandatory functionalities of [13].
b) For upstream direction all possible data rates in steps of < 32 kbit/s in the range 64 kbit/s to at least 1 200 kbit/s shall be supported.
c) For downstream direction all possible data rates in steps of < 32 kbit/s in the range 128 kbit/s to at least 24 000 kbit/s shall be supported.
d) All rate adaptation modes according to [16] (MANUAL, AT INIT, DYNAMIC) have to be supported.

e) Use of the "interleaved channel" with support of the interleave depths / delay which can be adjusted according to [16] and use of the "fast channel" has to be supported.
f) Support of different delay- and INP settings per transmission direction is mandatory.
g) The optional „extended Framing Mode“ according to [13], Annex K for transmission of higher data rates when using INP_min > 0 has to be supported. (For example DS rates of more than 16 Mbit/s with INP_min = 1 / maxDELAY = 8 ms).
h) Duplex procedure: FDD non overlapped spectrum.
i) PSD for FDD conform to [5]; this shall comply within all operational states.
j) The use of carriers #1 through #32 during show time is not allowed in order to avoid interoperability problems with ISDN 4B3T. In addition to i), the PSD below 138 kHz shall not exceed – 80 dBm/Hz.
k) Only power management with automatic transition to L2 is used, L3 in power management mode is not used (L0-time, L2-time, L2-ATPR and L2-ATPRT are to be expected in the ranges as defined in [16]). Any transition to L2 state or any performed power trim must not cause a synchronization loss. The sum of the successfully performed power trims must not cause a resulting noise margin lower than the target margin.
The following enhancements shall be supported (see also ITU-T G.992.3 Amendment 4):
   - removal of the Lp ≤ 1024 constraint, which allows for higher L2 min rates and restricts the delay increments
   - allow gi shaping during the L2 state by the ATU-R in order to allow increased power savings in L2 mode
l) Loop diagnostic mode has to be supported (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.
m) The ADSL2plus modem shall support the shaping of the Downstream transmit PSD.
n) In case of Cabinet Operation Mode (Downstream PSD located above ADSL spectrum, beginning at 1,1 MHz), tone set B43c has to be used during handshake.
o) In case of Cabinet Operation Mode, transmit signals must not exceed the specified levels according the following breakpoints and corresponding PSD slope as defined in [13]:
   - t(1)= 233 (1004,8125 kHz), PSD1= -95 dBm/Hz,
   - t(2)= 260 (1121,25 kHz), PSD2= -36,5 dBm/Hz

These apply to all operational states (e.g. training, show time, DELT).

p) The ADSL2plus modem shall support transmission with configured downstream RFI bands. The following bands are defined:
   - RFI band 1: from 1 800 kHz up to 2 000 kHz, Level < -80 dBm/Hz
   - RFI band 2: from 2 173,5 kHz up to 2 190,5 kHz, Level < -80 dBm/Hz
q) In case of configured RFI bands, transmit signals must not exceed the specified levels inside the RFI bands. These apply to all operational states (e.g. training, show time, DELT).
r) Layer 1 OAM (configuration, fault and performance monitoring data) shall conform to [13], including dying gasp (loss of power).
s) IDFT has to be realized according to [12], B2.4.

5.1.2.2.2 Requirements for ADSL2plus Annex B Downstream Power back Off (DPBO)

a) DPBO has to be supported
b) DPBO is used by the DSLAM to protect DSL connections, which are distributed from the central office in a common distribution cable together with DSL connections which are operated from the cabinet according to [13] (Amendment 2) and [16].
c) The reduced downstream PSD (PEPSD(f)) has to be calculated as follows:

$$PEPSD(f) = DPBOEPSD(f) - \left(DPBOESCMA + DPBOESCMB \cdot \sqrt{f} + DPBOESCMC.f\right) \cdot DPBOESEL + 10 \cdot \log_{10}\left(1 + \frac{DPBOESEL}{6.65dB}\right)$$

in [dBm/Hz] with f in [MHz].

d) The following definitions apply:
- DPBOEPSD(f): PSD [dBm/Hz] of the DSL type operated from the central office that has to be protected, in this case: VDSL2 Annex B, Limit PSD Mask 998ADE17-M2x-B according to [14].
- DPBOESCMA, DPBOESCMB, DPBOESCMC: cable model parameters. These parameters are configured at the DSLAM and are taking into account the standard granularity according to [16]. Since the following values do not match the standard granularity, always the nearest value, matching the granularity (lower or higher), is configured.

	Value according to G.997.1
DPBOESCMA	0,0546875
DPBOESCMB	0,9140625 [1/√Hz]
DPBOESCMC	0,03125 [1/Hz]

Table L: DPBO Cable Model Parameters

- DPBOESEL: Main cable insertion loss [dB] @ 1 MHz. If ADSL2plus is operated from the CO then DPBOESEL=0 applies.
- The Maximum Usable Frequency (DPBOMUF), for which DPBO is active, is calculated according to [16]. The necessary level DPBOMUS for calculating MUF may vary within the specified limits according to [16].

e) In addition to the automatic DPBO configuration an individual configuration of PSD masks (MIB PSD Mask Construction) according to [13] is supported by using breakpoints.

5.1.2.3 Electrical Characteristics of the U-R2 Interface at Splitter R

The splitter details in the following section are presented solely for information purposes and description of the U-R2 interface's electrical characteristics. The splitter itself is not covered by this interface description. The splitter serves as the network termination and in addition to the provision of the narrow band services (POTS and ISDN) it provides the U-R2 interface as well. The interface is implemented at splitter R. This splitter consists of a low pass filter that separates the narrow band signals from the ADSL signals. Due to the design of splitter R, signals from the POTS or ISDN are applied in parallel to the ADSL signal at the input of the ADSL modem. The splitter is designed for both narrow band services (switch-selectable or universal version).
- POTS: conform to [2]
- ISDN: conform to Annex 6

In general, these provisions require a high pass implemented in the ADSL modem.

Figure 5-2 shows the general schematic layout of the splitter. Please note that this figure is presented solely to support description of the interface between splitter R and the ADSL modem.

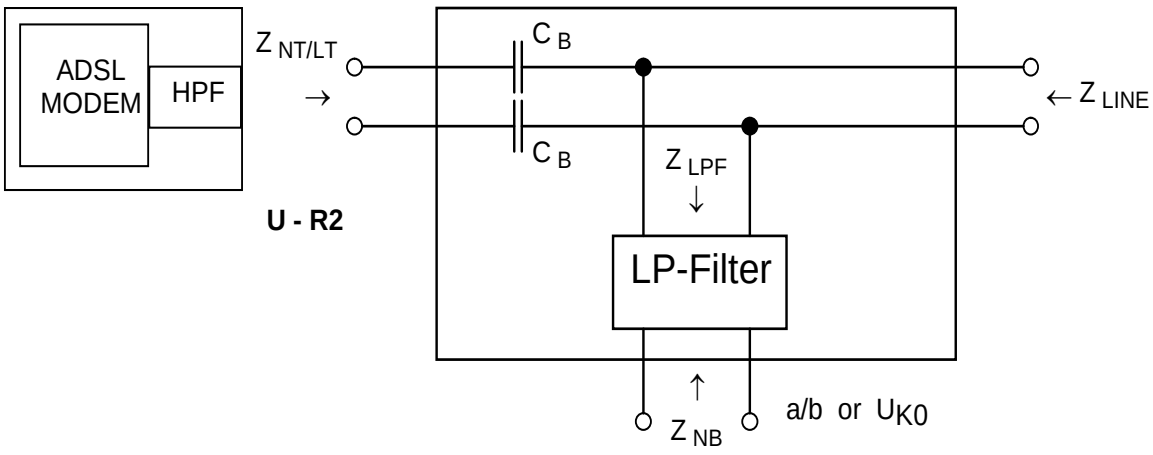

Figure 5-2: General Schematic Layout of Splitter R

The following levels can be expected:

Designation	**Value**	**Frequency Range**
C_B	27nF ± 5%	n. A.
$Z_{NT/LT}$	100 Ohm	f > 138 kHz
$Z_{LPF} = Z_{NB}$	ISDN: 150 Ohm POTS: 820 Ohm // 115nF + 220 Ohm	0 Hz ≤ f ≤ 80 kHz

Table M: Values for the Splitter Components

The maximum insertion loss, as caused by splitter C and splitter R (not including the line) in the ADSL path, is 2 dB within the frequency range 170 kHz to 2,208 MHz and ≤ 6 dB within the frequency range 120 kHz to 170 kHz.
This splitter concept and the minimum requirements for the relevant characteristic values of the splitter, for operation of ISDN or POTS in the base band, are described in [7].
The input impedance of the ADSL modem is expected to conform to [7] on the splitter side (which applies for both ISDN and POTS in the base band):

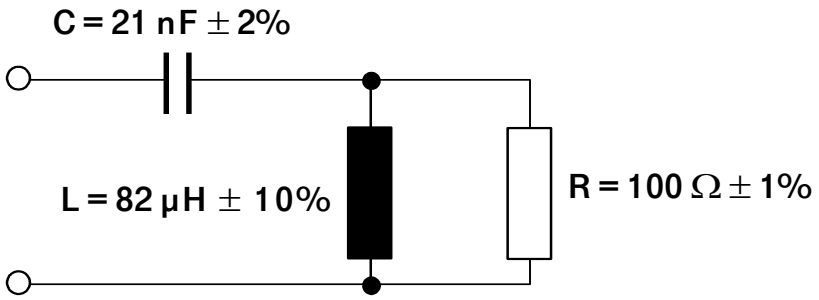

Figure 5-3: Input Impedance Model of the ADSL Modem

5.1.2.4 Impact on the ISDN Service

Operation of the ADSL modem must not have a greater impact on parallel ISDN transmission (see also Annex 6) than what is permitted by the ADSL standard [11] (maximum 4 dB range loss). Only during switching power ON/OFF, a one-time impact of no more than 320 bit errors in one B channel (64 kbit/s) is permitted. This impact can be compared approximately to the effect

of a short interruption of < 5 ms. Related to these events neither the U_{k0} interface shall be deactivated nor the call be released.

5.1.2.5 Longitudinal Conversion Loss (LCL)

The LCL values of the ADSL modem, conform to [9], section 4.1.3 shall comply with the following levels:

Frequency (kHz)	LCL (dB)
0,3 – 30	> 40
30 – 1 104	> 50
1 104 – 6 000	> 40

Table N: ADSL Requirements for LCL

Frequency (kHz)	LCL (dB)
0,3 – 30	> 40
30 – 2 208	> 50
2 208 – 6 000	> 40

Table O: ADSL2plus Requirements for LCL

5.1.2.5.1 Common Mode Voltage Limits and Measurement Methods

The HG shall comply with recommendation ITU-T G.995.2 [70].

5.1.2.6 Performance Requirements

5.1.2.6.1 ADSL Performance Tests

The performance requirements shall be proved according to [34], Annex B. For the tests the setup and the settings of the mentioned section have to be used. All tests regarding noise margin verification (B.2.1, B.2.2), verification of downstream fine gain values (B.2.3), performance with rate adaptive configuration (B.2.4) and performance with fixed rate configuration (B.2.5) have to be performed. The pass/fail criteria of [34] apply.

NOTE: The network of Deutsche Telekom is designed for an impedance of 135 Ω +/-20 Ω in the ADSL frequency range. The modems have to meet the performance objectives in an impedance range of 100 Ω up to 150 Ω.

5.1.2.6.1.1 Tests with Rate Adaptive Configuration

Rate adaptive configuration enables an automatic data rate adaptation on the attenuation and noise conditions of a particular loop, independent for upstream and downstream. For the rate adaptive configuration minimum and maximum data rate limits (ranges) are configured in the DSLAM independently in both transmission directions in the range of the absolute ADSL data rate limits (32 kbit/s – 768 kbit/s in upstream direction and 32 kbit/s – 7 616 kbit/s in downstream direction).

For rate adaptive operation with white noise impairment and European FB noise impairment the requirements of [34], section B.2.4 apply. The herein given sync rates are boundary values. The ADSL Modem shall support all sync rates in between these values with a granularity of 32 kbit/s with a minimum performance assuming a linear interpolation of corner values.

5.1.2.6.1.2 Tests with Fixed Rate Configuration

5.1.2.6.1.2.1 White Noise Impairment

For fixed rate operation with white noise impairment the requirements of [34], section B.2.5.1, apply.
Additionally the following performance requirement has to be met:

data rates [kbps]		loop attenuation [dB @ 300 kHz]	actual margin	
DS	**US**	**Interleaver High**	**down [dB]**	**up [dB]**
448	96	3 900 m (55,3 dB)	≥ 3	≥ 3

Table P: Additional ADSL Performance Requirement for Long Loops

5.1.2.6.1.2.2 European Noise FB Impairment

Since different data rate combinations for the T-DSL service are used the following tables have to be regarded as performance requirements for the tests with fixed data rates and noise FB impairments (section B.2.5.2 of [34]). In these tables the loop attenuation measured in dB @ 300 kHz is given as performance requirement (named max. loop length requirement in [34]); where in [34] cable lengths are mentioned. If a loop simulator is used for the tests, the used loop should be adjusted in a way that the below mentioned values are met. For example the loop attenuation for ETSI loop #1 is approx. 14,2 dB per km @ 300 kHz.
As required in [34], it has also to be verified that the data rate combinations are also supported for lower loop attenuation (shorter loop lengths) than the required minimum loop attenuation (max. loop length), particularly in the region where power cut back functionality is active.
For the data rate combinations with a downstream rate > 5 000 kbps, it is necessary to switch off the noise at the DSLAM side for loop lengths below 750 m. With this set up, one can check the interoperability also on short loop lengths.

data rates [kbps]		loop attenuation [dB @ 300 kHz]		actual margin	
DS	**US**	**Fast Channel**	**Interleaver High**	**down [dB]**	**up [dB]**
448	96	2 900 m (41,3 dB)	3 000 m (42,7 dB)	≥ 3	≥ 3
1 184	160	2 800 m (39,8 dB)	2 900 m (41,3 dB)	≥ 3	≥ 3
1 728	224	2 650 m (37,7 dB)	2 750 m (39,1 dB)	≥ 3	≥ 3
2 304	224	2 550 m (36,3 dB)	2 650 m (37,7 dB)	≥ 3	≥ 3
3 456	448	2 200 m (31,2 dB)	2 300 m (32,7 dB)	≥ 3	≥ 3
3 456	576	1 900 m (26,6 dB)	2 000 m (28,1 dB)	≥ 3	≥ 3
6 656	640	1 600 m (22,7 dB)	1 650 m (23,4 dB)	≥ 3	≥ 3

Table Q: ADSL Performance Requirements for Fixed Data Rates with 3 dB Noise Margin

data rates [kbps]		loop attenuation [dB @ 300 kHz]		actual margin	
DS	US	Fast Channel	Interleaver High	down [dB]	up [dB]
448	96	2 800 m (39,8 dB)	2 900 m (41,2 dB)	≥ 6	≥ 6
1 184	160	2 700 m (38,3 dB)	2 800 m (39,8 dB)	≥ 6	≥ 6
1 728	224	2 550 m (36,2 dB)	2 650 m (37,6 dB)	≥ 6	≥ 6
2 304	224	2 450 m (34,8 dB)	2 550 m (36,2 dB)	≥ 6	≥ 6
3 456	448	2 050 m (29,1 dB)	2 150 m (30,5 dB)	≥ 6	≥ 6
3 456	576	1 700 m (24,1 dB)	1 800 m (25,6 dB)	≥ 6	≥ 6
6 656	640	1 400 m (19,9 dB)	1 450 m (20,6 dB)	≥ 6	≥ 6

Table R: ADSL Performance Requirements for Fixed Data Rates with 6 dB Noise Margin

5.1.2.6.2 ADSL2plus Performance Tests

The performance requirements shall be proved according to [35], Annex B. For the tests the setup and the settings of the mentioned section have to be used. All tests regarding noise margin verification, verification of downstream fine gain values, performance with rate adaptive configuration, performance with fixed rate configuration, performance in L2 mode and performance with configured RFI bands and operation above ADSL (cabinet operation) have to be performed. The pass/fail criteria of [35] according performance Class A (The DSLAM – modem combination does support the optional extended framing parameters according [12] and [13]) apply.

NOTE: The network of Deutsche Telekom is designed for an impedance of 135 Ω +/-20 Ω in the ADSL2plus frequency range. The modems have to meet the performance objectives in an impedance range of 100 Ω up to 150 Ω.

5.1.2.6.2.1 Tests with Rate Adaptive Configuration

Rate adaptive configuration enables an automatic data rate adaptation on the attenuation and noise conditions of a particular loop, independent for upstream and downstream. For the rate adaptive configuration minimum and maximum data rate limits (ranges) are configured independently in the DSLAM in both transmission directions in the range of the absolute ADSL2plus data rate limits (32 kbit/s – 1 200 kbit/s in upstream direction and 32 kbit/s – 24 000 kbit/s in downstream direction).
For rate adaptive operation with white noise impairment and European FB noise impairment the requirements of [35] apply. The herein given sync rates are boundary values. The ADSL2plus Modem shall support all sync rates in between these values with a granularity of < 32 kbit/s with a minimum performance assuming a linear interpolation of corner values.

5.1.2.6.2.2 Tests with Fixed Rate Configuration

5.1.2.6.2.2.1 White Noise Impairment

For fixed rate operation with white noise impairment the requirements of [35] apply.
Additionally the following performance requirement has to be met:

data rates [kbps]		loop attenuation [dB @ 300 kHz]	actual margin	
DS	**US**	**Interleaver High**	**down [dB]**	**up [dB]**
448	96	3 900 m (55,3 dB)	≥ 3	≥ 3

Table S: Additional ADSL2plus Performance Requirement for Long Loops

5.1.2.6.2.2.2 European Noise FB Impairment

For fixed rate operation with noise FB impairment the requirements of [35] apply.
As required in [35], it has also to be verified that the data rate combinations are also supported for lower loop attenuation (shorter loop lengths) than the required minimum loop attenuation (max. loop length).

5.1.2.7 Mechanical Properties of U-R2 Interface at Splitter R

At the customer side the U-R2 interface is provided at the RJ45 socket, which is integrated in splitter R and at the terminal blocks inside the splitter box.
The pins in the RJ45 socket (designated "DSL") are allocated as follows:

Pin	Allocation
1	not allocated
2	not allocated
3	not allocated
4	U-R2 a
5	U-R2 b
6	not allocated
7	not allocated
8	not allocated

Table T: U-R2 Pin Allocation at Splitter R

5.1.3 Element Management of the ADSL Modem

The EOC specified in [11] is provided as the management channel between the DSLAM and the ADSL modem. The DSLAM expects all the functions and management information specified according to [11], in conjunction with the EOC from a connected ADSL modem.

For operation and maintenance purposes the equipment vendor (not chip manufacturer) of the ADSL modem and the type of the modem need to be uniquely identified by information stored in the ATU-R registers “ATU-R vendor ID” (Register #0), “ATU-R version number minus one” (Register #1) and “ATU-R serial number” (Register #2) as specified in [11] or in case of ADSL2plus specified as Inventory Command Response as specified in [12].

After power up the ADSL modem needs to perform a self test and reports the self test result via the ATU-R register “Self test result” (Register #3). If the self test succeeded and the ADSL modem is able to transfer data, the most significant byte of the self test result register should be “0x00”. If the self test fails, the result should be “0x01”. Further detailed information about the failure reason is vendor discretionary.

The clear EOC as described in [11] must not be supported.

Software updates and configuration of the ADSL modem cannot be carried out via the DSLAM. Functions at the customer interface must not provide any access to the DSLAM (manipulation or configuration). Furthermore, it must not impair the DSLAM in any way.

6 Technical description of SDSL

6.1 General Requirements

The transmission mode "SDSL" according to [6] is used. The following requirements distinguish between SDSL systems based on ATM adaptation layer (providing connectivity to ATM-based DSLAM) and Ethernet (EFM) adaptation layer (providing connectivity to Ethernet based MSAN).

6.1.1 Applied Recommendations

At the U-RS interface, SDSL signals are provided or expected as defined in [6].
The guidelines cited in [10] and [15] shall apply where appropriate.

6.1.2 Specific Requirements for SDSL – ATM-Support

a) Remote Power Feeding for customer premises equipment is not provided at the U-RS interface.
b) The optional operation of regenerators between the SDSL modem and the DSLAM is reserved for future use.
c) The optional four wire operational mode is supported. Wire pairs (U-RS / Pair 1 - U-RS2 / Pair 2) can be swapped.
d) The support of all data rates in the range 192 kbit/s to 2 304 kbit/s with the corresponding granularity according to the used application specific Transmission Protocol Specific Transmission Convergence (TPS-TC) layer is required. Rates up to 4608 kbit/s together with the optional four wire operational mode are supported.
e) The support for a rate adaptive mode using the Power Measurement Modulation Session PMMS (Line Probe) is required. The support of the current condition target margin is mandatory; the support of the worst case condition target margin is optional.
f) The value for the target noise margin (min. required noise margin) has to be considered by the SDSL modem according to [6]. For the configuration the DSLAM is the master.
g) The support of symmetric Power Spectrum Density (PSD) masks according to [6] chapter 9.4.1 is mandatory. The support of asymmetric PSD according to [6] chapter 9.4.2 is optional. Default configuration is symmetric PSD.
h) The SDSL embedded operations channel (eoc) shall be supported according to [6].
i) The support of the optional reduced power mode, the deactivation and the warm-start is reserved for future use.
j) The Vendor ID to be exchanged between SDSL modem and DSLAM during the handshake procedure in the „Vendor ID information block“ of the „Identification field“ according to [15] represents the chipset manufacturer. 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.

6.1.3 Specific Requirements for SDSL – EFM-Support

a) Remote Power Feeding for customer premises equipment is not provided at the U-RS interface.
b) The optional operation of regenerators between the SDSL modem and the DSLAM is required. The regenerator support is limited up to rates of 2304 kbit/s per wire pair.
c) The support of all data rates in the range 192 kbit/s to enhanced SDSL rates up to 5696 kbit/s acc. [6], Annex E is required.
d) The support for a rate adaptive mode using the Power Measurement Modulation Session PMMS (Line Probe) is required. The support of the current condition target margin is mandatory; the support of the worst case condition target margin is optional.
e) The support of symmetric Power Spectrum Density (PSD) masks according to [6] chapter 9.4.1 is mandatory. The support of asymmetric PSD according to [6] chapter 9.4.2 is optional. Default configuration is symmetric PSD.
f) The SDSL embedded operations channel (eoc) shall be supported according to [6].
g) The support of the optional reduced power mode, the deactivation and the warmstart is reserved for future use.
h) The Vendor ID to be exchanged between SDSL modem and DSLAM during the handshake procedure in the „Vendor ID information block“ of the „Identification field“ according to [15] represents the chipset manufacturer. 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.

6.1.4 Specific Requirements for SDSL – EFM-Bonding-Support

To increase the transfer rate and/or range, support of EFM bonding is required as per ITU-T G.998.2. At least four SDSL ports must be capable of being combined into one bonding group, so that data rates (line rates) of at least 4 x 5.696 Mbit/s can be achieved symmetrically.

Different line rates for a single SDSL link within one EFM bonding group must be possible.

For EFM bonding, data transport must remain possible even if individual SDSL links go down. The remaining data rate should not be reduced by any more than the sum rate of the lost links.

6.1.5 Electrical Characteristics of the U-RS Interface

6.1.5.1 Unbalance about Earth

The Minimum longitudinal conversion loss and the maximum longitudinal component of the output signal for a SDSL modem shall be according to [6], chapter 11.3.

6.1.5.2 Return loss

The minimum return loss of a SDSL modem shall be according to [6], chapter 11.2..

6.1.5.3 Signature

There is no additional signature required for the U-RS interface.

6.1.5.4 Common Mode Voltage Limits and Measurement Methods

The HG shall comply with recommendation ITU-T G.995.2 [70].

6.1.6 Performance Requirements for Single-Pair Operation

The following performance requirements are valid for single pair operation. In case of four wire (2 pair) operation, each pair has to fulfil these requirements. The operation of the four wire connection has to be guaranteed also if one pair has maximum loop length and the other pair has zero loop length.

6.1.6.1 Fixed Bit rates

The achieved performance shall conform to the test loop length requirements for ETSI Noise Model B, table 12.3 and E.8 of [6], for loop 1 and loop 2. The performance test procedure shall be carried out according to [6], chapter 12.6.1. This means noise B shall apply for downstream and upstream direction performance tests separately. The BER shall be less or equal than 10^{-7} when the test noise is increased by 6 dB (this is equivalent to 6 dB of noise margin).

In addition to that, for bit rates below 384 kbit/s the following performance is required for Loop 1 and Loop 2 with Noise Model B in up- and downstream direction separately by using the same test procedure:

Payload Bit rate [kbit/s]	Test frequency f_T [kHz]	Y [dB] @f_T, @135 Ω	L1 [m]	L2 [m]
320	150	53,0	< 3	5 050
192	150	57,0	< 3	5 450

Table U: Values of the Electrical Length Y of the SDSL Noise Test loops, when Testing SDSL with Noise Model B

NOTE: The network of Deutsche Telekom is designed for an impedance of 135 Ω at 150 kHz. The modems have to meet the performance objectives in an impedance range of 100 Ω up to 150 Ω.

6.1.6.2 PMMS Mode

The following tests are to be carried out in PMMS mode (line probe) and shall show the ability of the SDSL DSLAM and HG combination to work in a rate adaptive mode considering a given target noise margin (upstream) of 6 dB. It is accepted that at a maximum of 10% of all test points gets into data state with a reported noise margin of 5 dB.
The test setup shall be as follows:

Test setup:

- PMMS Target Noise Margin current condition, upstream: 6 dB
- Loop #2
- Noise model B upstream: Fixed for 1280 kbit/s (2725 m Loop 2) for all lengths
- Noise model B downstream: Fixed for 1280 kbit/s (2725 m Loop 2) for all lengths
- Noise coupling disconnected on one side (single side noise injection) for proof of fulfillment of the upstream and downstream requirements independently

Loop length Loop #2	**Minimum Payload Bit rate [kbit/s] Line code 16-TC-PAM** Noise model B upstream: Fixed for 1280 kbit/s (2725 m Loop 2) for all lengths Noise model B downstream Fixed for 1280 kbit/s (2725 m Loop 2) for all lengths	**Minimum Payload Bit rate [kbit/s] Line code 16-TC-PAM eSDSL** Noise model B upstream: Fixed for 1280 kbit/s (2725 m Loop 2) for all lengths Noise model B downstream Fixed for 1280 kbit/s (2725 m Loop 2) for all lengths	**Minimum Payload Bit rate [kbit/s] Line code 32-TC-PAM** Noise model B upstream: Fixed for 4096 kbit/s (1039 m Loop 2) for all lengths Noise model B downstream Fixed for 4096 kbit/s (1039 m Loop 2) for all lengths
[m]	US / DS [kbps]	US / DS [kbps]	US / DS [kbps]
0	2304	2560	5696
200	2304	2560	5696
500	2304	2560	5696
1000	2304	2560	4224
1500	2304	2560	2816
2000	2240	2240	1792
2250	1856	1856	1512
2500	1472	1472	1280
2750	1280	1280	1024
3000	1088	1088	896
3250	896	896	768
3500	768	768	N/A
3750	640	N/A	N/A
4000	576	N/A	N/A
4250	512	N/A	N/A
4500	448	N/A	N/A
4750	384	N/A	N/A
5000	320	N/A	N/A
5450	192	N/A	N/A

Table V: Performance Requirements in PMMS Mode

6.1.7 Mechanical Properties of U-RS Interface

At the customer side the U-RS interface is provided at a separate RJ45 socket (UAE).
The pins in the RJ45 socket (designated "DSL") are allocated as follows:

Pin	Allocation
1	U-RS2 a (if bonding is supported)
2	U-RS2 b (if bonding is supported)
3	U-RS3 a (if bonding is supported)
4	U-RS a
5	U-RS b
6	U-RS3 b (if bonding is supported)
7	U-RS4 a (if bonding is supported)
8	U-RS4 b (if bonding is supported)

Table W: U-RS Pin Allocation

6.1.8 Element Management of the SDSL Modem

The EOC specified in [6] is provided as the management channel between the DSLAM and the SDSL modem. The DSLAM expects all the functions and management information specified conform to [6], in conjunction with the EOC from a connected SDSL modem.

For operation and maintenance purposes the vendor (not chip manufacturer) of the SDSL modem and the type of the modem needs to be uniquely identified by information via the STU-R Inventory Request/Response Messages.

Software updates and configuration of the SDSL modem over and above the in [6] specified means cannot be carried out via the DSLAM.

Functions at the customer interface must not provide any access to the DSLAM (manipulation or configuration). Furthermore, it must not impair the DSLAM in any way.

7 Technical description of VDSL2

The transmission mode "VDSL2" according to [14], Annex B is used. In addition to the VDSL2 data transmission it shall be possible to use the base band for telephony services (POTS or ISDN).

7.1 VDSL2 Requirements

7.1.1 U-RV Interface

7.1.1.1 Specific Requirements for VDSL2

At the U-RV interface, VDSL2 signals are provided or expected, as defined in [14], Annex B. The VDSL2 modem has to support all mandatory functionalities defined in [14].

The following additional requirements are valid for U-RV2 interfaces:

a) Frequency Plan: 998
b) The following profiles and PSD masks shall be supported:

Profile	8b	17a
PSD mask	998-M2x-B (US0 138 kHz – 276 kHz)	998ADE17-M2x-B with US0 138 kHz – 276 kHz

Table X: VDSL2 Profile and Limit PSD Mask support

c) Support of upstream band US0 is required for both profiles (8b and 17a).
d) To avoid impact while Upstream Power back Off is applied the handshake carrier sets B43 and B43c have to be used. The handshake carrier set V43 is not allowed (see also [15], Table 2, Note 4 with regard to the usage of US0).
e) For upstream direction all possible data rates in steps of < 64 kbit/s in the range from 64 kbit/s to at least 50 000 kbit/s shall be supported.
f) For downstream direction all possible data rates in steps of < 64 kbit/s in the range from 128 kbit/s to at least 100 000 kbit/s shall be supported.
g) The rate adaptation modes MANUAL and AT INIT have to be supported.
h) Loop diagnostic mode (DELT) has to be supported.
i) After the DELT procedure is finished (successful or not successful), the line has to fall back into the same state as before the DELT procedure was started.
j) If implemented, the option Virtual Noise shall be deactivated per default.
k) Use of the "interleaved channel" with support of the interleave depths / delay which can be adjusted according to [16] and use of the "fast channel".
l) Support of dual latency and dual interleaver is optional.
m) Support of different delay- and INP settings per transmission direction is mandatory.
n) The target noise margin has to be considered by the VDSL2 modem according to [14]. For the configuration the DSLAM is the master.
o) Layer 1 OAM (configuration, fault and performance monitoring data) shall conform to [16], including dying gasp (loss of power).
p) The VDSL2 modem shall support transmission with configured RFI bands. Annex 3 lists all necessary frequency bands. The PSD within activated RFI bands shall be < -80 dBm/Hz.
At least 16 RFI bands (notches) have to be supported simultaneously.

7.1.1.1.1 Retransmission

The support of retransmission according ITU-T G.998.4 (ex G.inp) [55] is required in order to improve the DSL line stability under impulse noise conditions.

Specific requirements for retransmission:

- Both impulse noise characteristics SHINE and REIN are to be considered.
- For VDSL2s the EFM TPS-TC specific requirements are valid.
- All mandatory control parameters acc. [55] and [16] are to be supported.

  For VDSL2, support of Retransmission is mandatory for both Upstream and Downstream direction..
- All mandatory OAM parameters (performance counter implementations) acc. [55] and [16] are to be supported.
- All mandatory channel initialization modes and parameters acc. [55] and [16] are to be supported.
- The full compatibility to an operation without retransmission support is mandatory.

7.1.1.1.2 Vectoring for VDSL2

VDSL2 Vectoring (DSM Layer3) shall be supported according ITU-T G.993.5. The following requirements apply:

- Vectoring shall be supported in Downstream and Upstream direction simultaneously.
- All mandatory control and configuration parameters acc. [65] and [16] are to be supported. For vectored VDSL2 the support of profiles 8b and 17a is mandatory. The support of profile 30a is optional.
- Data rate key requirement for Profile 17a support: In downstream direction at least 100 Mbit/s net data rate (NDR) are to be supported with configured Impulse Noise Protection (MinINP = 2, MaxDelay = 8 ms) or using a comparable retransmission configuration.
- The following line initialization modes (Rate Adaptation Modes) are mandatory:
- RATE ADAPTIVE AT INIT
- RATE ADAPTIVE DYNAMIC (Seamless rate adaptation)
- For tests of the VDSL2 Vectoring functionality and performance the Broadband-Forum WT-249 (most recent draft) applies.
- Disorderly leaving events (line interruption) shall be detected within a short period (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.

  Note: The xDSL systems with active vectoring support will be configured such that HGs not supporting vectoring are not allowed to initialize in VDSL2 mode.

7.1.1.2 Power Back Off and PSD Configuration

7.1.1.2.1 Upstream Power Back Off (UPBO) Requirements

a) UPBO shall be supported. Upstream band 0 (US0) requires no additional UPBO.
b) If UPBO is not supported, reach of show time state is prohibited by the DSLAM.
c) UPBO Implementation is required according to [14] and [16].
d) The insertion loss LOSS(kl0,f) resp. the electrical length kl0 [dB/√Hz] is determined individually per port by the system.
e) In addition to the automatic UPBO individual configured PSD masks (MIB PSD Mask Construction) according to [14] by using breakpoints shall be supported. For the configuration the DSLAM is the master.
f) The Upstream PSD is calculated as follows:

$$UPBOMASK(kl_0, f) = UPBOPSD(f) + LOSS(kl_0, f) + 10 \cdot \log_{10}\left(\frac{a_{\max@1MHz}[dB]}{LOSS(kl_0, 1MHz)}\right) + 3{,}5dB$$

in [dBm/Hz] with f in [MHz].

g) The following definitions apply:

- UPBOMASK: max. Transmit- PSD with activated UPBO. This PSD must never exceed the valid Limit- PSD- mask.
  $LOSS(kl_0, f) = kl_0 \cdot \sqrt{f}$ [dB] with f in [MHz]

- UPBOPSD(f): Reference- PSD
  $UPBOPSD(f) = -a - b \cdot \sqrt{f}$ [dBm/Hz] with f in [MHz].

The following values are set as default:

	a	b
Upstream band 1 3 750 kHz – 5 200 kHz	44,5 dBm/Hz	29,3 dB/√Hz
Upstream band 2 8 500 kHz – 12 000 kHz	45,5 dBm/Hz	16,6 dB/√Hz

Table Y: UPBO Reference PSDs

- Table AA:$a_{max@1MHz}$: maximum insertion loss for every separate upstream band. The following values are used as default:

	$a_{max@1MHz}$
Upstream band 1: 3 750 kHz – 5 200 kHz	23,7 dB
Upstream band 2: 8 500 kHz – 12 000 kHz	11,8 dB

Table Z: UPBO additional parameters

7.1.1.2.2 Downstream Power back Off (DPBO) Requirements

a) DPBO shall be supported.
b) DPBO is used by the VDSL2 DSLAM to protect DSL connections, which are distributed from the central office in a common distribution cable together with VDSL2 connections which are operated from the cabinet.
c) The DPBO implementation is done according to [14] and [16].
d) Reduced downstream PSD (PEPSD(f)) shall be calculated as follows:

$$PEPSD(f) = DPBOEPSD(f) - \left(DPBOESCMA + DPBOESCMB \cdot \sqrt{f} + DPBOESCMC.f\right) \cdot DPBOESEL + 10 \cdot \log_{10}\left(1 + \frac{DPBOESEL}{6.65dB}\right)$$

in [dBm/Hz] with f in [MHz].

e) The following definitions apply:

- DPBOEPSD(f): PSD [dBm/Hz] of the DSL type operated from the central office that has to be protected, in this case: ADSL2plus Annex B according to [13]
- DPBOESCMA, DPBOESCMB, DPBOESCMC: cable model parameters. These parameters are configured at the DSLAM and are taking into account the standard granularity according to [16]. Since the following values do not match the standard granularity, always the nearest value, matching the granularity (lower or higher), is configured.

	Value according to G.997.1
DPBOESCMA	0,0546875
DPBOESCMB	0,9140625 [1/√Hz]
DPBOESCMC	0,03125 [1/Hz]

Table AA: DPBO Cable Model Parameters

- DPBOESEL: Main cable insertion loss [dB] @ 1 MHz. If VDSL2 is operated from the CO DPBOESEL=0 applies.
- The Maximum Usable Frequency (MUF), for which DPBO is active, is calculated according to G.997.1. The necessary power DPBOMUS for calculating MUF may vary within the specified limits according to [16].

f) In addition to the automatic DPBO configuration, an individual configuration of PSD masks (MIB PSD Mask Construction) according to [14] by using breakpoints is supported.

7.1.1.3 Backward Compatibility

At U-RV interfaces in addition to VDSL2 also ADSL2plus according to clause 5.1.1 (U-R interfaces, Annexes B and/or J) is supported. The DSLAM is the master for selecting the active operational mode during the handshake procedure according to [15]. If both DSLAM and modem support and the DSLAM allows more than one mentioned operational mode, the mode with the highest priority shall be selected. The priorities are defined as follows (1 = highest priority, 3 = lowest priority):

Priority	Mode
1	VDSL2
2	ADSL2plus

Table BB: Priority of xDSL Modes

Depending on the selected mode the corresponding chapter in this document applies.
Multi Mode operation is currently not used.

7.1.1.4 Electrical Characteristics of the U-R Interface

7.1.1.4.1 Safety

The relevant safety regulations are met at the U-R interface of the Deutsche Telekom Network [DIN EN 41003 [38], DIN EN 60950-1 [39], (as applicable)].

7.1.1.4.2 Electromagnetic Compatibility

7.1.1.4.2.1 Basic Conditions

Equipment, deployed within the area of responsibility of Deutsche Telekom as Network Operator, complies with the "Gesetz über die elektromagnetische Verträglichkeit von Geräten" (EMVG [39]).

7.1.1.4.2.2 Non-DSL Signals at the U-R interface

Due to the fact that ISDN or POTS ports may be connected to the U_{k0} / a/b-interface of splitter C (see Figure 4-4 and Figure 4-5) the following voltages and Signals are to be expected at the U-R interface, parallel to ADSL/ADSL2plus signals.

DC Voltages

At the U-R interface DC voltages of up to 105 V in any polarity between tip and ring (a and b) in open loop state may occur.

POTS Signals

Ringing and Calling Line Identity Presentation (CLIP) signals according [2] may occur at the U-R interface.

7.1.1.4.2.3 Interference with External Voltages

Longitudinal Voltages

Due to interference from adjacent electric power lines (power supply, railway) into the local loop longitudinal voltages may be induced. The access interface is designed such that induced longitudinal voltages of

- Ueff = 60 V during long term interference and
- Ueff = 430 V during short term interference or
- Ueff = 650 V during short term interference from power systems with high reliability

are not exceeded (DIN VDE 0228 [40]).

Atmospherical Discharges

Due to atmospherical discharges (lightning) short-time voltages may occur. Deutsche Telekom has normally not provided protection measures against such voltages. In areas with high lightning risk protection measures may be provided (e. g. insertion of over-voltage protection). Protection measures of terminal equipment connected at the U-R interface require a potential equalisation.

NOTE: The function of terminal equipment may be disturbed during the ignition of over-voltage protection elements.

The U-R interface is designed such that the probability of exceeding longitudinal voltages of 1500 V, induced due to atmospherical discharges, is low (ITU-T recommendation K.11 [41]; DIN EN 41003 [38]; DIN VDE 0845 part 4-2 [42]).

7.1.1.4.3 Signature

The following scheme represents a signature network which is expected to be present at the U-RV-Interface, independent from the xTU-R state (e.g. switched off, training, show time, low power mode, etc.).
The signature network shall be designed in a way that all applicable requirements of this specification (e.g. performance, safety, LCL) are fulfilled.

> Note: The purpose is to enable a test system, connected to the line at the far end, to recognize the modem at the U-RV interface.

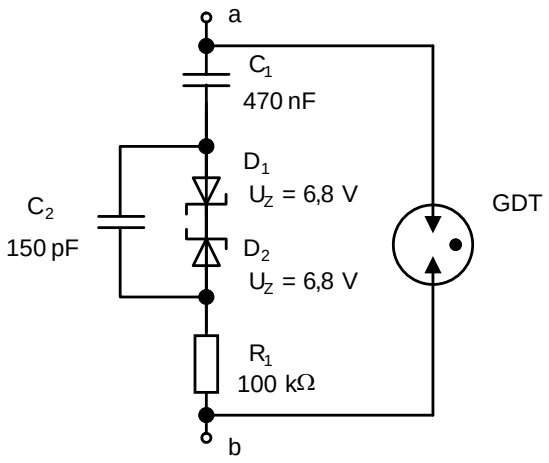

Figure 7-1: Signature Network at the U-RV interface

7.1.1.4.4 Longitudinal Conversion Loss (LCL)

The LCL values of the VDSL2 modem, conform to [9], section 4.1.3 shall comply with the following levels:

Frequency (kHz)	LCL (dB)
0,3 – 30	> 40
30 – 2 208	> 50
2 208 – 30 000	> 38

Table CC: VDSL2 Requirements for LCL

7.1.1.4.5 Common Mode Voltage Limits and Measurement Methods

The HG shall comply with recommendation ITU-T G.995.2 [70].

7.1.1.5 Mechanical Properties of U-RV Interface

The network terminal adapter for the U-RV interface (Telekommunikations-Anschluss-Einheit [TAE]), provided by Deutsche Telekom, meets the requirements of DIN 41 715 Part 3, model “NFN” or model "F" (according [43]). For operation the connection points “1” and “2” respectively “a” and “b” are used.

7.1.1.6 VDSL2 Performance Requirements

a) The performance requirements are valid without splitters only.
b) Additionally when profile 8b is used the performance requirements for ADSL2plus according to [35] shall be met for higher loop lengths.
c) The maximum BER allowed for a noise margin of 0 dB is 10E-7.
d) The BER for a noise margin of 6 dB shall be better than 10E-10.
e) In the VDSL2 frequency range, an impedance of 100 Ω up to 150 Ω can be expected. All performance objectives have to be met in this impedance range.

7.1.1.6.1 Performance Requirements for Down- and Upstream

7.1.1.6.2 Performance Requirements for Down- and Upstream

All performance requirements acc. [37] (Broadband Forum TR-114) for VDSL2 Annex B Profiles 8b and 17a are to be passed.

7.1.1.6.3 Additional Performance Requirements for the Upstream Direction

Test configuration:

- Loop model PE04 (extrapolated up to 30 MHz) according to [5]
- Noise templates according to Annex 4
- Noise injection for upstream direction only

Minimum Upstream performance requirements with activated UPBO:

Configuration	**UPBO activated; no notches activated 6 dB Target Noise Margin Up- and Downstream US0 active INP = 2; Max Delay = 8 (Interleaved) Rate Adaptive Mode: At Init**	
Loop length [m, PE0,4mm]	Upstream in Mbit/s Profile 8b B8-6 (998-M2x-B)	Upstream in Mbit/s Profile 17a B8-12 (998ADE17-M2x-B)
200	6,3	17,8
475	4,75	11,9
950	3,35	3,4
1100	1,95	2

Table DD: Upstream Performance with UPBO

7.1.2 U-RV2 Interface

7.1.2.1 Specific Requirements for VDSL2

At the U-RV2 interface, VDSL2 signals are provided or expected, as defined in [14], Annex B. The VDSL2 modem has to support all mandatory functionalities defined in [14].

The following additional requirements are valid for U-RV2 interfaces:

a) Frequency Plan: 998
b) The following profiles and PSD masks shall be supported:

Profile	8b	17a
PSD mask	998-M2x-B (US0 138 kHz – 276 kHz)	998ADE17-M2x-B (US0 138 kHz – 276 kHz)

Table EE: VDSL2 Profile and Limit PSD Mask support

c) Support of upstream band US0 is required for both profiles (8b and 17a).
d) To avoid impact while Upstream Power back Off is applied the handshake carrier sets B43 and B43c have to be used. The handshake carrier set V43 is not allowed (see also [15], Table 2, Note 4 with regard to the usage of US0).
e) For upstream direction all possible data rates in steps of < 64 kbit/s in the range from 64 kbit/s to at least 50 000 kbit/s shall be supported.
f) For downstream direction all possible data rates in steps of < 64 kbit/s in the range from 128 kbit/s to at least 100 000 kbit/s shall be supported.
g) The rate adaptation modes MANUAL and AT INIT have to be supported.
h) Loop diagnostic mode (DELT) has to be supported.
i) After the DELT procedure is finished (successful or not successful), the line has to fall back into the same state as before the DELT procedure was started.
j) If implemented, the option Virtual Noise shall be deactivated per default.
k) Use of the "interleaved channel" with support of the interleave depths / delay which can be adjusted according to [16] and use of the "fast channel".
l) Support of dual latency and dual interleaver is optional.
m) Support of different delay- and INP settings per transmission direction is mandatory.
n) The target noise margin has to be considered by the VDSL2 modem according to [14]. For the configuration the DSLAM is the master.
o) Layer 1 OAM (configuration, fault and performance monitoring data) shall conform to [16], including dying gasp (loss of power).
p) The VDSL2 modem shall support transmission with configured RFI bands. Annex 3 lists all necessary frequency bands. The PSD within activated RFI bands shall be < -80 dBm/Hz.
At least 16 RFI bands (notches) have to be supported simultaneously.

7.1.2.1.2 Retransmission

The support of retransmission according ITU-T G.998.4 (ex G.inp) [55] is required in order to improve the DSL line stability under impulse noise conditions.

Specific requirements for retransmission:

- Both impulse noise characteristics SHINE and REIN are to be considered.
- For VDSL2s the EFM TPS-TC specific requirements are valid.
- All mandatory control parameters acc.[55] and [16] are to be supported.
- For VDSL2, support of Retransmission is mandatory for both Upstream and Downstream direction..
- All mandatory OAM parameters (performance counter implementations) acc. [55] and [16] are to be supported.
- All mandatory channel initialization modes and parameters acc. [55] and [16] are to be supported.
- The full compatibility to an operation without retransmission support is mandatory.

7.1.2.1.3 Vectoring for VDSL2

VDSL2 Vectoring (DSM Layer3) shall be supported according ITU-T G.993.5. The following requirements apply:

- Vectoring shall be supported in Downstream and Upstream direction simultaneously.
- All mandatory control and configuration parameters acc. [65] and [16] are to be supported. For vectored VDSL2 the support of profiles 8b and 17a is mandatory. The support of profile 30a is optional.
- Data rate key requirement for Profile 17a support: In downstream direction at least 100 Mbit/s net data rate (NDR) are to be supported with configured Impulse Noise Protection (MinINP = 2, MaxDelay = 8 ms) or using a comparable retransmission configuration.
- The following line initialization modes (Rate Adaptation Modes) are mandatory:
  - RATE ADAPTIVE AT INIT
  - RATE ADAPTIVE DYNAMIC (Seamless rate adaptation)
- For tests of the VDSL2 Vectoring functionality and performance the Broadband-Forum WT-249 (most recent draft) applies.
- Disorderly leaving events (line interruption) shall be detected within a short period (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.

  Note: The xDSL systems with active vectoring support will be configured such that HGs not supporting vectoring are not allowed to initialize in VDSL2 mode.

7.1.2.2 Power Back Off and PSD Configuration

7.1.2.2.1 Upstream Power Back Off (UPBO) Requirements

a) UPBO shall be supported. Upstream band 0 (US0) requires no additional UPBO.
b) If UPBO is not supported, reach of show time state is prohibited by the DSLAM.
c) UPBO Implementation is required according to [14] and [16].
d) The insertion loss LOSS(kl0,f) resp. the electrical length kl0 [dB/√Hz] is determined individually per port by the system.
e) In addition to the automatic UPBO individual configured PSD masks (MIB PSD Mask Construction) according to [14] by using breakpoints shall be supported. For the configuration the DSLAM is the master.
f) The Upstream PSD is calculated as follows:

$$UPBOMASK(kl_0, f) = UPBOPSD(f) + LOSS(kl_0, f) + 10 \cdot \log_{10}\left(\frac{a_{\max@1MHz}[dB]}{LOSS(kl_0, 1MHz)}\right) + 3{,}5dB$$

in [dBm/Hz] with f in [MHz].

The following definitions apply:

- UPBOMASK: max. Transmit- PSD with activated UPBO. This PSD must never exceed the valid Limit- PSD- mask.
  $LOSS(kl_0, f) = kl_0 \cdot \sqrt{f}$ [dB] with f in [MHz]

- UPBOPSD(f): Reference- PSD
  $UPBOPSD(f) = -a - b \cdot \sqrt{f}$ [dBm/Hz] with f in [MHz].

The following values are set as default:

	a	b
Upstream band 1 3 750 kHz – 5 200 kHz	44,5 dBm/Hz	29,3 dB/√Hz
Upstream band 2 8 500 kHz – 12 000 kHz	45,5 dBm/Hz	16,6 dB/√Hz

Table FF: UPBO Reference PSDs

- Table GG:$a_{max@1MHz}$: maximum insertion loss for every separate upstream band. The following values are used as default:

	$a_{max@1MHz}$
Upstream band 1: 3 750 kHz – 5 200 kHz	23,7 dB
Upstream band 2: 8 500 kHz – 12 000 kHz	11,8 dB

Table GG: UPBO additional parameters

7.1.2.2.2 Downstream Power back Off (DPBO) Requirements

a) DPBO shall be supported.
b) DPBO is used by the VDSL2 DSLAM to protect DSL connections, which are distributed from the central office in a common distribution cable together with VDSL2 connections which are operated from the cabinet.
c) The DPBO implementation is done according to [14] and [16].
d) Reduced downstream PSD (PEPSD(f)) shall be calculated as follows:

$$PEPSD(f) = DPBOEPSD(f) - \left(DPBOESCMA + DPBOESCMB \cdot \sqrt{f} + DPBOESCMC.f\right) \cdot DPBOESEL + 10 \cdot \log_{10}\left(1 + \frac{DPBOESEL}{6.65dB}\right)$$

in [dBm/Hz] with f in [MHz].

e) The following definitions apply:

- DPBOEPSD(f): PSD [dBm/Hz] of the DSL type operated from the central office that has to be protected, in this case: ADSL2plus Annex B according to [13]
- DPBOESCMA, DPBOESCMB, DPBOESCMC: cable model parameters. These parameters are configured at the DSLAM and are taking into account the standard granularity according to [16]. Since the following values do not match the standard granularity, always the nearest value, matching the granularity (lower or higher), is configured.

	Value according to G.997.1
DPBOESCMA	0,0546875
DPBOESCMB	0,9140625 [1/√Hz]
DPBOESCMC	0,03125 [1/Hz]

Table HH: DPBO Cable Model Parameters

- DPBOESEL: Main cable insertion loss [dB] @ 1 MHz. If VDSL2 is operated from the CO DPBOESEL=0 applies.
- The Maximum Usable Frequency (MUF), for which DPBO is active, is calculated according to G.997.1. The necessary level DPBOMUS for calculating MUF may vary within the specified limits according to [16].

f) In addition to the automatic DPBO configuration, an individual configuration of PSD masks (MIB PSD Mask Construction) according to [14] by using breakpoints is supported.

7.1.2.3 Backward Compatibility

At U-RV2 interfaces in addition to VDSL2 also ADSL2plus according to clause 5 is supported. The DSLAM is the master for selecting the active operational mode during the handshake procedure according to [15]. If both DSLAM and modem support and the DSLAM allow more than one mentioned operational mode, the mode with the highest priority shall be selected. The priorities are defined as follows (1 = highest priority, 3 = lowest priority):

Priority	Mode
1	VDSL2
2	ADSL2plus

Table II: Priority of xDSL Modes

Depending on the selected mode the corresponding chapter in this document applies.
Multi Mode operation is currently not used.

7.1.2.4 Electrical Characteristics of the U-RV2 Interface at Splitter R

The splitter details in the following section are presented solely for information purposes and description of the U-RV2 interface's electrical characteristics. The splitter itself is not covered by this interface description. The splitter serves as the network termination and in addition to providing the narrow band services (POTS and ISDN) it provides the U-RV2 interface as well. The interface is implemented at splitter R. This splitter consists of a low pass filter that separates the narrow band signals from the VDSL2 signals. Due to the design of splitter R, signals from the POTS or ISDN are applied parallel to the VDSL2 signal at the input of the VDSL2 modem. The splitter is designed for both narrow band services (switch-selectable or universal version).

- POTS: conform to [2]
- ISDN: conform Annex 6

In general, these provisions require that a high pass is implemented in the VDSL2 modem. Figure 7-2 shows the general schematic layout of the splitter. Please note that this figure is presented solely to support description of the interface between splitter R and the VDSL2 modem.

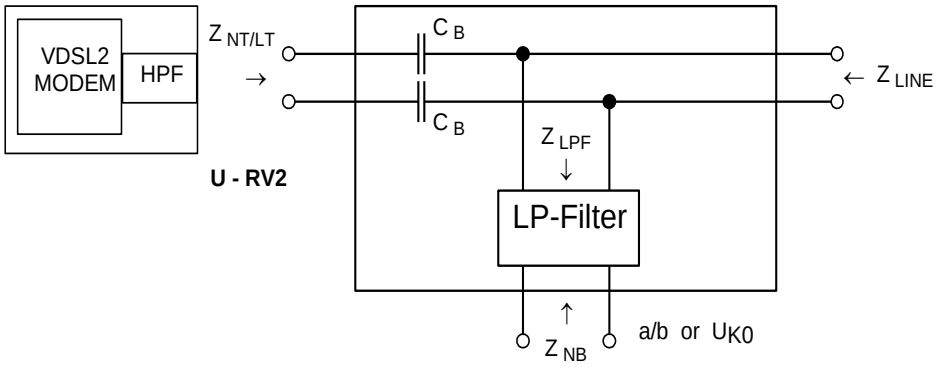

Figure 7-2: General Schematic Layout of Splitter R

The following levels can be expected:

Designation	Value	Frequency Range
C_B	27nF ± 5%	n. A.
$Z_{NT/LT}$	100 Ohm	f > 138 kHz
$Z_{LPF} = Z_{NB}$	ISDN: 150 Ohm POTS: 820 Ohm // 115nF + 220 Ohm	0 Hz ≤ f ≤ 80 kHz

Table JJ: Values for the Splitter Components

The maximum insertion loss, as caused by splitter C and splitter R (not including the line) in the VDSL2 path, is 2 dB within the frequency range 170 kHz to 30 MHz and ≤ 6 dB within the frequency range 120 kHz to 170 kHz.

The input impedance of the VDSL2 modem is expected as follows:

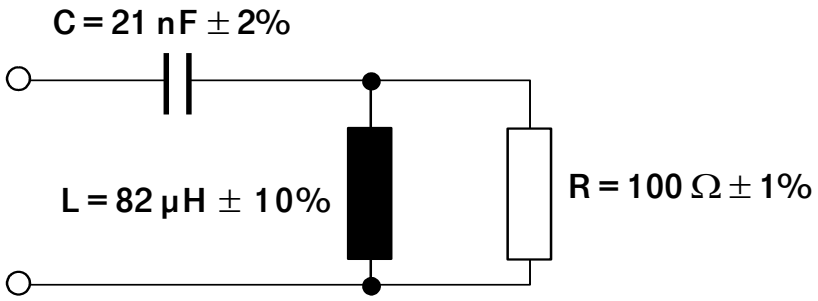

Figure 7-3: Input Impedance Model of the VDSL2 Modem

7.1.2.5 Impact on the ISDN Service

Operation of the VDSL2 modem must not have a greater impact on parallel ISDN transmission (see also Annex 6) than what is permitted by [14] (maximum 4 dB range loss). Only during switching of power ON/OFF, a one-time impact of no more than 320 bit errors in one B channel (64 kbit/s) is permitted. This impact can be compared approximately to the effect of a short interruption of < 5ms. Under no circumstances the U_{k0} interface shall be deactivated or the call be released.

7.1.2.6 Longitudinal Conversion Loss (LCL)

The LCL values of the VDSL2 modem, conform to [9], section 4.1.3 shall comply with the following levels:

Frequency (kHz)	LCL (dB)
0,3 – 30	> 40
30 – 2 208	> 50
2 208 – 30 000	> 38

Table KK: VDSL2 Requirements for LCL

7.1.2.6.1 Common Mode Voltage Limits and Measurement Methods

The HG shall comply with recommendation ITU-T G.995.2 [70].

7.1.2.7 VDSL2 Performance Requirements

a) The performance requirements are valid with and without splitters.
b) Additionally when profile 8b is used the performance requirements for ADSL2plus according to [35] shall be met for higher loop lengths.
c) The maximum BER allowed for a noise margin of 0 dB is 10E-7.
d) The BER for a noise margin of 6 dB shall be better than 10E-10.
e) In the VDSL2 frequency range, an impedance of 100 Ω up to 150 Ω can be expected. All performance objectives have to be met in this impedance range.

7.1.2.7.1 Performance Requirements for Down- and Upstream

7.1.2.7.2 Performance Requirements for Down- and Upstream

All performance requirements acc. [37] (Broadband Forum TR-114) for VDSL2 Annex B Profiles 8b and 17a are to be passed.

7.1.2.7.3 Additional Performance Requirements for the Upstream Direction

Test configuration:

- Loop model PE04 (extrapolated up to 30 MHz) according to [5]
- Noise templates according to Annex 4
- Noise injection for upstream direction only

Minimum Upstream performance requirements with activated UPBO:

Configuration	**UPBO activated; no notches activated 6 dB Target Noise Margin Up- and Downstream US0 active INP = 2; Max Delay = 8 (Interleaved) Rate Adaptive Mode: At Init**	
Loop length [m, PE0,4mm]	Upstream in Mbit/s Profile 8b B8-6 (998-M2x-B)	Upstream in Mbit/s Profile 17a B8-12 (998ADE17-M2x-B)
200	6,3	17,8
475	4,75	11,9
950	3,35	3,4
1100	1,95	2

Table LL: Upstream Performance with UPBO

7.1.2.8 Mechanical Properties of U-RV2 Interface at Splitter R

At the customer side the U-RV2 interface is provided at the RJ45 socket, which is integrated in splitter R and at the terminal blocks inside the splitter box.
The pins in the RJ45 socket (designated "DSL") are allocated as follows:

Pin	Allocation
1	not allocated
2	not allocated
3	not allocated
4	U-RV2 a
5	U-RV2 b
6	not allocated
7	not allocated
8	not allocated

Table MM: U-RV2 Pin Allocation at Splitter R

7.1.3 Element Management of the VDSL2 Modem

The EOC specified in [14] is provided as the management channel between the DSLAM and the VDSL2 modem. The DSLAM expects all the functions and management information specified in [14], in conjunction with the EOC from a connected VDSL2 modem.
For operation and maintenance purposes the equipment vendor (not chip manufacturer) of the VDSL2 modem and the type of the modem needs to be uniquely identified by information transferred via the VTU-R Inventory Response Messages.
Software updates and configuration of the VDSL2 modem over and above the in [14] specified means cannot be carried out via the DSLAM.
Functions at the customer interface must not provide any access to the DSLAM (manipulation

or configuration). Furthermore, it must not impair the DSLAM in any way.

7.2 VDSL2 Profile 35b (Super Vectoring)

7.2.1 U-RV Interface

7.2.1.1 Specific Requirements

a) Full support and interoperability to VDSL2 and Vectoring as specified in section 7.1.1.1 and 7.1.1.2 is mandatory.
b) Full support of
   - Amendment 1 to Recommendation ITU-T G.993.2 (2015): ITU-T G.993.2 Annex Q
   - Profile 35b (see Table Q-1/G.993.2 –Annex Q profiles)
   - Band Plan 998ADE35
   - Limit PSD mask options (see Table B.3 – European limit PSD mask options for band plan 998 and its extensions)
     - 998ADE35-M2x-M (B8-22)
     - 998ADE35-M2x-B (B8-21)
   - downstream net data rate of at least 310 Mbit/s system capability
   - upstream net data rate of at least 55 Mbit/s system capability
   - compatible with VDSL2 profile 17a with vectoring
   - adaption of ITU-T G.998.4, G.994.1, G.997.1 to support profile 35b
c) All mandatory functions of ITU-T G.993.2 must be supported
d) The requirements of the Broadband Forum VDSL2 Functional Test Plan TR-115 as applicable to VDSL2 Annex B 17a must be fulfilled for Super Vectoring

   Test requirements:

   The functional tests must be carried out in accordance with TR-115. However, no splitters shall be included in the test configuration, and the tests must be carried out without "Same Pair ISDN" noise and without the "line sharing noise generator G8".

e) To avoid problems when using Upstream Power Back Off during the “Handshake” phase as specified in ITU-T G.994.1, carrier sets B43 and B43c must be used. Use of carrier set V43 is not permitted (see also ITU-T G.994.1, Table 2, Note 4 in conjunction with the required use of the upstream band US0).
f) OAM functions in Layer 1 (Configuration, Error and Performance data) including Dying Gasp (Loss of Power Remote) must be supported.
g) The VDSL2 modem must support transmission with configured RFI bands. Annex 3 of 1 TR 112 Version 12.3 lists all necessary frequency bands. The PSD within activated RFI bands must be < -80 dBm/Hz.
   At least 16 RFI bands (notches) must be supported simultaneously.
h) In order to achieve higher bitrates in downstream direction a functionality must be implemented that supports an adaptation of the target noise margin per Downstream Band. This functionality is managed by the AN as following:
   - The AN has the capability to decrease the target noise margin per Downstream Band DS2 and DS3 by 2 dB.

   Note: In future releases the AN will have the capability to decrease or increase the target noise margin per Downstream Band in 0.1 dB steps in the range of -8 dB and +7.9 dB.
   The AN has the capability to configure the start subcarrier for this margin

offset.
This function is not defined for the Upstream.

7.2.1.1.1 Retransmission

The support of retransmission according ITU-T G.998.4 is required in order to improve the DSL line stability under impulse noise conditions.

Specific requirements for retransmission:

a) Both impulse noise characteristics SHINE and REIN are to be considered.
b) For Super Vectoring the EFM TPS-TC specific requirements are valid.
c) All mandatory control parameters acc. [55] and [16] must be supported.
d) For Super Vectoring, support of Retransmission is mandatory for both Upstream and Downstream direction.
e) All mandatory OAM parameters (performance counter implementations) acc. [55] and [16] must be supported.
f) All mandatory channel initialization modes and parameters acc. [55] and [16] must be supported.
g) The full compatibility to an operation without retransmission support is mandatory.

7.2.1.1.2 Vectoring

Vectoring must be supported according ITU-T G.993.5. The following requirements apply:

a) Vectoring must be supported in Downstream and Upstream direction simultaneously.
b) All mandatory control and configuration parameters acc. [65] and [16] must be supported.
c) The following line initialization modes (Rate Adaptation Modes) are mandatory:
    - RATE ADAPTIVE AT INIT
    - RATE ADAPTIVE DYNAMIC (Seamless rate adaptation)
d) For tests of the Vectoring functionality and performance the Broadband-Forum WT-249 (most recent draft) applies.
e) Disorderly leaving events (line interruption) must be detected within a short period (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.

Note: The xDSL systems with active vectoring support will be configured such that
- HGs not supporting vectoring are not allowed to initialize in vectoring mode. A Fall Back profile applies allowing operation in VDSL2 mode without vectoring and limited spectrum usage up to 2208 kHz only.
- For HGs not supporting Super Vectoring, but vectoring for VDSL2 profile 17a, a Fall Back profile applies allowing operation in VDSL2 Profile 17a vectoring mode.

7.2.1.2 Power Back Off and PSD Configuration

7.2.1.2.1 Upstream Power Back Off (UPBO) Requirements

a) UPBO must be supported. Upstream band 0 (US0) requires no additional UPBO.
b) When UPBO is not supported, the reach of show time state is prohibited by the DSLAM.
c) UPBO Implementation is required according to [14] and [16].
d) The insertion loss LOSS(kl0,f) resp. the electrical length kl0 [dB/√Hz] is determined individually per port by the system.
e) In addition to the automatic UPBO individual configured PSD masks (MIB PSD Mask Construction) according to [14] by using breakpoints must be supported. For the configuration the DSLAM is the master.
f) The Upstream PSD is calculated as follows:

$$UPBOMASK(kl_0, f) = UPBOPSD(f) + LOSS(kl_0, f) + 10 \cdot \log_{10}\left(\frac{a_{\max@1MHz}[dB]}{LOSS(kl_0, 1MHz)}\right) + 3{,}5dB$$

in [dBm/Hz] with f in [MHz].

g) The following definitions apply:
   - UPBOMASK: max. Transmit- PSD with activated UPBO. This PSD must never exceed the valid Limit- PSD- mask.
   - $LOSS(kl_0, f) = kl_0 \cdot \sqrt{f}$ [dB] with f in [MHz]
   - UPBOPSD(f): Reference-PSD
   - $UPBOPSD(f) = -a - b \cdot \sqrt{f}$ [dBm/Hz] with f in [MHz].

7.2.1.2.2 Downstream Power back Off (DPBO) Requirements

a) DPBO must be supported.
a) DPBO is used by the VDSL2 DSLAM to protect DSL connections, which are distributed from the central office in a common distribution cable together with VDSL2 connections which are operated from the cabinet.
b) The DPBO implementation is done according to [14] and [16].
c) Reduced downstream PSD (PEPSD(f)) must be calculated as follows:

$$PEPSD(f) = DPBOEPSD(f) - \left(DPBOESCMA + DPBOESCMB \cdot \sqrt{f} + DPBOESCMC.f\right) \cdot DPBOESEL + 10 \cdot \log_{10}\left(1 + \frac{DPBOESEL}{6.65dB}\right)$$

in [dBm/Hz] with f in [MHz].

d) The following definitions apply:
   - DPBOEPSD(f): PSD [dBm/Hz] of the DSL type operated from the central office must be protected, in this case: ADSL2plus Annex B according to [13].
   - DPBOESCMA, DPBOESCMB, DPBOESCMC: cable model parameters. These parameters are configured at the DSLAM and are taking into account the standard granularity according to [16]. Since the following values do not match the standard granularity, always the nearest value, matching the granularity (lower or higher), is configured.

	Value according to G.997.1
DPBOESCMA	0,0546875
DPBOESCMB	0,9140625 [1/√Hz]
DPBOESCMC	0,03125 [1/Hz]

Table 7.2-1: Performance requirements for Vectored Super Vectoring

   - DPBOESEL: Main cable insertion loss [dB] @ 1 MHz. If VDSL2 Annex Q is operated from the CO DPBOESEL=0 applies.
   - The Maximum Usable Frequency (MUF), for which DPBO is active, is calculated

according to G.997.1. The necessary power DPBOMUS for calculating MUF may vary within the specified limits according to [16].

e) In addition to the automatic DPBO configuration, an individual configuration of PSD masks (MIB PSD Mask Construction) according to [14] by using breakpoints is supported.

7.2.1.3 Backward Compatibility

At U-RV interfaces in addition to VDSL2 Profile 35b also VDSL2 according clause 7.1.1 and ADSL2plus according to clause 5.1.1 (U-R interfaces, Annex J) is supported. The DSLAM is the master for selecting the active operational mode during the handshake procedure according to [15]. If both DSLAM and modem support and the DSLAM allows more than one mentioned operational mode, the mode with the highest priority shall be selected.

Depending on the selected mode the corresponding chapter in this document applies.
Multi Mode operation is currently not used.

7.2.1.4 Electrical Characteristics of the U-R Interface

7.2.1.4.1 Safety

The relevant safety regulations are met at the U-R interface of the Deutsche Telekom Network [DIN EN 41003 [38], DIN EN 60950-1 [39], (as applicable)].

7.2.1.4.2 Electromagnetic Compatibility

7.2.1.4.2.1 Basic Conditions

Equipment, deployed within the area of responsibility of Deutsche Telekom as Network Operator, complies with the "Gesetz über die elektromagnetische Verträglichkeit von Geräten” (EMVG [39]).

7.2.1.4.2.2 Non-DSL Signals at the U-R interface

Due to the fact that ISDN or POTS ports may be connected to the U_{k0} / a/b-interface of splitter C (see Figure 4-4 and Figure 4-5 of 1 TR 112 Version 12.3) the following voltages and Signals are to be expected at the U-R interface, parallel to broadband signals.

DC Voltages

At the U-R interface DC voltages of up to 105 V in any polarity between tip and ring (a and b) in open loop state may occur.

POTS Signals

Ringing and Calling Line Identity Presentation (CLIP) signals according [2] may occur at the U-R interface.

7.2.1.4.2.3 Interference with External Voltages

Longitudinal Voltages

Due to interference from adjacent electric power lines (power supply, railway) into the local loop longitudinal voltages may be induced. The access interface is designed such that induced longitudinal voltages of
Ueff = 60 V during long term interference and
Ueff = 430 V during short term interference or
Ueff = 650 V during short term interference from power systems with high reliability
are not exceeded (DIN VDE 0228 [40]).

Atmospherical Discharges

Due to atmospherical discharges (lightning) short-time voltages may occur. Deutsche Telekom has normally not provided protection measures against such voltages. In areas with high lightning risk protection measures may be provided (e. g. insertion of over-voltage protection). Protection measures of terminal equipment connected at the U-R interface require a potential equalisation.
NOTE: The function of terminal equipment may be disturbed during the ignition of over-voltage protection elements.
The U-R interface is designed such that the probability of exceeding longitudinal voltages of 1500 V, induced due to atmospherical discharges, is low (ITU-T Recommendation K.11 [41]; DIN EN 41003 [38]; DIN VDE 0845 part 4-2 [42]).

7.2.1.4.3 Signature

The following scheme represents a signature network which is expected to be present at the U-RV-Interface, independent from the xTU-R state (e.g. switched off, training, show time, low power mode, etc.).
The signature network must be designed in a way that all applicable requirements of this specification (e.g. performance, safety, LCL) are fulfilled.

Note: The purpose is to enable a test system, connected to the line at the far end, to recognize the modem at the U-RV interface.

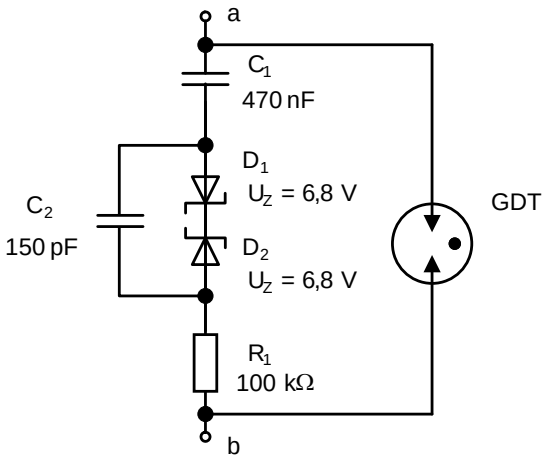

Figure 7.2-1: Signature Network at the U-RV interface

7.2.1.4.4 Longitudinal Conversion Loss (LCL)

The LCL values of the VDSL2 modem, conform to [9], section 4.1.3 shall comply with the following levels:

Frequency (kHz)	LCL (dB)
0,3 – 30	> 40
30 – 2 208	> 50
2 208 – 35 328	> 38

Table 7.2-2: LCL requirements

7.2.1.4.5 Common mode voltage limits and measurement method

The HG shall comply with recommendation ITU-T G.995.2 [70].

7.2.1.5 Mechanical Properties of U-RV Interface

The network terminal adapter for the U-RV interface (Telekommunikations-Anschluss-Einheit [TAE]), provided by Deutsche Telekom, meets the requirements of DIN 41 715 Part 3, model “NFN” or model "F" (according [43]). For operation the connection points “1” and “2” respectively “a” and “b” are used.

7.2.1.6 Performance Requirements

a) The performance requirements are valid without splitters only.
b) The maximum BER allowed for a noise margin of 0 dB is 10E-7.
c) The BER for a noise margin of 6 dB shall be better than 10E-10.
d) In the Super Vectoring frequency range, an impedance of 100 Ω up to 150 Ω can be expected. All performance objectives must be met in this impedance range.

Cable attenuation @ 4 MHz	Minimum downstream NDR	Minimum Upstream NDR
10.5 dB	300 MBit/s	55 MBit/s
16 dB	200 MBit/s	53 MBit/s
27 dB	100 MBit/s	40 MBit/s
36 dB	50 MBit/s	15 MBit/s
48 dB	30 MBit/s	8 MBit/s

Table 7.2-3: Performance requirements for Vectored Super Vectoring

e) Test conditions and configuration:
   - Cable model: I-O2YS(ST)H 10x2x0.5 STVI Bd as defined in Broadband Forum WT-285 but assuming 50 pairs, quad structured
   - Crosstalk environment
     24 vectored VDSL2 17a, PSD acc. 998ADE-M2x-M (same vectored group with self disturbers Super Vectoring)
   - 24 self disturbers Super Vectoring
   - No UPBO, no DPBO, no RFI notching
   - Target Noise Margin US and DS: 6 dB
   - Retransmission according G.998.4 active

     Note: The rate requirements refer to Net Data Rate and hence do not count for any retransmission overhead.

   - initialization mode (Rate Adaption Mode): RATE ADAPTIVE DYNAMIC (Seamless rate adaption)

7.2.2 Element Management of the Super vectoring Modem

The EOC specified in [14] is provided as the management channel between the DSLAM and the VDSL2 modem. The DSLAM expects all the functions and management information specified in [14], in conjunction with the EOC from a connected VDSL2 modem.
For operation and maintenance purposes the equipment vendor (not chip manufacturer) of the VDSL2 modem and the type of the modem needs to be uniquely identified by information transferred via the VTU-R Inventory Response Messages.
Software updates and configuration of the VDSL2 modem over and above the in [14] specified means cannot be carried out via the DSLAM.
Functions at the customer interface must not provide any access to the DSLAM (manipulation or configuration). Furthermore, it must not impair the DSLAM in any way.

8 Technical description of GPON Access

The U-Interface between a Home Gateway (HG) and an Optical Network Termination (ONT) within a Gigabit-capable Passive Optical Network (GPON) systems in the network of Deutsche Telekom is described in Annex A6 (see also 4.2.4).

Note: A description of the IFPON-Interface (R/S-Reference point) between Optical Line Termination (OLT) and Optical Network Termination (ONT) within a Gigabit-capable Passive Optical Network (GPON) system in the network of Deutsche Telekom is in preparation and will be published in a separate Amendment.

9 Service Specific Requirements

The parameters of layer 2, in contrast to the parameters of the physical layer – which were described at the beginning of this document – are service dependent. For this reason, the parameters have been listed individually for each service.
The ATM and EFM functions on layer 2 and the required adaptation from layer 3 ⇔ layer 2 are defined in the following chapters. The below listed parameters at the U-Interface interface are valid for both transmission directions, unless nothing else is stated.

Please note that services produced on legacy access platforms are described in chapter 9.5.

9.1 Scope

The present chapter applies to the following products of Deutsche Telekom:

- PPP based dial in broadband services (using PPPoE), for ATM and for Ethernet based access platforms
- Business products (formerly: T-ATM dsl/sdsl)

Other products which have already been introduced or will be introduced in the future by Deutsche Telekom may require other DSL-modem functionalities which are not described in this document.
Descriptions of the currently valid products for the different DSL technologies can be found in the corresponding paragraphs.

NOTE: After the physical layer setup is finished (e.g. DSL Showtime state reached), any function and service specified for layer 2 and layer3 is available without noticeable

delay. PPPoE service procedures shall be available and according traffic shall be processed and forwarded by the related network elements immediately.

9.2 UNI Reference Model

The description of U-Interface is made by using the MEF 11 UNI reference model as shown in f. An overview of the different building blocks that constitute the UNI functions is presented, and the various layers, capabilities and processes that are part of each building block are described. This model must be considered.

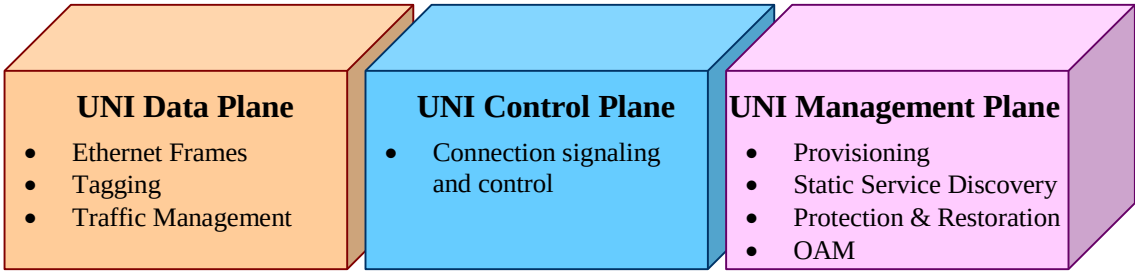

Figure 9-1: UNI Reference Model (according to MEF 11)

The UNI Reference Model consists of three planes:

- The **UNI data plane**, which defines the means of transporting information across the UNI reference point;
- The **UNI control plane**, which defines the means for the subscriber and Deutsche Telekom to communicate to make use of the UNI data plane;
- The **UNI management plane**, which configures and monitors the operation of the UNI data and control plane.

9.3 Requirements for Retail Services

Table NN shows which services will be produced via the different transmission technologies:

Technology	Data and Control Plane				Management-Plane		ATM-Adaptation Layer	EFM Adaptation Layer
	Data	IPTV	Data and VoIP	Data, VoIP and IPTV	ATM	EFM		
ADSL Annex B U-R2	yes	yes	yes	no	yes	no	yes	no
ADSL2plus Annex B U-R	yes	yes	yes	yes	yes	no	yes	no
ADSL2plus Annex B U-R2	yes	yes	yes	yes	yes	no	yes	no
ADSL2plus Annex J U-R	yes	yes	yes	yes	yes	no	yes	no
VDSL2 Annex B U-RV	yes	yes	yes	yes	no	yes	no	yes
VDSL2 Annex B U-RV2	yes	yes	yes	yes	no	yes	no	yes
SDSL ATM U-RS (see note)	no	no	no	no	no	no	yes	no
SDSL/eSDSL EFM U-RS	yes	no	no	no	no	yes	no	yes

Table NN: Retail Services with corresponding transmission technologies

Note: SDSL ATM based service is described in chapter 9.5, legacy access platforms.

The following tables summarize the parameters used for retail services. In chapter 9.4 each parameter will be explained.

9.3.1 Data Plane

9.3.1.1 Data Plane for Data and Voice (VoIP) Services

The following table OO applies for DATA and Voice over IP (VoIP) services.

Service	Data	Data and VoIP
Host-Protocols	PPPoE	PPPoE
Max. number of MAC-Adresses	4	4
Global unique MAC-Address	not relevant	not relevant
MTU-Size [byte]	1500	1500
Frame-Size (FS) [byte]	1522	1522
Max. number of VLAN-IDs	1	1
VLAN-Tagging	single-tagged	single-tagged
VLAN-ID VoIP/Data	7	7
VLAN-ID IPTV	n/a	n/a
TPID	0x8100	0x8100
QoS-US: .1p VoIP	n/a	5 (Note 1)
QoS-US: .1p Data	0	0
QoS-US: .1p IPTV-Multicast	n/a	n/a
QoS-US: .1p IPTV-Unicast	n/a	n/a
QoS-US: .1p LCP Echo Request	6	6
QoS-DS: .1p VoIP	n/a	5 (Note 2)
QoS-DS: .1p Data	0	0
QoS-DS: .1p IPTV-Multicast	n/a	n/a
QoS-DS: .1p IPTV-Unicast	n/a	n/a
QoS-DS: .1p LCP Echo Request	6	6

Note 1: QoS-US .1p VoIP = 6 is also supported but subject for deprecation in future releases of this TR.
Note 2: QoS-DS .1p VoIP = 6 is also used but subject for deprecation in future releases of this TR.

Table OO: Parameters of the Data Plane for Retail Services Data and VoIP

9.3.1.2 Data Plane for Data and Voice (VoIP) and IPTV Services

The following table PP applies for DATA, VoIP and IPTV services if VLAN8 is available.

Service	Data, VoIP and IPTV
Host-Protocols	PPPoE/IPoE (DHCP)
Max. number of MAC-Adresses	4
Global unique MAC-Address	not relevant
MTU-Size [byte]	1500
Frame-Size (FS) [byte]	1522
Max. number of VLAN-IDs	2
VLAN-Tagging	single-tagged
VLAN-ID VoIP/Data	7
VLAN-ID IPTV	8
TPID	0x8100
QoS-US: .1p VoIP	5 (Note 1)
QoS-US: .1p Data	0
QoS-US: .1p IPTV-Multicast	4
QoS-US: .1p IPTV-Unicast	3
QoS-US: .1p LCP Echo Request	6
QoS-DS: .1p VoIP	5 (Note 2)
QoS-DS: .1p Data	0
QoS-DS: .1p IPTV-Multicast	4
QoS-DS: .1p IPTV-Unicast	3
QoS-DS: .1p LCP Echo Request	6

Note 1: QoS-US .1p VoIP = 6 is also supported but subject for deprecation in future releases of this TR.

Note 2: QoS-DS .1p VoIP = 6 is also supported but subject for deprecation in future releases of this TR.

Table PP: Parameters of the Data Plane for Retail Services Data, VoIP and IPTV with VLAN8

In the absence of VLAN8 connectivity the following table QQ applies.

Service	Data, VoIP and IPTV
Host-Protocols	PPPoE
Max. number of MAC-Adresses	4
Global unique MAC-Address	not relevant
MTU-Size [byte]	1500
Frame-Size (FS) [byte]	1522
Max. number of VLAN-IDs	1
VLAN-Tagging	single-tagged
VLAN-ID IPTV/VoIP/Data	7
TPID	0x8100
QoS-US: .1p VoIP	5 (Note 1)
QoS-US: .1p Data	0
QoS-US: .1p IPTV-Multicast	4
QoS-US: .1p IPTV-Unicast	3
QoS-DS: .1p VoIP	5 (Note 2)
QoS-US: .1p LCP Echo Request	6
QoS-DS: .1p Data	0
QoS-DS: .1p IPTV-Multicast	4
QoS-DS: .1p IPTV-Unicast	3
QoS-DS: .1p LCP Echo Request	6

Note 1: QoS-US .1p VoIP = 6 is also supported but subject for deprecation in future releases of this TR.
Note 2: QoS-DS .1p VoIP = 6 is also supported but subject for deprecation in future releases of this TR.

Table QQ: Parameters of the Data Plane for Retail Services

The presence or absence of VLAN8 shall be detected automatically.

9.3.2 Control Plane

Service	Data	Data and VoIP	Data, VoIP and IPTV
PPPoE Intermediate Agent Option	Line-ID	Line-ID	Line-ID
DHCP Relay Agent Option 82	Line-ID	Line-ID	Line-ID

Table RR: Parameters of the Control Plane for Retail Services

9.3.3 Management Plane

Parameter	TC-Layer	
	ATM	Ethernet
OAM: ATM F5	X	
EFM-OAM (802.3-2008 Clause 57		X

Table SS: Parameters of the Management Plane for Retail Services

9.3.4 ATM and EFM Adaptation Layer

9.3.4.1 ATM Adaptation Layer

Parameter	Value
Cell format UNI	conform to [17]
GFC (Generic Flow Control)	0
VPI (Virtual Path Identifier)	1
VCI (Virtual Channel Identifier)	32
PTI (Payload Type Indication)	101: F5 OAM End to End 100: F5 OAM segment
CLP (Cell Loss Priority)	0: Downstream 0/1: Upstream
HEC (Header Error Correction)	conform to [17], chapter 2.3.5 and [19], chapter 7.3.2
ATM Adaptation layer	AAL5 shall conform to [18]
Encapsulation Ethernet / ATM	conform to [25] and [30], chapter 5.2
EncapsulationPPP / Ethernet	PPPoE shall conform to [29] Maximum time interval between PADI and PADO = 0,5 s Password length: at least 42 characters Appendix A: Service name: "any service" Appendix A: AC Cookie
PPP (Point to Point Protocol)	conform to [23], [24], [26], [27] and [28] with additions

Table TT: ATM-Parameters for Retail Services

9.3.4.2 EFM Adaptation Layer

The EFM parameters are specified in ITU 993.2 Annex K and IEEE 802.3-2008 Clause 57. There are no additional parameters defined by Deutsche Telekom.

9.4 Description of Used Parameters

9.4.1 Data Plane

The transport layer of the U-Interface must be Ethernet or ATM.

The EFM data link layer (layer 2) parameters must conform to IEEE 802.2 [48] and IEEE 802.3 - 2008 [46].
The ATM data link layer is described in chapter 9.5.

The U-Interface has to be transparent to OSI [53] protocols above layer 3.

9.4.1.1 Host-Protocols

On the U-Interface, only the protocols PPPoE and IPoE (DHCP) are allowed for retail services according [29].

9.4.1.2 MAC Addresses

Maximum number of supported MAC addresses. Frames from additional MAC addresses will be discarded.

9.4.1.3 Global unique MAC-Address

The MAC addresses assigned to the HG by the manufacturer should be unique.
For retail services this parameter is not relevant. The MAC addresses from the HG will not be transported through the network. It will be translated to another address (MAT).

9.4.1.4 MTU Size

The MTU size is the maximum transmit unit size a packet based network can handle.

9.4.1.5 Frame Size

The frame size is defined by the whole Ethernet frame including all overhead, e.g. PPPoE encapsulation, VLAN tags, etc.

9.4.1.6 VLAN Support /Handling

IEEE 802.1Q must be supported for the specified number of VLANs on the U-Interface. Additionally the support of recommendation TR-101 ("Migration to Ethernet Based DSL Aggregation") is required. At the U-Interface the VLAN-ID range of 1 to 4094 is defined. However for the different services VLAN IDs are predefined according Table OO: Parameters of the Data Plane for Retail Services.

9.4.1.7 TPID (Tagged Protocol Identifier)

The VLAN at the U-Interface must be marked with the specified TPID.

9.4.1.8 QoS

QoS is used to prioritize and mark traffic in all traffic classes using MAC layer frame tagging according IEEE 802.1D-2004 Annex G [47].

9.4.1.9 Policing

Policing is used to limit bandwidth for QoS marked traffic.

9.4.2 UNI Control Plane

9.4.2.1 Maximum number of PPP sessions

This parameter specifies the maximum number of simultaneous PPP sessions.

9.4.2.2 Relay Session ID

A Relay Session ID according [29] on the U-Interface will be discarded or overwritten by the access node.

9.4.3 UNI Management Plane

9.4.3.1 ATM-OAM Functions

The OAM loop back function on the ATM VC level is used to check the connection. For this purpose, the terminal device connected to the U-Interface shall be the segment end point.

An OAM F5 ete LB cell with default ID 0xFFFF, formed conform to [20] (Edition 2/99), chapter 10, shall be evaluated and answered. In addition, an F5 VC-AIS ete and seg. cell, with VC-RDI ete or seg., shall be acknowledged.

9.4.3.2 EFM/Ethernet-OAM Functions

For DSL-based interfaces, Link Layer OAM requirements in accordance with IEEE 802.3 apply for the link to the subscriber (customer NT). This standard is also referred to as the Ethernet OAM in the First Mile (EFM).

9.4.3.2.1 Link Layer OAM

Support of Link Layer OAM functions according to [33], Clause 57 are required.
Especially the following functions have to be supported:

- Link Monitoring ([33], Section 57.1.2 c)
- OAM Discovery ([33], Section 57.3.2 Control)
- The critical link events (section 57.2.10.1 table 57-2).
  Note: The EFM dying gasp signal is not mandatory.

The HG has to use the passive mode described in chapter 57.2.9.2. This has to be always enabled.

9.5 Product-specific Requirements for Legacy Access Platforms

9.5.1 Product-specific Requirements for ADSL

The parameters of layer 2, in contrast to the parameters of the physical layer – which were described in the general section – are service dependent. For this reason, the parameters have been listed individually for each service. The ATM functions on layer 2 and the required adaptation from layer 3 ⇔ layer 2 are defined in the following chapters. The below listed parameters at the U-R2 interface are valid for both transmission directions, unless nothing else is stated.

9.5.1.1 PPP based Dial in Broadband Services over an ATM based Access Platform

For this service the original customer interface is the 10BaseT interface. For this, the U-R2 interface shall have parameters of layer 1-2b. In addition to ATM, this includes information about encapsulation of 10BaseT over ATM and PPP, the latter one is required for authentication at the BRAS.
If an interface other than 10BaseT is implemented in the ADSL modem, the manufacturer has to ensure that the expected parameters are provided in the manner described below.

9.5.1.1.1 Cell format UNI

The cell format shall conform to [17]

9.5.1.1.2 GFC (Generic Flow Control)

GFC = 0000

9.5.1.1.3 VPI (Virtual Path Identifier)

VPI = 1

9.5.1.1.4 VCI (Virtual Channel Identifier)

VCI = 32

VCI = 16 currently not used; optional for auto-configuration

9.5.1.1.5 PTI (Payload Type Indication)

PTI = 101: F5 OAM End to End

PTI = 100: F5 OAM segment

Full functionality shall be according to [17], chapter 2.3.3

9.5.1.1.6 CLP (Cell Loss Priority)

Upstream: CLP = 0

Downstream: CLP = 0/1

9.5.1.1.7 HEC

Coding and function shall conform to [17], chapter 2.3.5 and [19], chapter 7.3.2; only support of bit error detection based on HEC field is used

9.5.1.1.8 ATM Adaptation layer

AAL5 shall conform to [18]

9.5.1.1.9 Encapsulation Ethernet / ATM

Encapsulation Ethernet / ATM shall conform to [25] and [30], chapter 5.2.

9.5.1.1.10 Encapsulation PPP / Ethernet

PPPoE shall conform to [29]

Maximum time interval between PADI and PADO = 0,5 s

Password length: at least 42 characters

Appendix A: Service name: "any service"

Appendix A: AC Cookie

The HG should incorporate a random timing delay prior to starting each IP (v4 or v6) and PPP session according to BBF TR-124 WAN.PPP.8 [69].

If the HG receives an authentication failure when attempting an automated PPP connection attempt, it should re-try immediately to establish the connection. After three unsuccessful attempts, the RG should wait for five minutes, then repeat the connection attempt three times. If authentication still fails, the RG should back off to thirty minute intervals between groups of three attempts, according to BBF TR-124 WAN.PPP.9 [69].

NOTE: When Layer 1 showtime status is reached Client side sent PADI being forwarded immediately through all related network elements and from client side point of view and traffic flow for Layer 2/3 is available immediately for all specified services.

9.5.1.1.11 Point to Point Protocol (PPP)

PPP shall conform to [23], [24], [26], [27] and [28] with additions

9.5.1.1.12 ATM OAM

The OAM loop back function on the ATM VC level is used to check the connection. For this purpose, the terminal device connected to the U-R2 interface shall be the segment end point.

An OAM F5 ete LB cell with default ID 0xFFFF, formed conform to [20] (Edition 2/99), chapter 10, shall be evaluated and answered. In addition, an F5 VC-AIS ete and seg. cell, with VC-RDI ete or seg., shall be acknowledged.

9.5.1.2 Business Products over an ATM Based Access Platform

Business products, like T-ATM dsl, provide access to T-ATM for the provision of either PVC or SVC services or the combination of both.
Based on the reference model given in Figure 9-2 the requirements for business products are described with respect to the identified functional areas.

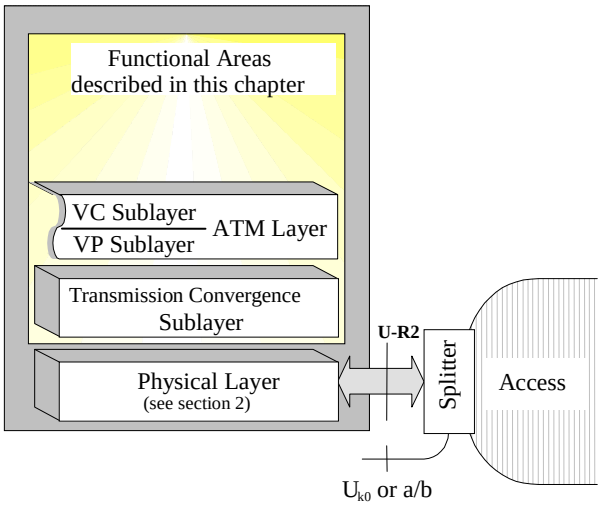

Figure 9-2: Reference Model

The services and capabilities offered on T-ATM dsl access are a subset of those offered on another T-ATM access. However, the seamless interoperation between terminal devices attached to T-ATM dsl access and ATM terminal devices attached to another T-ATM access is a mandatory requirement. The main characteristics of this subset are:

- Connections are based on Permanent Virtual Connections (PVC) and/or Switched Virtual Connections (SVC);
- Supported connection types are exclusively Virtual Channel Connections (VCC);

The specific and detailed definitions for services and capabilities offered on T-ATM dsl access are contained in the T-ATM Product Descriptions.

9.5.1.2.1 Cell format UNI

The cell format shall conform to [17].

9.5.1.2.2 GFC (Generic Flow Control)

Only “uncontrolled equipment/access” mode is required. The GFC function is not used. Therefore, no action is performed on the GFC field setting at the receive side and the GFC field is always set to all zero at the transmit side according to [17].

9.5.1.2.3 VPI (Virtual Path Identifier)

SVC support ①	PVC support ②
VPI = 0	VPI = 1 ③

① Only if support for VC-SVC is required
② Only if support for PVCC is required
③ VPI = 1 is the recommended Identifier. The VPI-Value 0 may also be used.

Both VPIs are required if SVC and PVC support is requested.

9.5.1.2.4 VCI (Virtual Channel Identifier)

SVC support (VPI = 0)		PVC support (VPI = 1) ③
Signalling channel	VCI = 5	For PVCC: VCI = 32 … 39
ILMI ①	VCI = 16	For ILMI: VCI = 16 ②
SVCs	VCI = 32 … 34	

① Currently not used, optional required for Address Registration
② Currently not used, reserved for Auto-configuration of PVC's
③ If more than one PVC is used, it is not allowed to apply different VP-Identifier

9.5.1.2.5 PTI (Payload Type Indication)

Full functionality shall be supported according to [17], chapter 2.3.3.

9.5.1.2.6 CLP (Cell Loss Priority)

Upstream: CLP = 0/1
Downstream: CLP = 0/1

NOTE: On the receive side, the values 0 and 1 shall be accepted without any cell loss. On the transmit side the CLP field may be used for loss priority indication by the terminal device dependent applications for user data cells. However, cells related to signalling, OAM functions and Resource Management shall be handled according to the relevant standards.

9.5.1.2.7 HEC

Coding and function shall be pursuant to [17], chapter 2.3.5 and [19], chapter 7.3.2.

9.5.1.2.8 ATM Adaptation Layer (optional)

AAL5 shall be implemented pursuant to [18]

9.5.1.2.9 ATM OAM Functions

In general the OAM functionalities described in [20] apply.
For Fault Management functionality, especially for verification of the VCC service visibility, F5 OAM flow for segment management shall be supported.

9.5.1.3 PPP based Dial in Broadband Services over an Ethernet based Access Platform

The following services are realized over ADSL2plus technology only!

All services are transmitted inside the PPPoE connection.

The PPPoE is transmitted in single tagged frames (VLAN-ID = 7).

9.5.1.3.1 Cell Format UNI

The cell format shall conform to [17].

9.5.1.3.2 GFC (Generic Flow Control)

GFC = 0000

9.5.1.3.3 VPI (Virtual Path Identifier)

VPI = 1

9.5.1.3.4 VCI (Virtual Channel Identifier)

VCI = 32

9.5.1.3.5 PTI (Payload Type Indication)

PTI = 101: F5 OAM End to End.

PTI = 100: F5 OAM segment.

Full functionality shall be supported according to [17], chapter 2.3.3.

9.5.1.3.6 CLP (Cell Loss Priority)

Upstream: CLP = 0

Downstream: CLP = 0/1

9.5.1.3.7 HEC

Coding and function shall conform to [17], chapter 2.3.5 and [19], chapter 7.3.2; only support of bit error detection based on HEC field is used.

9.5.1.3.8 ATM Adaptation Layer

AAL5 shall conform to [18]

9.5.1.3.9 Encapsulation Ethernet / ATM

Encapsulation Ethernet / ATM shall conform to [25] and [30] , chapter 5.2.

9.5.1.3.10 Encapsulation PPP / Ethernet

PPPoE shall conform to [29]

Maximum time interval between PADI and PADO = 0,5 s

Password length: at least 42 characters

Appendix A: Service name : "any service"

Appendix A: AC Cookie

The HG should incorporate a random timing delay prior to starting each IP (v4 or v6) and PPP session according to BBF TR-124 WAN.PPP.8 [69].

If the HG receives an authentication failure when attempting an automated PPP connection attempt, it should re-try immediately to establish the connection. After three unsuccessful attempts, the RG should wait for five minutes, then repeat the connection attempt three times. If authentication still fails, the RG should back off to thirty minute intervals between groups of three attempts, according to BBF TR-124 WAN.PPP.9 [69].

NOTE: When Layer 1 showtime status is reached Client side sent PADI being forwarded immediately through all related network elements and from client side point of view and traffic flow for Layer 2/3 is available immediately for all specified services.

9.5.1.3.11 Point to Point Protocol (PPP)

PPP shall conform to [23], [24], [26], [27] and [28] with additions

9.5.1.3.12 ATM OAM

The OAM loop back function, on the ATM VC level, is used to check the connection. For this purpose, the terminal device connected to the U-R2 interface shall be the segment end point.

An OAM F5 ete LB cell with default ID FFFF, formed conform to [20], chapter 10, shall be evaluated and answered. In addition, an F5 VC-AIS ete and seg. cell, with VC-RDI ete or seg., shall be acknowledged.

9.5.1.3.13 Connection Symmetry

Although the ADSL system provides bit rate asymmetrical connections, it shall be possible to set up both “bit rate asymmetrical” and “bit rate symmetrical” connections. The bit rates that shall be supported depends on the settings in the ADSL-LTs (ATU-C).

9.5.1.3.14 OAM Functions

The basis for the OAM functions is provided by the standards [20], [22] and [21].

9.5.1.4 Product specific requirements for ADSL2plus Annex J

Product specific requirements for ADSL2plus Annex J are for further study.

9.5.2 Product specific Requirements for SDSL

The parameters of layer 2, unlike the parameters of the physical layer – which were described in the general section – are service dependent. For this reason, the parameters have been listed individually for each service. The ATM functions on layer 2 and the required adaptation from layer 3 ⇔ layer 2 are defined in the following chapters. The below listed parameters at the U-RS interface are valid for both transmission directions, unless nothing else is stated.

9.5.2.1 PPP based Dial in Broadband Services

For this service the original customer interface is the 10BaseT interface. For this, the U-RS interface shall have parameters of layer 1-2b. In addition to ATM, this includes information about encapsulation of 10BaseT over ATM and PPP, the latter one is required for authentication at the BRAS.
If an interface other than 10BaseT is implemented in the SDSL modem, the manufacturer has to guarantee that the expected parameters are provided, in the manner described below.

9.5.2.1.1 Cell Format UNI

The cell format shall conform to [17]

9.5.2.1.2 GFC (Generic Flow Control)

GFC = 0000

9.5.2.1.3 VPI (Virtual Path Identifier)

VPI = 1

9.5.2.1.4 VCI (Virtual Channel Identifier)

VCI = 32
VCI = 16 currently not used; optional for auto configuration

9.5.2.1.5 PTI (Payload Type Indication)

PTI = 101: F5 OAM End to End
PTI = 100: F5 OAM segment
Full functionality shall be supported according to [17], chapter 2.3.3

9.5.2.1.6 CLP (Cell Loss Priority)

Upstream: CLP = 0
Downstream: CLP = 0/1

9.5.2.1.7 HEC

Coding and function shall conform to [17], chapter 2.3.5 and [19], chapter 7.3.2; only support of bit error detection based on HEC field is used.

9.5.2.1.8 ATM Adaptation Layer

AAL5 shall conform to [18]

9.5.2.1.9 Encapsulation Ethernet / ATM

Encapsulation Ethernet / ATM shall conform to [25] and [30], chapter 5.2

9.5.2.1.10 Encapsulation PPP / Ethernet

PPPoE shall conform to [29]

- Maximum time interval between PADI and PADO = 0,5 s
- Password length: at least 42 characters
- Appendix A: Service name : "any service"
- Appendix A: AC Cookie

The HG should incorporate a random timing delay prior to starting each IP (v4 or v6) and PPP session according to BBF TR-124 WAN.PPP.8 [69].
If the HG receives an authentication failure when attempting an automated PPP connection attempt, it should re-try immediately to establish the connection. After three unsuccessful attempts, the RG should wait for five minutes, then repeat the connection attempt three times. If authentication still fails, the RG should back off to thirty minute intervals between groups of three attempts, according to BBF TR-124 WAN.PPP.9 [69].

NOTE: When Layer 1 showtime status is reached Client side sent PADI being forwarded immediately through all related network elements and from client side point of view and traffic flow for Layer 2/3 is available immediately for all specified services.

9.5.2.1.11 Point to Point Protocol (PPP)

PPP shall conform to [23], [24], [26], [27] and [28] with additions

9.5.2.1.12 ATM OAM

The OAM loop back function, on the ATM VC level, is used to check the connection. For this purpose, the terminal device connected to the U-RS interface shall be the segment end point.

An OAM F5 ete LB cell with default ID FFFF, formed conform to [20], chapter 10, must be evaluated and answered. In addition, an F5 VC-AIS ete and seg. cell, with VC-RDI ete or seg., must be acknowledged.

9.5.2.2 Business Products

Business products, like ATM sdsl, provide access to the ATM platform for the provision of either PVC or SVC services or the combination of both.
Based on the reference model given in Figure 9-3 the requirements for the ATM sdsl product are described with respect to the identified functional areas.

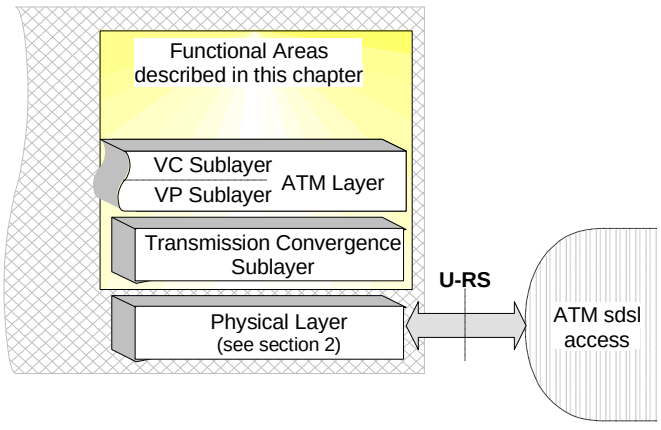

Figure 9-3: Reference Model

The services and capabilities offered on ATM sdsl access are a subset of those offered on another ATM access. However, the seamless interoperation between terminal devices attached to ATM sdsl access and ATM terminal devices attached to another ATM access is a mandatory requirement. The main characteristics of this subset are:

Connections are based on Permanent Virtual Connections (PVC) and/or Switched Virtual Connections (SVC);

Supported connection types are:

- For PVC: either Virtual Channel Connections (VCC) or Virtual Path Connections (VPC);
- For SVC exclusively Virtual Channel Connections (VCC);

The specific and detailed definitions for services and capabilities offered on ATM SDSL access are contained in the ATM Product Descriptions.

9.5.2.2.1 Cell Format UNI

According to [17].

9.5.2.2.2 GFC (Generic Flow Control)

Only “uncontrolled equipment/access” mode is required, the GFC function is not used. Therefore, no action is performed on the GFC field setting at the receive side and the GFC field is always set to all zero at the transmit side, according to [17].

9.5.2.2.3 VPI (Virtual Path Identifier)

SVC support ①	PVC support for VCC ②
VPI = 0	VPI = 1 ③

① Only if support for VC-SVC is required.
③ Only if support for PVCC is required.
③ VPI = 1 is the recommended Identifier. The VPI-Value 0 may also be used.

Both VPIs are required if SVC and PVC support is requested.

9.5.2.2.4 VCI (Virtual Channel Identifier)

SVC support (VPI = 0)		PVC support (VPI = 1) ③
Signalling channel	VCI = 5	For PVCC: VCI = 32 … 39
ILMI ①	VCI = 16	For ILMI: VCI = 16 ②
SVCs	VCI = 32 … 34	

① Currently not used, optionally required for Address Registration.
② Currently not used, reserved for Auto-configuration of PVC's.
③ If more then one PVC is used, it is not allowed to apply different VP-Identifier.

9.5.2.2.5 PTI (Payload Type Indication)

Full functionality shall be according to [17], chapter 2.3.3.

9.5.2.2.6 CLP (Cell Loss Priority)

Upstream: CLP = 0/1
Downstream: CLP = 0/1

NOTE: On the receive side, the values 0 and 1 must be accepted without any cell loss. On the transmit side the CLP field may be used for loss priority indication by the terminal device dependent applications for user data cells. However, cells related to signalling, OAM functions and Resource Management shall be handled according to the relevant Standards.

9.5.2.2.7 HEC

Coding and function shall be pursuant to [17], chapter 2.3.5 and [19] , chapter 7.3.2.

9.5.2.2.8 ATM Adaptation Layer (optional)

AAL5 shall be implemented pursuant to [18].

9.5.2.2.9 ATM OAM Functions

In general the OAM functionalities described in [20] apply.
For Fault Management functionality, especially for verification of the VCC service visibility, F5 OAM flow for segment management shall be supported.

Annexes

A1 ADSL Interoperability Tests, Functional (mandatory)

This annex lists interoperability tests which have to be performed additionally to the interoperability performance tests according to clause 5.1.2.6. The tests referenced herein shall show that the required functions for ADSL DSLAM – HG combinations work properly.

All tests shall be performed according to [34]. The following test cases from [34] are mandatory:

- ADSL Functionality Tests (section 8.1.1, 8.1.2, 8.1.4, 8.1.8, 8.1.9)
- Electrical Compatibility Tests (section 8.5.1, 8.5.2, 8.5.3, 8.5.4)

All other test cases described in section 8 of [34] are optional.

A2 ADSL2plus Interoperability Tests, Functional (mandatory)

Layer 1 interoperability and functionality have to be proven according to [36].

A3 Frequencies relevant for RFI Bands

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

Table Annex A 1: List of RFI Frequencies

[1] Priority 1: very important, actually to be implemented
Priority 2: for future use

A4 Noise Templates

The relevant Noise Templates for Performance-Tests with activated Upstream Power Back Off (UPBO) (see section 7.1.2.7.3 and 7.1.1.6.3) are summarized in the attached Excel-File:

1TR112_Annex_4_VDSL2_US_NoiseTemplates-V1.1.xls

The relevant Noise Templates for Specific Performance-Tests for ADSL2plus Annex J Upstream (see section 5.1.1.6.3.2) are summarized in the attached Excel-File

1TR112 _Annex_4_Annex J Noise Template.xls

A5 Specific Characteristics of ISDN Signals at Uk0 Interface

Either POTS or ISDN may be used for voice band transmission on the same wire pair with ADSL, ADSL2plus and VDSL2. This Annex outlines specific properties of ISDN within the context of the interface descriptions in the present document.

Reference Model including ISDN Transmission

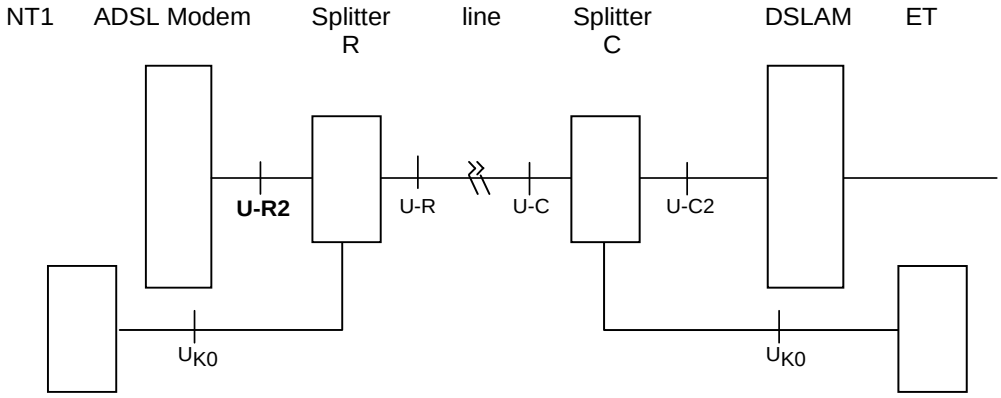

Figure A6-1 reference model for ISDN transmission

Applicable Standards and additional characteristics

ISDN signals at the U_{k0}-interface are conform to ETSI TS 102 080 [8], Annex B, Line code MMS43 (4B3T). This includes specifications for Power Spectral Density (PSD), pulse shapes, return loss and longitudinal conversion loss.

The following additional layer 1 characteristics apply:

- Maximum voltage of the modulated line signal at the U_{k0}-interface: U_{max} = 4 V
- Single side transmit signal power during show time: typically P_{ISDN} < 14 dBm into a resistive load of 150 Ohm

The following additional requirements apply for remote feeding of the NT1 at the U_{k0}-Interface:

- Feeding Voltage U_{feed} = 53 V … 99 V
- Maximum feeding current I_{max} = 55 mA, limited at ET side
- current – voltage – conditions at the U_{k0}-Interface: see figure A6-2

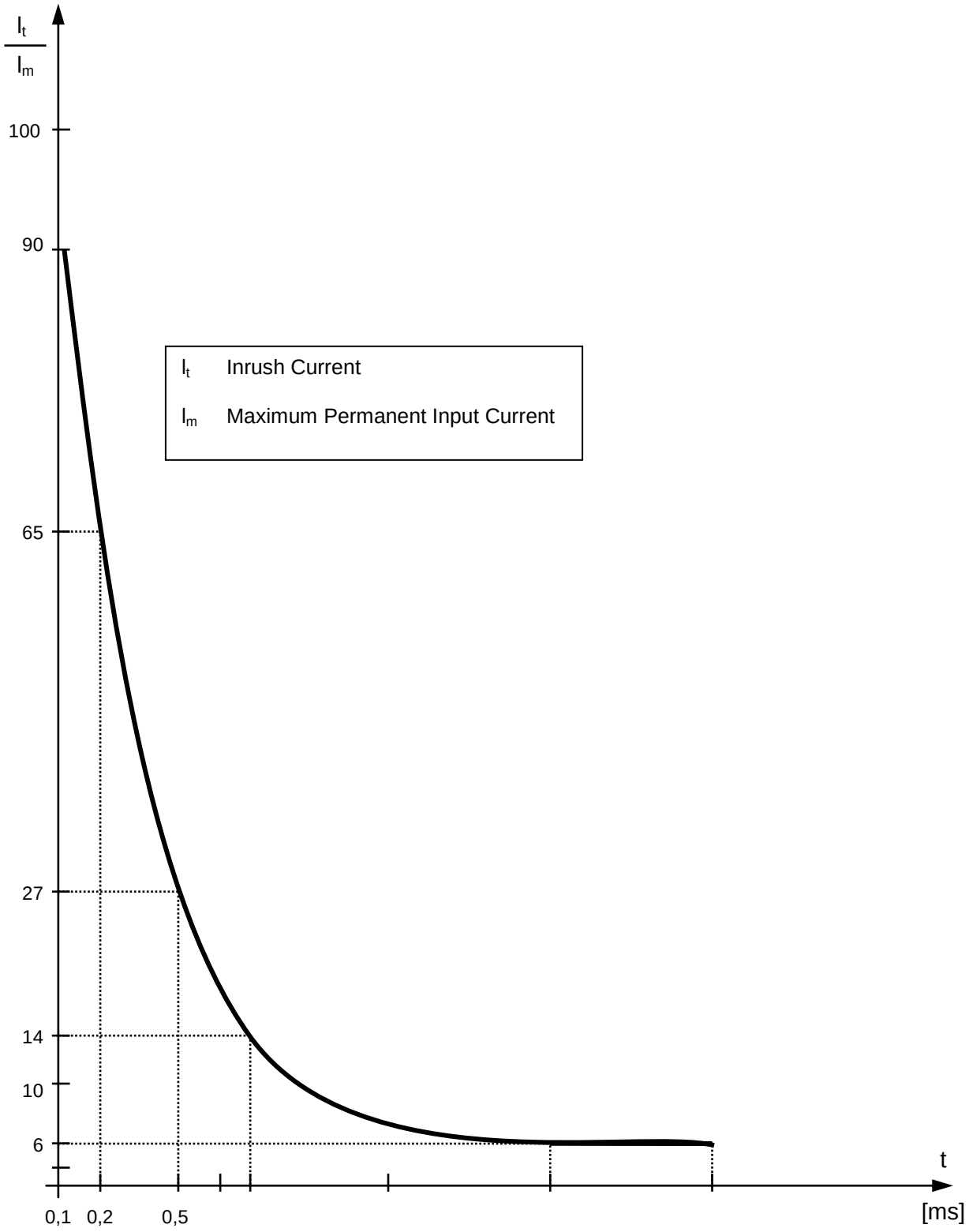

Figure A6-2: Current Surge limits

A6 Technical Specification of the U-Interface between GPON ONT and RG in the network of Deutsche Telekom

A6.1 Foreword

This Annex has been produced by Deutsche Telekom AG (in the following named as Deutsche Telekom) and describes the U-Interface (user interface) between a Residential Gateway (RG) and an Optical Network Termination (ONT) within a Gigabit-capable Passive Optical Network (GPON) systems in the network of Deutsche Telekom.

Compatibility with this document guarantees full functionality between GPON ONT and RG.

A6.2 Statement of Broadband Forum (BBF) TR-156 (chapter 4.1 “ONU/ONT and the Residential Gateway”)

Historical deployment perspectives have differed between DSL and PON. Historically, DSL has specified the transport protocol as the customer interface at the U reference point. This came from the perspective that the DSL modem would be CPE, and therefore the U reference point should be on the network side of the modem. PON systems have been defined with an alternate assumption: that the ONU or ONT would be Network Equipment (not CPE) and that they may be deployed outside the customer premises or even at the curb. Therefore, the U reference point is placed at the customer-facing side of the ONU and ONT. This is essentially flipped from the DSL modem assumption set.

A6.3 Scope

The present Technical Specification (TR) is applicable to Gigabit-capable Passive Optical Network (GPON) systems ONT of Deutsche Telekom on the customer side behind the network termination point (NTP) of Deutsche Telekom according to the AGB/LB [56] of Deutsche Telekom. Especially in a wholesale scenario where other service providers are connected to the access network of Deutsche Telekom or the functionality of the connected RG must be fully compliant to this document. The same scenario is in effect with wholebuy customer, where Deutsche Telekom network is connected to other operator´s Access Network and the functionality of the Deutsche Telekom RG must be fully compliant to this document, too.
The description defines the U-Interface of ONT and specific Layer 2 transmission requirements to the RG and ONT interfaces provided by Deutsche Telekom or other operator via GPON systems.
The description does not contain any terminal equipment (TE) requirements

A6.4 General

A6.4.1 Purpose of this Document

This document describes the requirements on U-Interface on the customer side for connecting RG to ONT GPON System of Deutsche Telekom. It incorporates requirements for the electrical Ethernet interface only.
This interface description simply presents the parameters that have been made available, and that are expected for the described interface.

A6.5 Technical description of U-Interface

A6.5.1 General Reference Model of GPON System and Customer RG

The following reference model encompasses OLT and ONT (ONU) elements as well as the U reference point.

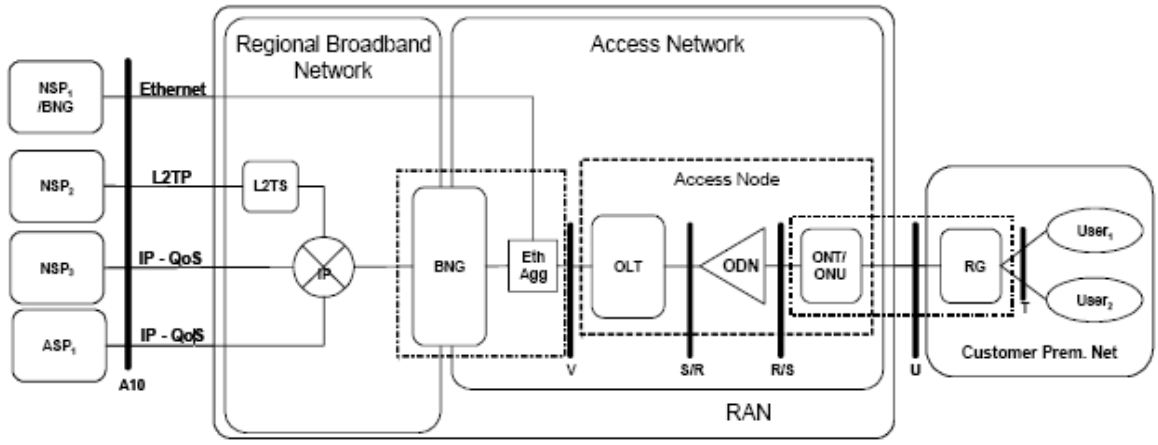

Figure 4: Network architecture for Ethernet-based GPON aggregation (according to BBF TR-156)

A6.5.2 GPON to Ethernet Adaptation

FTTH deployment depicts a single-family residential scenario using a typical ONT. FTTH is deployed at the user's premise and connects a single-family unit. FTTH connects the RG, using a single Gigabit Ethernet (GE) link, to an ONT that provides the GPON adaptation function. The RG performs standard RG functionality; however its WAN uplink is a physical Ethernet interface.

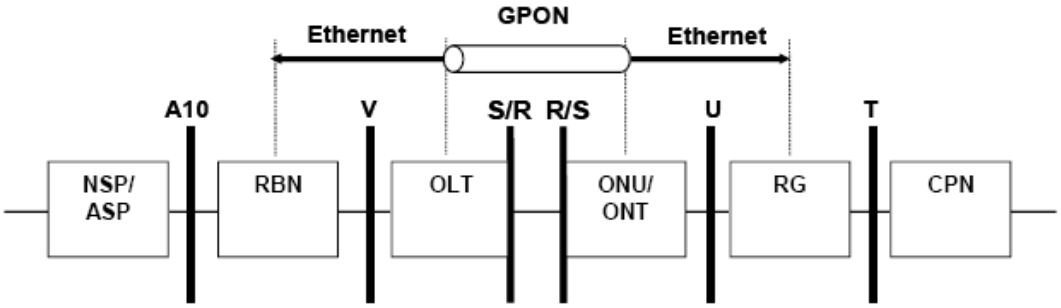

Figure 5: GPON to Ethernet adaptation (according to BBF TR-156)

A6.5.3 GPON ONT and the Residential Gateway (RG)

The following section shows details and provides a reference diagram. Figure 6 depicts a single-subscriber solution for GPON ONT provided by Deutsche Telekom with separate RG.

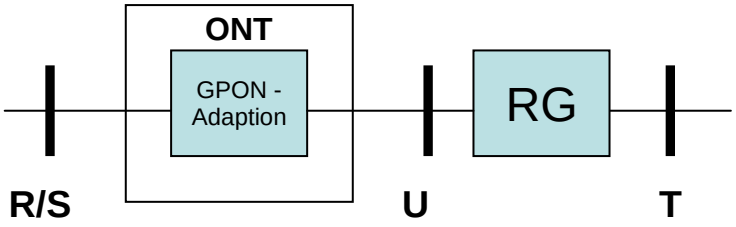

Figure 6: ONT and RG as separate entities (according to BBF TR-156)

The first entity is an RG performing standard RG functionality with a standard Ethernet uplink (100/1000Mbps) at U reference point. The second entity, the ONT, provides the adaptation to the GPON uplink, providing mapping of tagged Ethernet frames to the standard GPON specific scheduling and traffic management mechanisms in the upstream direction and extraction of the relevant traffic from the GPON interface in the downstream direction.
This technical description will only cover the functionality of the Interface between the GPON-ONT and RG (Residential Gateway), as well as the Ethernet protocol specification at U reference point.

A6.5.4 Reference Point Interfaces

The interface and protocol stacks described in BBF TR-156 at the U reference point must be supported. The protocol stacks of the U reference point depicted in Figure 7 are added to support Ethernet physical layer interfaces.
xDSL technology are not supported on the U reference point as described in BBF [61]

Following protocol stack options are depicted in Figure 7:

Option a represents an Ethernet network access using an IP over Ethernet stack.

Option b represents the same for a PPPoE access stack.

Option c represents a stack that could be used to provide a Business Ethernet service, commonly referred to as a Transparent LAN Service (TLS).

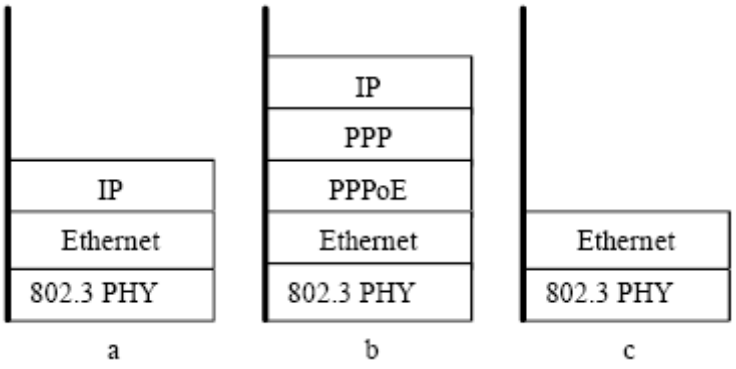

Figure 7: Protocol Stacks for Interfaces at the U Reference Point

A6.6 General Requirements

A6.6.1 Physical layer Requirements

The physical layer (layer 1) parameters must conform to IEEE 802.3 [57].

U reference point must support one 100/1000Base-T Ethernet interface.

A RJ45 socket (Version: MDI-X) at the GPON ONT with pin assignment according to IEEE 802.3 [57] should be used for the connector.

The RJ45 socket supports Auto-MDI(X) and auto-negotiation. The GPON ONT must support the use of a straight-through (patch) cable between the U-Interface and the RG.

Devices connected to the U interface must support auto-negotiation function. The default value is activated.

A6.6.2 Pin and pair grouping assignment

100/1000Base-T
The pins in the RJ45 socket are allocated as follows:

PIN	Signal
1	Transmit Data Plus (TD1+)
2	Receive Data Minus (RD1-)
3	Transmit Data Plus (TD2+)
4	Transmit Data Plus (TD3+)
5	Receive Data Minus (RD3-)
6	Receive Data Minus (RD2-)
7	Transmit Data Plus (TD4+)
8	Receive Data Minus (RD4-)

100/1000Base-T must support cable lengths up to 100m.

A6.6.3 UNI Reference Model

The description of U-Interface is made by using the MEF 11 UNI reference model as shown in Figure 8. An overview of the different building blocks that constitute the UNI functions is presented, and the various layers, capabilities and processes that are part of each building block are described. This model must be considered.

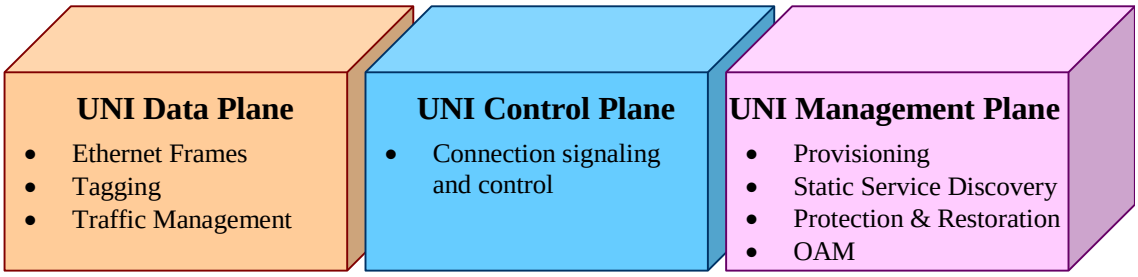

Figure 8: UNI Reference Model (according to MEF 11)

The UNI Reference Model consists of three planes:

- The **UNI data plane**, which defines the means of transporting information across the UNI reference point;
- The **UNI control plane**, which defines the means for the Subscriber and the ONT of GPON systems in the network of Deutsche Telekom to communicate to make use of the UNI data plane;
- The **UNI management plane**, which configures and monitors the operation of the UNI data and control plane.

A6.6.3.1 Ethernet Parameter Requirements

The transport layer of the U-Interface between ONT and RG must be Ethernet.

The data link layer (layer 2) parameters must be conform to IEEE 802.2 [59] and IEEE 802.3 - 2008 [57].

U-Interface must be transparent to higher layer protocols.

The following chapters contain general requirements for the Ethernet layer.

A6.6.3.2 UNI data plane

A6.6.3.3.1 MAC addresses

Maximum number of supported MAC addresses per ONT port is 64 (per default only 4 MAC addresses are supported per ONT port).

A6.6.3.3.2 MTU Size

Every packet-based network has a MTU size (maximum transmit unit) which that network can transmit. The MTU size must be configurable up to 2000 bytes. The default value must be set to 1500 bytes.

A6.6.3.3.3 Ethernet Structure

Ethernet frames must be supported according to IEEE802.3 [57]
The C-VLAN on the U-Interface must be used with TPID = 0x8100. All p-bit values can be used.

A6.6.3.3 UNI control plane

A6.6.3.3.1 Ethernet Flow Control

Devices connected to the U-Interface must support Ethernet flow control. It must be possible to activate / deactivate this function. Default is deactivated.

A6.6.3.4 UNI Management Plane

A6.6.3.4.1 OAM Functions

OAM mechanisms according to [57] and [63] are currently under investigation.
Details are for further study.

A6.6.4 Product specific Requirements (Deutsche Telekom) for Ethernet

see chapter 9.3.1

History

Version	Published	Remarks
4.3	September 2002	First Edition
5.0	May 2003	Corrections and clarifications
6.0	January 2005	References to DSL-Forum TR-067 and requirements for TDSL 6000 included
7.0	September 2005	Requirements for ADSL2 and ADSL2plus added
7.0 Supplement	February 2006	Supplement U-RS SDSL description
8.0	November 2007	8. edition of 1TR112; ADSL, ADSL2, ADSL2+, SDSL and VDSL2 included.
8.1	January 2008	Corrected version 8.0; clause 7.1.2.1 f) deleted; File name of the Excel document added; Annex 4 (Excel file) editorial corrected
9.0	March 2008	9. edition of 1TR112; new section 4.2.1.1 U-R Interface (without HG splitter)
9.1	November 2008	Revision of Version 9: • Added section 4.2.3.1 U-RV interface (splitterless VDSL2 operation) • refinement of DPBO parameter DPBOMUS Added descriptions for VDSL2 double play services
9.2	January 2009	Revision of Version 9.1 • Added Signature for U-R • Added Signature for U-RS • Added Signature for U-RV

Version	Published	Remarks
10.0	02/2011	10. edition of 1TR112; new sections for ADSL2plus Annex J (for U-R interface) and U-RV with M-Mode operation • Aligned with Version 9.2 • Added Annex J specific requirements: Multi-Mode operation start sequence, performance requirements • Removed ADSL2 Annex B for U-R and U-R2 • Removed informal performance requirements for cable models TP100, AWG24 and AWG 26 • Removed DPBOESELMIN for ADSL2plus and VDSL2 • added U-RV mechanical properties • major change for VDSL2 performance requirements: alignment to BBF TR114 • editorial rework for corporate design • changed signature resistor from 33k to 100k • removed signature for U-RS • prohibit usage of V43 handshake carrier set for U-RV and U-RV2 interfaces
11	08/2011	• modification of document structure: merge all service related requirements into new chapter 8 • EFM OAM added/clarified SDSL chapter • add eSDSL support and performance requirements • add EFM and EFM bonding support and add pin allocation accordingly ADSL, VDSL2 chapters • clarification added for multi mode operation
11.2	12/2011	• Added requirements for Retransmission support for ADSL2plus Annex J at U-R Interface • Added requirements for Retransmission support for VDSL2 at U-RV and U-RV2 Interface • Added chapter 4.2.4 and Annex A6: Technical Specification of the U-Interface between GPON ONT and RG in the network of Deutsche Telekom
12	03/2012	• Added requirements to support VDSL2 Vectoring

Version	Published	Remarks
12.1	06/2013	• Added 2nd IPTV data plane option: single VLAN 7 for all services • Added requirements to support enhanced L2 mode in ADSL2plus Annex B and Annex J • editorial corrections in Annex 6
12.2	02/2014	• Added Common Mode emission limit requirements to all xDSL sections
12.3	03/2015	• Relaxed requirements for Common Mode emission limits to all xDSL sections • GPON: alignment of Product specific Requirements (Deutsche Telekom) for Ethernet with main body chapter 9.3.1 • Editorial corrections
13	05/2017	• Added chapter 7.2 as description for support of VDSL2 profile 35b (SuperVectoring) • Corrected QoS-US .1p VoIP from 5/6 to 5 in Tables OO, PP, QQ, but allowing still 6 as well • Added QoS-DS: .1p LCP Echo Request and QoS-US: .1p LCP Echo Request in Tables OO, PP, QQ • Removed US-Policer 1.p bandwidth limit in Tables OO, PP, QQ • Added additional detailed requirements for Encapsulation PPP / Ethernet (PPPoE) to prevent session failures in sections 9.5.1.1.10, 9.5.1.3.10, 9.5.2.1.10 • Added TAE model F in sections 5.1.1.7 and 7.1.1.5 • Changed Common mode limits requirements to reference ITU-T G.995.2 • Added note and description in GPON paragraphs for future description of IF_{PON}-Interface (new future amendment) • Added details for Handshake carrier set B43c • 1TR112_Annex_4_VDSL2_US_NoiseTemplates-V2: removed unused cable models and profiles • Editorial corrections