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Transmission and interface characteristics of VDSL service

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0. Document history

Every update of this document results in a complete new version with new version number and release date.

Version	Date	Main or important changes since previous version
1.0	18 MAR 2004	• Initial version

1. Scope

The goal of this document is to provide the technical specifications of the User To Network Interface (UNI) for VDSL equipment to be connected to the Belgacom network.

As VDSL may provide a variety of bearer channels in conjunction with other services, this document deals with the VDSL service on the same pair with voice–band services (i.e. POTS or ISDN).

The UNI technical specifications for the VDSL service, mentioned in this document, are based on the currently relevant international specifications and recommendations for VDSL equipment, namely:

- The ETSI TS 101 270-1 V1.3.1 [1];
- The ETSI TS 101 270-2 V1.2.1 [2];
- The ITU-T G.993.1 Recommendation [3];
- The ITU-T G.994.1 Recommendation [4].

2. References

[1] ETSI TS 101 270-1 V1.3.1 *"Very High Speed Digital Subscriber Line (VDSL); Part 1: Functional requirements"*

[2] ETSI TS 101 270-2 V1.2.1 *"Very High Speed Digital Subscriber Line (VDSL); Part 2: Transceiver specification"*

[3] ITU-T G.993.1 Recommendation "*Very high speed digital subscriber line foundation*"

[4] ITU-T G.994.1 Recommendation "*Handshake procedures for digital subscriber line (DSL) transceivers*"

3. Definitions and abbreviations

3.1. Definitions

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

downstream: transmission in the direction of LT towards NT (network to customer premise)

FTTEx: used to define when VDSL LT transceivers are located physically at the serving Local Exchange

upstream: transmission in the direction of NT towards LT (customer premise to network)

xDSL:generic term covering the family of all DSL technologies, e.g. DSL, HDSL, SDSL, ADSL, VDSL

3.2. Abbreviations

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

ATM	Asynchronous Transfer Mode
CPE	Customer Premise Equipment
DMT	Discrete Multi-Tone
DSL	Digital Subscriber Line (or Loop)
EMC	ElectroMagnetic Compatibility
FTTCab	Fibre To The Cabinet
ISDN	Integrated Services Digital Network
LT	Line Termination
NT	Network Termination (at the customer premise end of the line)
OAM	Operations, Administration and Maintenance
ONU	Optical Network Unit
POTS	Plain Old Telephony Service
PSD	Power Spectral Density (usually quoted in dBm/Hz, and in the present document is restricted to single sided PSDs).
TE	Terminal Equipment
UNI	User Network Interface
UPBO	Upstream Power Back-Off
VDSL	Very high speed Digital Subscriber Line
VTU-O	VDSL Transmission Unit-Optical
VTU-R	VDSL Transmission Unit-Remote

4. System reference model

Figure 1 shows the reference model used for VDSL [1][2]. It is essentially a Fibre to the Node architecture with a Remote Optical Platform (ROP) - Optical Network Unit (ONU) in the ETSI terminology- sited in the existing metallic access network (or at the serving Local Exchange or Central Office). From the ONU, existing unscreened twisted metallic access wire-pairs are used to convey the broadband (VDSL) and narrowband (POTS and ISDN) signals to and from the customer's premises. Between the ONU and the Central Office Exchange, POTS and ISDN signals are transfered on existing copper pairs.

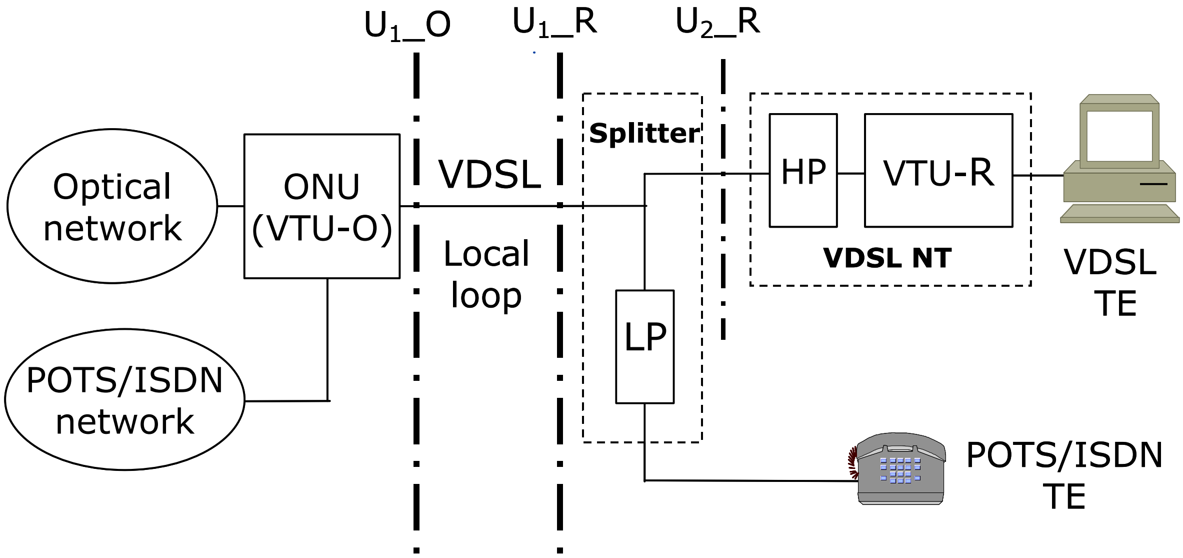

Figure 1: General reference model

At the CPE side, the VDSL NT block (Network Termination) contains the VDSL transmission functionality (VTU-R) and the High-Pass functionality (HP).

At the network side, the ONU contains the VDSL transmission functionality (VTU-O), the VDSL splitter and filtering functionalities and the backhaul to the optical network.

This reference model allows to define two User Network Interfaces (UNI) for the various applications served by VDSL.

5. VDSL UNI characteristics

The user network interfaces are:

- U_1_R, which is located between the copper access pair (local loop) and the splitter;
- U_2_R, which is located between the splitter and the VDSL network termination.

The characteristics of the local loop are described in annex A.

5.1. U_1_R interface

This interface allows the connection of both the broadband (VDSL) and the narrowband (PSTN /ISDN) CPEs to the ONU via the copper access network. The next section specifies the VTU-R and VTU-O functional requirements in order to establish a VDSL connection.

The functional characteristics of the VTU-R and VTU-O comply with ETSI specifivation TS 101 270-1 V1.3.1 and with ETSI specification ETSI TS 101 270-2 V1.2.1.

Amongst the characteristics which are not strictly defined in these specifications, the following ones are fixed for deployment in Belgacom network:

1. the multi-carrier modulation, also called DMT (discrete multi-tone) is used;
2. ATM is the current transport protocol;
3. at the ONU side universal splitters are used for narrowband signals (PSTN and ISDN).

Specifications related to PSTN and ISDN are described in the following documents:

- "*Transmission and interface characteristics of PSTN service*", version 2.1 (26-Feb-01), which can be found on the Belgacom web site, reference: BGC_D_48_9807_20_02_E.pdf

- "*Euro-ISDN (Basic Call)*", version 2.3 (24-Jan-03), which can be found on the Belgacom web site, reference: BGC_D_48_9809_30_01_E.pdf

5.2. U_2_R interface

In contrast to the U_1_R interface, the U_2_R interface doesn't allow the transmission of narrowband signals (PSTN/ISDN). As universal splitters (PSTN and ISDN compatible) are used at the ONU side, the VDSL bandwidth at the U_2_R interface starts only at 138 Khz, but in case of use of dedicated splitters for PSTN and ISDN at the CPE side, the bandwidth may start at 25 Khz with PSTN only splitters.

6. Transmission characteristics

This section describes the end-to-end transmission characteristics between the VTU-O and the VTU-R; these transport capacities and properties of VTU_O and VTU-C comply with ETSI specification TS 101 270-1 and with ETSI specification ETSI TS 101 270-2 V1.2.1.

Amongst the transmission characteristics which are not strictly defined in these specifications, the following ones are fixed for deployment in Belgacom network:

VDSL band allocation:

- the total VDSL bandwidth is comprised between 138 KHz and 12 MHz;
- the VDSL modems use the optional regional-specific VDSL band allocation, which corresponds to the formerly named 998 frequency plan.

Power Spectral Density (PSD):

- all PSD masks have to be supported by the VTU-R (see ETSI TS 101 270-1 chapter 8.1.5 and Annex E);
- the sole PSD mask FTTCab is currently implemented at the ONU, even when the ONU (VTU-O) is placed in the Central Office Exchange;

Upstream Power Back-Off (UPBO):

- ETSI UPBO method and all UPBO reference PSDs have to be supported (see ETSI TS 101 270-1 chapter 8.1.6) in order to optimize the network upstream performances.

ANNEX A : Local loop characteristics

A telecom cable consists of a number of *cores* surrounded by a layer of insulating material. The cores of such a cable are always grouped in *pairs* of *conductors*.

Cables in the local network are designed so as to ensure optimum transmission and guarantee minimum mechanical resistance. For this reason, the description of cables below consists of a section dealing with electrical characteristics and one dealing with mechanical characteristics.

Mechanical characteristics

• The conductors of a local cable are round, full wires consisting of 98%–99% pure electrolytic copper.
• A conductor is isolated by a layer of synthetic material (usually polyethylene).
• Most conductors have a 0.5 mm or 0.6 mm diameter with a maximum negative variance of 0.01 mm and a positive variance of 0.03 mm.
• The set of conductors is covered by a waterproof extruded cable sheath (usually polyethylene). Under normal circumstances, the cable is also longitudinally waterproof.
• The cable cores are arranged in a specific manner. The two conductors (e.g. of a telephone circuit) must be arranged symmetrically in relation to all other conductors. For this reason, conductors are twisted and placed in coaxial cylindrical layers *(a basic unit consists, for example, of four conductors twisted around one another and from which two telephone circuits can be created; a cross section shows that these four conductors form the corners of a square. The conductors located on two opposite angular points form a pair).*

Electrical characteristics

• Since the signals to be transmitted are changeable electrical voltages, the cable conductor must be a good transmission medium for electrical signals. The important elements are defined for a unit length of one kilometer and are called primary electrical parameters of a conductor. These parameters are kilometer resistance R, kilometer inductance L, kilometer capacity C and kilometer leakance G.

♦ <u>kilometer resistance R</u>

  * Kilometer resistance is the initial resistance of a one kilometer conductor pair that is looped at the remote end; the value of this parameter is therefore the resistance of a conductor with a length of two kilometers.
    ⇒ R is 180 Ohm for a conductor diameter of 0.5 mm (at 20°C);
    ⇒ R is 123 Ohm for a conductor diameter of 0.6 mm (at 20°C).

  * It should be noted that due to the skin effect, the alternating current resistance is higher than the direct current resistance indicated above.

♦ <u>kilometer inductance L</u>

  * In a symmetrical pair cable, conductors forming a pair lie very close to one another; kilometer inductance L is therefore very low (approx. 0.5 mH per kilometer).

- kilometer capacity C

  * The capacity between two conductors of the same pair can be measured when the rest of the cable conductors are connected to each other and to an equipotential point of a measuring device. The nominal value of kilometer capacity C is situated between 38.5 nF/km and 50 nF/km at 800 Hz.

- kilometer leakance G

  * Kilometer leakance G depends on the frequency concerned and kilometer capacity C. Theoretically, kilometer leakancy may be considered as negligible.
  * G can roughly be calculated with the help of the following formula, in which k has a value between 0.005 and 0.02 (ω = pulsation in rad/s):

$$G = k . \omega . C$$

- The insulation resistance of each conductor in relation to the rest of the conductors (and any shielding) is at least 5,000 MΩ/km.