
TITLE **Description of “VDSL2-NL1” signals, for spectral management in the Netherlands.**

PROJECT SpM-1 (to be re-opened for a revision)

SOURCE: KPN (Bob Hoefnagel), TNO (Rob van den Brink)

AUTHORS: Rob van den Brink (TNO), Teun van der Veen (TNO)

CONTACT:
Rob F. M. van den Brink,
TNO, KPN
PO Box 5050
2600 GB Delft
The Netherlands

tel +31.15.2857059
fax: +31.15.2857354
e-mail: Rob.vandenBrink@ tno.nl

NOTE THE CHANGE OF E-MAIL ADDRESS

SUPPORTED BY:
Thomson (Alex de Smedt)

STATUS: Proposal, for inclusion into SpM-1

ABSTRACT[1]: This contribution proposes a signal description for VDSL2, fully tailored to the Dutch access network, for inclusion into SpM-1 (ETSI TR 101 830-1). It has been derived from band plan 998, uses PSD mask B8-4 (up to 12 MHz), and is shaped in such a way that systems (from the cabinet) complying with these signal limits can coexist with deployed systems (from the local exchange).

---

1. The purpose of SpM-dedicated signal descriptions for VDSL2

The ITU VDSL2 Recommendation G993.2 enables VDSL2 products to transmit a wide range of PSD variants, supporting different band plans, PSD limits and power-back off values. This is adequate from a product point of view (flexibility), but inadequate from a spectral management point of view. Spectral Management requires an unambiguous specification of limits.

When VDSL2 will be deployed in the sub loop (from the cabinet) it may have a negative impact on services in the local loop (from the local exchange), when additional restrictions to its transmit signal are lacking. To deploy VDSL2 in an environment that *requires* that VDSL2/Cab can coexist with deployed xDSL services, the signal specification should ensure that the impact is not beyond acceptable.

However, a generic requirement on how much impact is accepted, and what the resulting PSD limits should be, does *not* exist. These limits are highly dependant on the scenario being considered (chosen band plan, chosen protection criteria, cable loss, cable crosstalk, disturber mix, etc), that the result may be very different for different countries, different cables or even different deployment areas.
In other words, such PSD limits can only be suitable for a very (country) specific scenario.

Solutions for the Netherlands

We have evaluated PSD limits for VDSL2, which are tailored to typical Dutch situations. These PSD limits have been derived from band plan 998 and are shaped. The PSD shaping facilitates that an *additional* VDSL2 system from the cabinet does not produce more disturbance to deployed services then any other *additional* deployed system from the exchange will do. This means that the PSD limits change with the “attenuation distance” between local exchange and cabinet, as illustrated in figure 1.

---

[1] **The scientific work behind this contribution has also been funded by MUSE, a European consortium of vendors, operators and knowledge institutes, cooperating within the 6th framework programme of the European Commission.**

Since ADSL2plus uses the widest frequency band of all deployed services, a VDSL2 PSD causing equal disturbance as an ADSL2plus PSD is considered as meeting the criterion of “no negative impact”.

The attached signal description has recently been proposed by KPN to a forum of Dutch xDSL operators, for use as mandatory access rules for the sub loop in the Netherlands. *Technical* objections against these limits are not expected, and therefore it is assumed that agreement in the Netherlands will be achieved later this year.
The full signal description has been included in the present contribution, and has been named “VDSL2-NL1” to enable future additions. Only systems (whether they are VDSL2 or not) transmitting signals compliant with these limits, will then be granted access to the Dutch access network.

Proposal:
We propose to include the attached signal description to the “library” of descriptions already captured in ETSI TR 101 830-1 (Spectral Management part 1). This enables vendors of xDSL equipment to verify if their products are flexible enough to operate within these limits. We also invite operators from other countries to communicate similar limits, tailored to their own needs, and to contribute it also for inclusion in SpM-1.
By the inclusion of a “VDSL2-NL1” signal description in SpM-1, ETSI will by no means impose anybody to make use of these limits. Using it is purely an issue of national concern and national regulation.

2. Characteristics of the proposed ”VDSL2-NL1” description

The PSD of the proposed signal description changes with the so called *attenuation distance* between local exchange and cabinet. Figure 1 shows a few PSD shapes associated with different attenuation distances, as illustrated in figure 2.
PSD shapes have been evaluated for each dB attenuation distance (measured at 300 kHz), up to 45 dB.

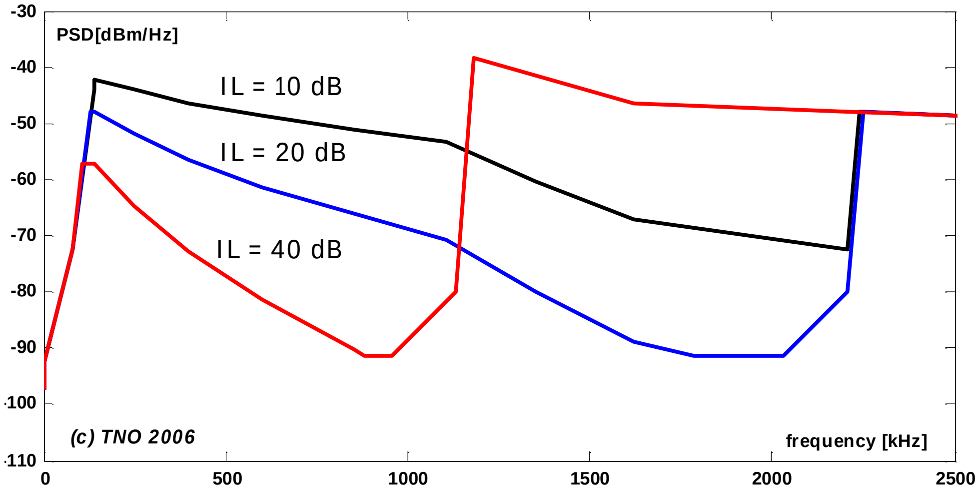

Figure 1: Example of different PSD shapes, to be used for different attenuation distances

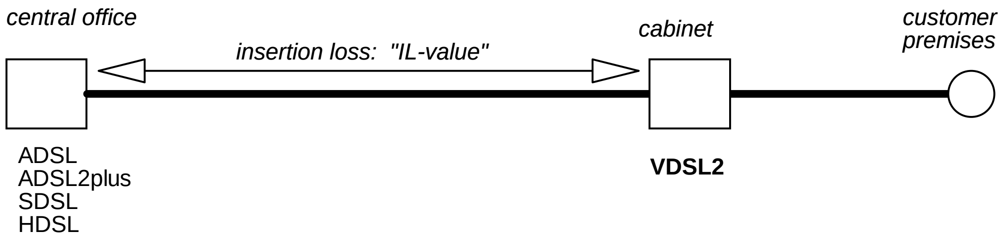

Figure 2: Attenuation distance is the insertion loss (IL) between central office and cabinet, measured at 300 kHz.

Starting points for finding the most favorable PSD shapes.

Band plan 998 was used as starting point, in combination with a maximal usage of the full frequency band up to 12 MHz, and with reserving the use of frequencies above 12 MHz for future applications. This resulted in choosing PSD mask B8-4, from [1], as starting point.

The need for a PSD mask dedicated to the combination of VDSL2 and ISDN over the same line has not been raised, so additional masks have not been considered.

Another starting point was to derive a signal description that enables an easy verification if a signal complies with it or not. This resulted in a specification that makes only use of break points, to avoid algorithmic definitions like the polynomial A, B and C parameter approach described in ITU G993.2.

Approach for finding the most favorable PSD shapes.

The basic form of the PSD shape originated from the combination of two curves:

- A first curve originated from multiplying an ADSL2plus PSD template with the transfer function of a cable model (by using model "KPN_L1", also known as "TP-150" specified in the test loops for VDSL). The remaining parameter that defines this curve is called the "shaping-distance" and represents the length being used in that cable model.
- A second curve is a horizontal floor representing the minimum usable signal level. The parameter that defines this floor is called the "signal floor" (also known as MUS).

Subsequently, the *combination*s of these two parameters have been chosen such that both (a) the equal disturbance criterion is met and (b) the drop in performance that the PSD shaping causes to VDSL2 is kept minimal. Finding this combination was the result of significant computational effort, by evaluating the performance and impact of VDSL2 for many cabinet locations, on a grid of the two parameters. The pair of values being found in this way was selected for the shape associated with that cabinet location.

The result is that the "shaping-distance" is sometimes significantly different from the "attenuation-distance" between cabinet and local exchange. This is illustrated in figure 3.

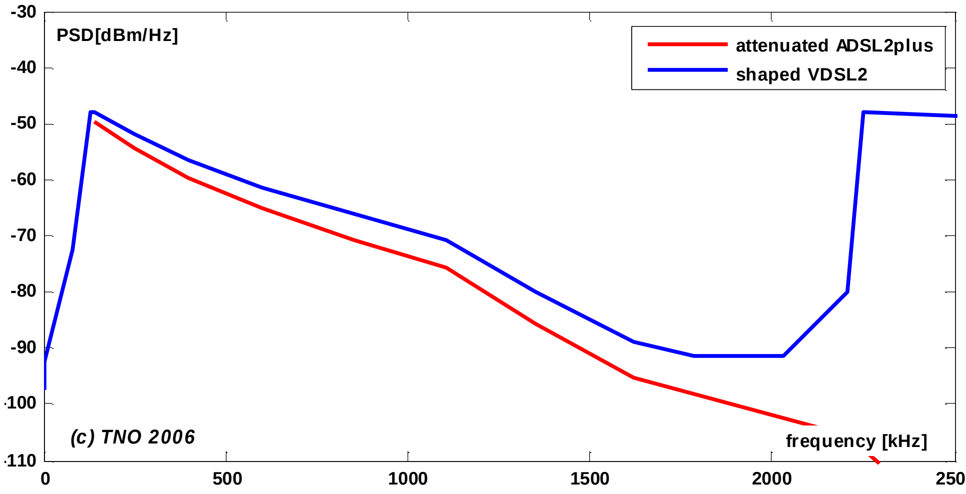

Figure 3: Example of how much the PSD may change if the "shaping distance" would have been made equal to the attenuation distance.

Approach for finding the PSD masks and maximum aggregate power.
All shapes have been evaluated from the PSD templates of involved systems.

- To derive a reasonable value for some *nominal* value of the spectrum, a first PSD mask was set to the template values, and serves as a signal limit when measuring the signal spectra in 100 kHz resolution bandwidth (and above the usable frequency bands even within 1MHz resolution bandwidth).
- To derive a reasonable value for some *peak* value of the spectrum, a second PSD mask was set to a value that is 3.5 dB higher then this template values, and serves a signal limit when measuring the signal spectra in 10 kHz resolution bandwidth.
- A signal should not exceed either of these limits.
- Outside the “shapingband” the limits of the originating PSD masks B8-4 are respected as much as possible.

In addition, the aggregate power that should never be exceeded was evaluated by calculating the power of a signal that occupies the PSD template to its full extent. This caused that for some loop-length a power is allowed that is higher then current VDSL2 implementations can generate. This is no issue of any concern since it is a signal description of *upper limits* only.
Mandatory power back-off in the *upstream* is explicitly foreseen, but currently left for further study.

3. Full description of the proposed signals

START OF LITERAL TEXT PROPOSAL
(References to clauses without further specification refer to the SpM-1 standard itself)

3.1. "VDSL2-NL1" signals

This category covers signals up to 12 MHz, generated by VDSL2 transmission equipment using band plan 998 (limit PSD mask B8-4). These signals may share the same wire pair with POTS signals.
This signal description is derived from the ITU VDSL2 recommendation [1], and enhanced by loop dependent PSD shaping, also known as downstream Power Backoff. The signal limits are therefore dependent on the *attenuation distance* between the local exchange and cabinet (“primary cable”), defined as the insertion loss (IL) of that loop measured at 300 kHz into a resistive load of 100 Ω.
The limits in this description are specified for a discrete number of (integer) attenuation distances. For all other attenuation distances, the limits for the nearest specified IL-values apply, and not by means of interpolating the limits.
A signal can be classified as a “VDSL2-NL1” signal if it is compliant with all clauses below.

3.1.1. Total signal power (downstream only)

To be compliant with this signal category, the mean downstream signal power into a resistive load of 100 Ω shall not exceed the levels given in table 1, measured within a frequency band from at least 4 kHz to 30 MHz. In the special case of VDSL2 deployment from the local exchange, the limits associated with IL=0 apply.

Reference: ITU- T Recommendation G.993.2 [1], chapter 6.

Table 1: Total downstream signal power as function of the measured insertion loss of the loop between local exchange and cabinet.

	IL [dB @ 300 kHz]	Downstream Total signal power [dBm]		L [m]	
	0	21,28		0	
	1	20,11		101	
	2	19,02		202	
	3	18,02		303	
	4	17,09		404	
	5	16,26		506	
	6	15,51		607	
	7	14,85		708	
	8	14,27		809	
	9	13,77		910	
	10	13,37		1011	
	11	12,95		1112	
	12	12,65		1213	
	13	12,4		1315	
	14	12,2		1416	
	15	12,04		1517	
	16	11,91		1618	
	17	11,81		1719	
	18	11,73		1820	
	19	11,66		1921	
	20	11,6		2022	
	21	11,55		2123	
	22	11,52		2225	
	23	11,48		2326	
	24	11,46		2427	
	25	11,7		2528	
	26	11,91		2629	
	27	12,15		2730	
	28	12,36		2831	
	29	12,55		2932	
	30	12,7		3034	
	31	12,82		3135	
	32	12,98		3236	
	33	13,15		3337	
	34	13,32		3438	
	35	13,56		3539	
	36	13,8		3640	
	37	14,03		3741	
	38	14,36		3842	
	39	14,67		3944	
	40	14,98		4045	
	41	15,36		4146	
	42	16,07		4247	
	43	16,63		4348	
	44	17,11		4449	
	45	17,49		4550	
	>45	17,5		>4550	

NOTE 1: The IL-values are normative. The L-values are informative and represent estimated loop lengths for a commonly used Dutch cable.

NOTE 2: Current implementations of VDSL2 transmitters, compliant with [1], are not expected to be capable of generating output powers of more then 20,5 dBm

NOTE 3: The power limit specified for IL>45 dB may be too restrictive for VDSL2; refinement is for further study.

3.1.2. Total signal power (upstream only)

To be compliant with this signal category, the mean upstream signal power into a resistive load of 100 Ω shall not exceed a level of +14,5 dBm, measured within a frequency band from at least 4 kHz to 30 MHz.

NOTE: This power limit is based on maxima specified in [1]. The use of (mandatory) upstream Power Back-off is foreseen, but left for further study

Reference: ITU- T Recommendation G.993.2 [1], chapter 6.

3.1.3. Peak amplitude (upstream and downstream)

To be compliant with this signal category, the nominal voltage peak of the largest signal pulse into a resistive load of 100 Ω shall not exceed a level of 19V (38 V peak-peak), measured within a frequency band from at least 100 Hz to 30 MHz. The definition and measurement method of peak amplitude is specified in clause 13.1.

3.1.4. Narrow-band signal power (downstream only)

To be compliant with this signal category, the Narrow-Band Signal Power (NBSP) into a resistive load impedance ***R*** for a given attenuation distance, shall not exceed the limits given in table 2 and 3, at any point in the frequency range 100 Hz to 30 MHz. These tables specify the break points of these limits. Limits for intermediate frequencies can be found by drawing a straight line between the break points on a logarithmic (Hz) **-** linear (dB) scale below 2500 kHz and on a linear (Hz) **-** linear (dB) scale above 2500 kHz. Figure 4 and 5 illustrate the NBSP in a bandwidth-normalized way.
The NBSP is the average power ***P*** of a sending signal into a load resistance ***R***, within a *power* bandwidth ***B***. The measurement method of the NBSP is described in clause 13.2.

NOTE 1: The NBSP specification in table 2 is reconstructed from the commonly used PSD specifications in [1] (similar to figure 4), and used here since it is much wider applicable. This enables a unified specification method. PSD specifications are adequate when signals are purely random in nature, but cannot cover harmonic components in a signal (would cause infinite high "PSD" levels at these harmonic frequencies). NBSP specifications cover both signal types.

NOTE 2: The NBSP specification of this signal category has been split into three overlapping limits: "X", “Y” and "Z". All these upper limits shall hold simultaneously. The 10 kHz bandwidth values represent the "peak PSD values" from [1], and includes the pass band ripple. The 100 kHz bandwidth values represent the "nomanal PSD values" in the passband to smooth out the spectral ripple of 3,5 dB. The 1 MHz bandwidth specification is equivalent to the sliding window specification, being common for ADSL (see 3 and 4).

NOTE 3: The description of this signal characteristic is derived from “VDSL2 band plan 998” signals with PSD mask “B8-4”. Downstream PSD Shaping has been applied between 80 KHz and 2500 kHz.

Reference: ITU-T Recommendation G.993.2 [1], clause B.2.5.

Table 2 Break points of the narrow-band power limits

Centre frequency f	Impedance R	Signal Level P	Power bandwidth B	Spectral Power P/B	
0,1 kHz	600 Ω	-77,5 dBm	100 Hz	-97,5 dBm/Hz	“X”
4 kHz	600 Ω	-77,5 dBm	100 Hz	-97,5 dBm/Hz	
4 kHz	100 Ω	-52,5 dBm	10 kHz	-92,5 dBm/Hz	
f_1	100 Ω	P_1 + 40 dB	10 kHz	P_1	
f_2	100 Ω	P_2 + 40 dB	10 kHz	P_2	
f_3	100 Ω	P_3 + 40 dB	10 kHz	P_3	
f_4	100 Ω	P_4 + 40 dB	10 kHz	P_4	
f_5	100 Ω	P_5 + 40 dB	10 kHz	P_5	
f_6	100 Ω	P_6 + 40 dB	10 kHz	P_6	
f_7	100 Ω	P_7 + 40 dB	10 kHz	P_7	
f_8	100 Ω	P_8 + 40 dB	10 kHz	P_8	
f_9	100 Ω	P_9 + 40 dB	10 kHz	P_9	
f_{10}	100 Ω	P_{10} + 40 dB	10 kHz	P_{10}	
f_{11}	100 Ω	P_{11} + 40 dB	10 kHz	P_{11}	
f_{12}	100 Ω	P_{12} + 40 dB	10 kHz	P_{12}	
f_{13}	100 Ω	P_{13} + 40 dB	10 kHz	P_{13}	
f_{14}	100 Ω	P_{14} + 40 dB	10 kHz	P_{14}	
2500 kHz	100 Ω	-8,8 dBm	10 kHz	-48,8 dBm/Hz	
3749,999 kHz	100 Ω	-11,2 dBm	10 kHz	-51,2 dBm/Hz	
3750 kHz	100 Ω	-40 dBm	10 kHz	-80 dBm/Hz	
3925 kHz	100 Ω	-60 dBm	10 kHz	-100 dBm/Hz	
4925 kHz	100 Ω	-60 dBm	10 kHz	-100 dBm/Hz	
5025 kHz	100 Ω	-60 dBm	10 kHz	-100 dBm/Hz	
5199,999 kHz	100 Ω	-40 dBm	10 kHz	-80 dBm/Hz	
5200 kHz	100 Ω	-12,7 dBm	10 kHz	-52,7 dBm/Hz	
8499,999 kHz	100 Ω	-14,8 dBm	10 kHz	-54,8 dBm/Hz	
8500 kHz	100 Ω	-40 dBm	10 kHz	-80 dBm/Hz	
8675 kHz	100 Ω	-60 dBm	10 kHz	-100 dBm/Hz	
30000 kHz	100 Ω	-60 dBm	10 kHz	-100 dBm/Hz	
50 kHz	100 Ω	-46 dBm	100 kHz	-96 dBm/Hz	“Y”
f_1	100 Ω	P_1 + 46,5 dB	100 kHz	P_1 –3,5 dB	
f_2	100 Ω	P_2 + 46,5 dB	100 kHz	P_2 –3,5 dB	
f_3	100 Ω	P_3 + 46,5 dB	100 kHz	P_3 –3,5 dB	
f_4	100 Ω	P_4 + 46,5 dB	100 kHz	P_4 –3,5 dB	
f_5	100 Ω	P_5 + 46,5 dB	100 kHz	P_5 –3,5 dB	
f_6	100 Ω	P_6 + 46,5 dB	100 kHz	P_6 –3,5 dB	
f_7	100 Ω	P_7 + 46,5 dB	100 kHz	P_7 –3,5 dB	
f_8	100 Ω	P_8 + 46,5 dB	100 kHz	P_8 –3,5 dB	
f_9	100 Ω	P_9 + 46,5 dB	100 kHz	P_9 –3,5 dB	
f_{10}	100 Ω	P_{10} + 46,5 dB	100 kHz	P_{10} –3,5 dB	
f_{11}	100 Ω	P_{11} + 46,5 dB	100 kHz	P_{11} –3,5 dB	
f_{12}	100 Ω	P_{12} + 46,5 dB	100 kHz	P_{12} –3,5 dB	
f_{13}	100 Ω	P_{13} + 46,5 dB	100 kHz	P_{13} –3,5 dB	
f_{14}	100 Ω	P_{14} + 46,5 dB	100 kHz	P_{14} –3,5 dB	
2500 kHz	100 Ω	-2,3 dBm	100 kHz	-52,3 dBm/Hz	
3749,999 kHz	100 Ω	-4,5 dBm	100 kHz	-54,7 dBm/Hz	
3750 kHz	100 Ω	-33,5 dBm	100 kHz	-83,5 dBm/Hz	
3894 kHz	100 Ω	-50 dBm	100 kHz	-100 dBm/Hz	
3999,999 kHz	100 Ω	-50 dBm	100 kHz	-100 dBm/Hz	
4000 kHz	100 Ω	-60 dBm	100 kHz	-110 dBm/Hz	
5055 kHz	100 Ω	-60 dBm	100 kHz	-110 dBm/Hz	
5056 kHz	100 Ω	-62 dBm	100 kHz	-99,9 dBm/Hz	
5199,999 kHz	100 Ω	-33,5 dBm	100 kHz	-83,5 dBm/Hz	
5200 kHz	100 Ω	-6,2 dBm	100 kHz	-56,2 dBm/Hz	
8499,999 kHz	100 Ω	-8,3 dBm	100 kHz	-58,3 dBm/Hz	
8500 kHz	100 Ω	-33,5 dBm	100 kHz	-83,5 dBm/Hz	
8644 kHz	100 Ω	-50 dBm	100 kHz	-100 dBm/Hz	

Centre frequency f	Impedance R	Signal Level P	Power bandwidth B	Spectral Power P/B	
8645 kHz	100 Ω	-60 dBm	100 kHz	-110 dBm/Hz	
30000 kHz	100 Ω	-60 dBm	100 kHz	-110 dBm/Hz	
9145 kHz	100 Ω	-52 dBm	1 MHz	-112 dBm/Hz	“Z”
30000 kHz	100 Ω	-52 dBm	1 MHz	-112 dBm/Hz	
Note 1: The limits between breakpoints shall be obtained by interpolation between adjacent breakpoints on a dB/ log(f) basis below 2500 kHz and on a dB/f basis above 2500 kHz Note 2: The limits “Y” between 50 kHz and 2500 kHz are 3,5 dB lower then the associated limits “X”. This may be a bit too restrictive for VDSL2 when the PSD slope in this shaping region becomes steep. Refinements for the limits at these breakpoints require further study.					

Table 3: Definition of parameter f_i and P_i, (with i = 1 to 14) as used in table 2.

IL		f_1 P_1	f_2 P_2	f_3 P_3	f_4 P_4	f_5 P_5	f_6 P_6	f_7 P_7	f_8 P_8	f_9 P_9	f_{10} P_{10}	f_{11} P_{11}	f_{12} P_{12}	f_{13} P_{13}	f_{14} P_{14}
0	f	80	137,999	138	1104	1622	2208	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
	P	-72,5	-44,2	-36,5	-36,5	-46,5	-48	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
1	f	80	137,999	138	600	1104	1622	2208	2211	N/A	N/A	N/A	N/A	N/A	N/A
	P	-72,5	-44,2	-37,1	-37,7	-38,2	-48,6	-50,3	-48	N/A	N/A	N/A	N/A	N/A	N/A
2	f	80	137,999	138	250	600	1104	1622	2208	2214	N/A	N/A	N/A	N/A	N/A
	P	-72,5	-44,2	-37,6	-38	-38,9	-39,8	-50,6	-52,7	-48	N/A	N/A	N/A	N/A	N/A
3	f	80	137,999	138	250	400	600	850	1104	1622	2208	2217	N/A	N/A	N/A
	P	-72,5	-44,2	-38,2	-38,8	-39,5	-40,1	-40,9	-41,5	-52,7	-55,2	-48	N/A	N/A	N/A
4	f	80	137,999	138	250	400	600	850	1104	1622	2208	2220	N/A	N/A	N/A
	P	-72,5	-44,2	-38,7	-39,5	-40,4	-41,4	-42,3	-43,2	-54,8	-57,6	-48	N/A	N/A	N/A
5	f	80	137,999	138	250	400	600	850	1104	1350	1622	2208	2223	N/A	N/A
	P	-72,5	-44,2	-39,3	-40,3	-41,4	-42,6	-43,8	-44,9	-51,1	-56,8	-60,1	-48,1	N/A	N/A
6	f	80	137,999	138	250	400	600	850	1104	1350	1622	2208	2226	N/A	N/A
	P	-72,5	-44,2	-39,8	-41,1	-42,4	-43,8	-45,2	-46,5	-52,9	-58,9	-62,5	-48,1	N/A	N/A
7	f	80	137,999	138	250	400	600	850	1104	1350	1622	2208	2229	N/A	N/A
	P	-72,5	-44,2	-40,4	-41,8	-43,4	-45	-46,7	-48,2	-54,8	-61	-65	-48,2	N/A	N/A
8	f	80	137,999	138	250	400	600	850	1104	1350	1622	2208	2232	N/A	N/A
	P	-72,5	-44,2	-41	-42,6	-44,4	-46,2	-48,1	-49,9	-56,7	-63	-67,5	-48,3	N/A	N/A
9	f	80	137,999	138	250	400	600	850	1104	1350	1622	2208	2235	N/A	N/A
	P	-72,5	-44,2	-41,5	-43,3	-45,4	-47,4	-49,6	-51,6	-58,5	-65,1	-69,9	-48,3	N/A	N/A
10	f	80	137,999	138	250	400	600	850	1104	1350	1622	2208	2239	N/A	N/A
	P	-72,5	-44,2	-42,1	-44,1	-46,4	-48,7	-51,1	-53,3	-60,5	-67,3	-72,5	-48,1	N/A	N/A
11	f	80	137,999	138	250	400	600	850	1104	1350	1622	2208	2242	N/A	N/A
	P	-72,5	-44,2	-42,7	-45	-47,5	-50,1	-52,8	-55,2	-62,6	-69,6	-75,3	-48,2	N/A	N/A
12	f	80	137,999	138	250	400	600	850	1104	1350	1622	2208	2246	N/A	N/A
	P	-72,5	-44,2	-43,4	-45,8	-48,6	-51,5	-54,4	-57,1	-64,7	-71,9	-78,1	-48,1	N/A	N/A
13	f	80	137,999	138	250	400	600	850	1104	1350	1622	2198	2208	2248	N/A
	P	-72,5	-44,2	-44	-46,7	-49,7	-52,8	-56	-58,9	-66,8	-74,2	-80,6	-80	-48,1	N/A
14	f	80	137	250	400	600	850	1104	1350	1622	2162	2208	2248	N/A	N/A
	P	-72,5	-44,6	-47,5	-50,7	-54,1	-57,6	-60,7	-68,8	-76,4	-82,9	-80	-48,1	N/A	N/A
15	f	80	136	138	250	400	600	850	1104	1350	1622	2129	2208	2248	N/A
	P	-72,5	-45,1	-45,1	-48,3	-51,8	-55,4	-59,1	-62,5	-70,7	-78,6	-85,1	-80	-48,1	N/A
16	f	80	134	138	250	400	600	850	1104	1350	1622	2097	2208	2248	N/A
	P	-72,5	-45,7	-45,7	-49,1	-52,8	-56,6	-60,6	-64,2	-72,6	-80,7	-87,2	-80	-48,1	N/A
17	f	80	133	138	250	400	600	850	1104	1350	1622	2067	2208	2248	N/A
	P	-72,5	-46,3	-46,3	-49,8	-53,8	-57,8	-62	-65,9	-74,5	-82,8	-89,2	-80	-48,1	N/A
18	f	80	131	138	250	400	600	850	1104	1350	1622	2039	2208	2248	N/A
	P	-72,5	-46,9	-46,8	-50,6	-54,7	-59	-63,5	-67,5	-76,3	-84,8	-91,1	-80	-48,1	N/A
19	f	80	130	138	250	400	600	850	1104	1350	1622	1912	2033	2208	2248
	P	-72,5	-47,3	-47,3	-51,3	-55,7	-60,2	-64,9	-69,1	-78,1	-86,7	-91,5	-91,5	-80	-48,1
20	f	80	129	138	250	400	600	850	1104	1350	1622	1782	2033	2208	2248
	P	-72,5	-47,9	-47,9	-52	-56,6	-61,3	-66,2	-70,6	-79,8	-88,7	-91,5	-91,5	-80	-48,1
21	f	80	127	138	250	400	600	850	1104	1350	1622	1673	2033	2208	2248
	P	-72,5	-48,5	-48,4	-52,7	-57,5	-62,4	-67,5	-72,2	-81,5	-90,5	-91,5	-91,5	-80	-48,1
22	f	80	126	138	250	400	600	850	1104	1350	1594	2033	2208	2248	N/A

IL		f_1 P_1	f_2 P_2	f_3 P_3	f_4 P_4	f_5 P_5	f_6 P_6	f_7 P_7	f_8 P_8	f_9 P_9	f_{10} P_{10}	f_{11} P_{11}	f_{12} P_{12}	f_{13} P_{13}	f_{14} P_{14}
	P	-72,5	-48,9	-48,9	-53,3	-58,3	-63,5	-68,8	-73,6	-83,2	-91,5	-91,5	-80	-48,1	N/A
23	f	80	125	138	250	400	600	850	1104	1350	1540	2033	2208	2248	N/A
	P	-72,5	-49,3	-49,3	-54	-59,2	-64,5	-70,1	-75,1	-84,8	-91,5	-91,5	-80	-48,1	N/A
24	f	80	124	138	250	400	600	850	1104	1350	1491	2031	2206	2246	N/A
	P	-72,5	-49,8	-49,8	-54,6	-60	-65,5	-71,3	-76,5	-86,3	-91,5	-91,5	-80	-48,1	N/A
25	f	80	123	138	250	400	600	850	1104	1350	1447	1911	2086	2126	2208
	P	-72,5	-50,3	-50,3	-55,2	-60,8	-66,5	-72,5	-77,8	-87,8	-91,5	-91,5	-80	-47,8	-48
26	f	80	122	138	250	400	600	850	1104	1350	1406	1807	1982	2022	2208
	P	-72,5	-50,7	-50,7	-55,8	-61,6	-67,5	-73,6	-79,2	-89,3	-91,5	-91,5	-80	-47,6	-48
27	f	80	121	138	250	400	600	850	1104	1369	1693	1868	1908	2208	N/A
	P	-72,5	-51,1	-51,1	-56,4	-62,3	-68,4	-74,7	-80,4	-91,5	-91,5	-80	-47,3	-48	N/A
28	f	80	120	138	250	400	600	850	1104	1334	1593	1768	1808	2208	N/A
	P	-72,5	-51,5	-51,5	-57	-63,1	-69,3	-75,8	-81,7	-91,5	-91,5	-80	-47	-48	N/A
29	f	80	119	138	250	400	600	850	1104	1301	1505	1680	1720	2208	N/A
	P	-72,5	-51,9	-51,9	-57,5	-63,8	-70,2	-76,8	-82,9	-91,5	-91,5	-80	-46,8	-48	N/A
30	f	80	118	138	250	400	600	850	1104	1270	1433	1608	1648	2208	N/A
	P	-72,5	-52,3	-52,3	-58,1	-64,5	-71	-77,9	-84	-91,5	-91,5	-80	-46,6	-48	N/A
31	f	80	117	138	250	400	600	850	1104	1240	1380	1555	1595	1622	2208
	P	-72,5	-52,8	-52,7	-58,6	-65,2	-71,9	-78,9	-85,2	-91,5	-91,5	-80	-46,1	-46,5	-48
32	f	80	116	138	250	400	600	850	1104	1205	1322	1497	1538	1622	2208
	P	-72,5	-53,2	-53,2	-59,3	-66	-73	-80,2	-86,7	-91,5	-91,5	-80	-45,1	-46,5	-48
33	f	80	115	138	250	400	600	850	1104	1172	1268	1443	1485	1622	2208
	P	-72,5	-53,7	-53,7	-59,9	-66,9	-74	-81,5	-88,2	-91,5	-91,5	-80	-44,2	-46,5	-48
34	f	80	114	138	250	400	600	850	1104	1141	1217	1392	1434	1622	2208
	P	-72,5	-54,2	-54,2	-60,6	-67,8	-75,1	-82,7	-89,6	-91,5	-91,5	-80	-43,6	-46,5	-48
35	f	80	113	138	250	400	600	850	1104	1111	1169	1344	1387	1622	2208
	P	-72,5	-54,7	-54,7	-61,3	-68,6	-76,2	-84	-91,1	-91,5	-91,5	-80	-42,4	-46,5	-48
36	f	80	112	138	250	400	600	850	1061	1122	1297	1341	1622	2208	N/A
	P	-72,5	-55,2	-55,2	-61,9	-69,5	-77,2	-85,3	-91,5	-91,5	-80	-41,6	-46,5	-48	N/A
37	f	80	111	138	250	400	600	850	1009	1077	1252	1296	1622	2208	N/A
	P	-72,5	-55,7	-55,7	-62,6	-70,4	-78,3	-86,6	-91,5	-91,5	-80	-41	-46,5	-48	N/A
38	f	80	110	138	250	400	600	850	962	1036	1211	1256	1622	2208	N/A
	P	-72,5	-56,2	-56,2	-63,3	-71,2	-79,4	-87,9	-91,5	-91,5	-80	-39,9	-46,5	-48	N/A
39	f	80	109	138	250	400	600	850	919	996	1171	1217	1622	2208	N/A
	P	-72,5	-56,6	-56,6	-63,9	-72,1	-80,5	-89,2	-91,5	-91,5	-80	-39	-46,5	-48	N/A
40	f	80	108	138	250	400	600	850	880	959	1134	1180	1622	2208	N/A
	P	-72,5	-57,1	-57,1	-64,6	-73	-81,5	-90,4	-91,5	-91,5	-80	-38,3	-46,5	-48	N/A
41	f	80	107	138	250	400	600	843	921	1096	1143	1622	2208	N/A	N/A
	P	-72,5	-57,6	-57,6	-65,3	-73,8	-82,6	-91,5	-91,5	-80	-37,4	-46,5	-48	N/A	N/A
42	f	80	106	138	250	400	600	803	857	1032	1079	1104	1622	2208	N/A
	P	-72,5	-58,1	-58,1	-66	-74,7	-83,7	-91,5	-91,5	-80	-36,5	-36,5	-46,5	-48	N/A
43	f	80	105	138	250	400	600	768	800	975	1021	1104	1622	2208	N/A
	P	-72,5	-58,6	-58,6	-66,6	-75,6	-84,8	-91,5	-91,5	-80	-36,7	-36,5	-46,5	-48	N/A
44	f	80	104	138	250	400	600	735	749	924	970	1104	1622	2208	N/A
	P	-72,5	-59,1	-59,1	-67,3	-76,4	-85,8	-91,5	-91,5	-80	-36,5	-36,5	-46,5	-48	N/A
45	f	80	103	138	250	400	600	703	877	922	1104	1622	2208	N/A	N/A
	P	-72,5	-59,6	-59,6	-68	-77,3	-86,9	-91,4	-80	-36,5	-36,5	-46,5	-48	N/A	N/A
>45	f	80	103	138	250	400	600	703	877	922	1104	1622	2208	N/A	N/A
	P	-91,5	-91,5	-91,5	-91,5	-91,5	-91,5	-91,4	-80	-36,5	-36,5	-46,5	-48	N/A	N/A

NOTE 1: The label “N/A” denotes that a breakpoint is not used. The equivalent physical cable length L of the cable (last column of the table) is for information only, and estimated from a 0.5 mm GPLK cable model (model “KPN_L1”, also known as “TP 150” in [2]).

NOTE 2: The breakpoints for IL > 45 dB may be too restrictive for VDSL2, refinements are for further study.

In the special case that VDSL2 is deployed from the local exchange, the attenuation length is zero (IL=0), and the associated rows from the table apply. Figure 4 illustrates the limits of the spectral powers (measured in 10 kHz and in 100 kHz) as function of the frequency, according to the specifications in table 2 and 3.

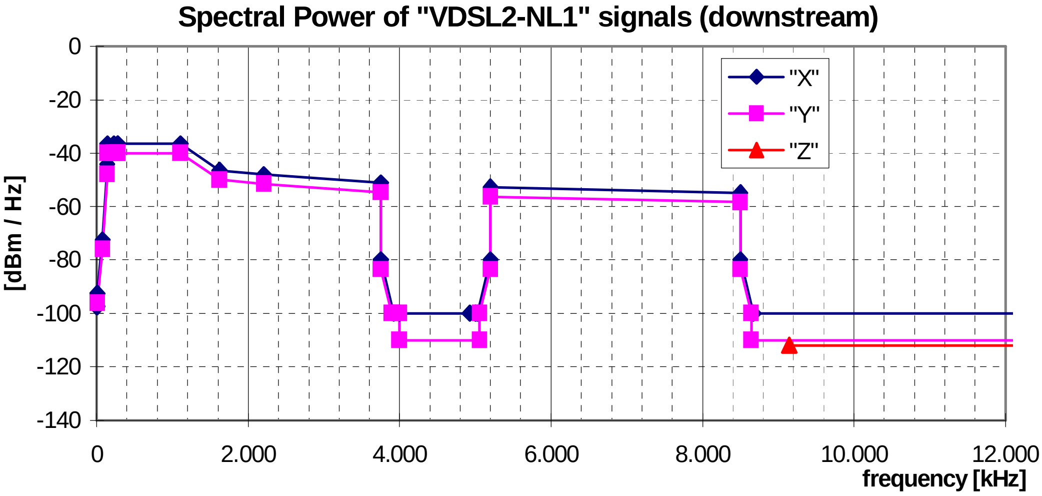

Figure 4: Spectral Power for “VDSL2-NL1” signals, as specified in table 2 and 3 for IL=0 dB.

When VDSL2 is deployed from the cabinet, shaping of the above spectral powers between 134 kHz and 2500 kHz can be significant. Figure 5 illustrates the limits of these spectral powers (measured in 10 kHz and in 100 kHz) for various attenuation distances (for IL =10 dB, IL=20 dB and IL=40 dB).

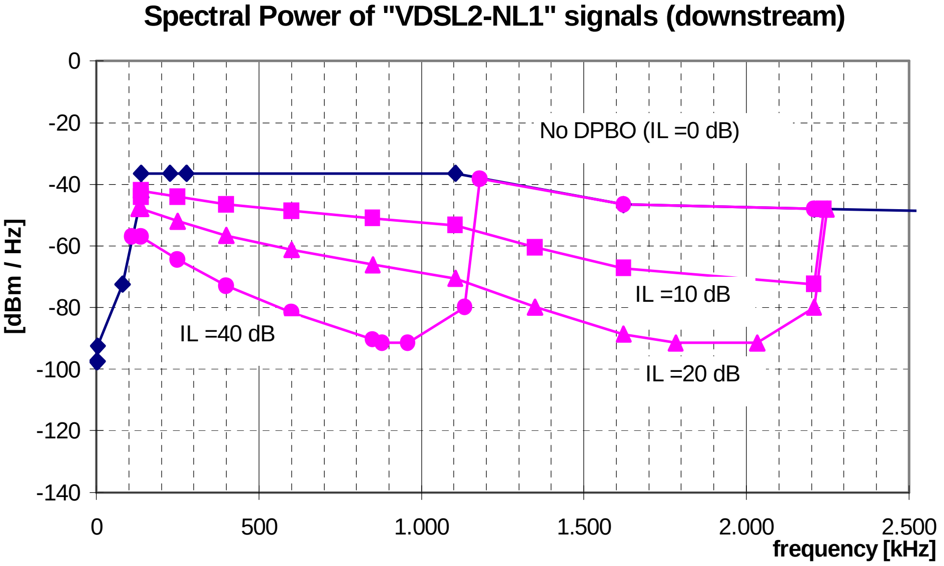

Figure 5: Spectral Power for “VDSL2-NL1” signals, as specified in table 2 and 3, for a frequency band where downstream PSD Shaping has been applied.

3.1.5. Narrow-band signal power (upstream only)

To be compliant with this signal category, the Narrow-Band Signal Power (NBSP) into a resistive load impedance R, shall not exceed the limits given in table 4, at any point in the frequency range 100 Hz to 30 MHz. This table specifies the break points of these limits. Limits for intermediate frequencies can be found by drawing a straight line between the break points on a logarithmic (Hz) - linear (dB) scale below 3575 KHz and linear (Hz) - linear (dB) scale above 3575 KHz. Figure 6 illustrates the NBSP in a bandwidth-normalized way.
The NBSP is the average power ***P*** of a sending signal into a load resistance ***R***, within a *power* bandwidth ***B***. The measurement method of the NBSP is described in clause 13.2.

NOTE 1: The NBSP specification in table 4 is reconstructed from the commonly used PSD specifications in [1] (similar to figure 6), and used here since it is much wider applicable. This enables a unified specification method. PSD specifications are adequate when signals are purely random in nature, but cannot cover harmonic components in a signal (would cause infinite high "PSD" levels at these harmonic frequencies). NBSP specifications cover both signal types.

NOTE 2: The NBSP specification of this signal category has been split into three overlapping limits: "X", "Y" and "Z". All three upper limits hold simultaneously. The 10 kHz bandwidth values represent the "maximum PSD values" from [1], and includes the pass band ripple. The 100 kHz bandwidth values represent the "average PSD values" in the pass band to smooth out the spectral ripple of 3,5 dB. The 1 MHz bandwidth specification is equivalent to the sliding window specification being common for ADSL (see [3] and [4]).

NOTE 3: The need for the inclusion of a normative upstream power back-off specification is foreseen. This topic is currently under discussion within ETSI and the ITU, and therefore left for further study in the present document.

Reference: ITU-T Recommendation G.993.2 [1], clause B2.4 reconstructed from PSD requirements.

Table 4: Break points of the narrow-band power limits

Centre frequency f	**Impedance R**	**Signal Level P**	**Power bandwidth B**	**Spectral Power P/B**	
0,1 kHz	600 Ω	-77,5 dBm	100 Hz	-97,5 dBm/Hz	“X”
4 kHz	600 Ω	-77,5 dBm	100 Hz	-97,5 dBm/Hz	
4 kHz	100 Ω	-52,5 dBm	10 kHz	-92,5 dBm/Hz	
25,875 kHz	100 Ω	5,5 dBm	10 kHz	-34,5 dBm/Hz	
50 kHz	100 Ω	5,5 dBm	10 kHz	-34,5 dBm/Hz	
80 kHz	100 Ω	5,5 dBm	10 kHz	-34,5 dBm/Hz	
120 kHz	100 Ω	5,5 dBm	10 kHz	-34,5 dBm/Hz	
138 kHz	100 Ω	5,5 dBm	10 kHz	-34,5 dBm/Hz	
243 kHz	100 Ω	-53,2 dBm	10 kHz	-93,2 dBm/Hz	
686 kHz	100 Ω	-60 dBm	10 kHz	-100 dBm/Hz	
783 kHz	100 Ω	-60 dBm	10 kHz	-100 dBm/Hz	
2825 kHz	100 Ω	-60 dBm	10 kHz	-100 dBm/Hz	
3000 kHz	100 Ω	-60 dBm	10 kHz	-100 dBm/Hz	
3000 kHz	100 Ω	-60 dBm	10 kHz	-100 dBm/Hz	
3575 kHz	100 Ω	-60 dBm	10 kHz	-100 dBm/Hz	
3750 kHz	100 Ω	-40 dBm	10 kHz	-80 dBm/Hz	
3750 kHz	100 Ω	-11,2 dBm	10 kHz	-51,2 dBm/Hz	
5200 kHz	100 Ω	-12,7 dBm	10 kHz	-52,7 dBm/Hz	
5200 kHz	100 Ω	-40 dBm	10 kHz	-80 dBm/Hz	
5375 kHz	100 Ω	-60 dBm	10 kHz	-100 dBm/Hz	
6875 kHz	100 Ω	-60 dBm	10 kHz	-100 dBm/Hz	
7050 kHz	100 Ω	-60 dBm	10 kHz	-100 dBm/Hz	
7050 kHz	100 Ω	-60 dBm	10 kHz	-100 dBm/Hz	
8325 kHz	100 Ω	-60 dBm	10 kHz	-100 dBm/Hz	
8500 kHz	100 Ω	-40 dBm	10 kHz	-80 dBm/Hz	
8500 kHz	100 Ω	-14,8 dBm	10 kHz	-54,8 dBm/Hz	
10000 kHz	100 Ω	-15,5 dBm	10 kHz	-55,5 dBm/Hz	
12000 kHz	100 Ω	-16,5 dBm	10 kHz	-56,5 dBm/Hz	
12000 kHz	100 Ω	-40 dBm	10 kHz	-80 dBm/Hz	
12175 kHz	100 Ω	-60 dBm	10 kHz	-100 dBm/Hz	
14350 kHz	100 Ω	-60 dBm	10 kHz	-100 dBm/Hz	
14351 kHz	100 Ω	-60 dBm	10 kHz	-100 dBm/Hz	

Centre frequency f	**Impedance R**	**Signal Level P**	**Power bandwidth B**	**Spectral Power P/B**	
14526 kHz	100 Ω	-60 dBm	10 kHz	-100 dBm/Hz	
30000 kHz	100 Ω	-60 dBm	10 kHz	-100 dBm/Hz	
50 kHz	100 Ω	18 dBm	100 kHz	-38 dBm/Hz	“Y”
80 kHz	100 Ω	18 dBm	100 kHz	-38 dBm/Hz	
120 kHz	100 Ω	18 dBm	100 kHz	-38 dBm/Hz	
138 kHz	100 Ω	18 dBm	100 kHz	-38 dBm/Hz	
243 kHz	100 Ω	-46,7 dBm	100 kHz	-96,7 dBm/Hz	
686 kHz	100 Ω	-50 dBm	100 kHz	-100 dBm/Hz	
783 kHz	100 Ω	-50 dBm	100 kHz	-100 dBm/Hz	
2825 kHz	100 Ω	-50 dBm	100 kHz	-100 dBm/Hz	
2999,999 kHz	100 Ω	-50 dBm	100 kHz	-100 dBm/Hz	
3000 kHz	100 Ω	-50 dBm	100 kHz	-100 dBm/Hz	
3575 kHz	100 Ω	-50 dBm	100 kHz	-100 dBm/Hz	
3749,999 kHz	100 Ω	-33,5 dBm	100 kHz	-83,5 dBm/Hz	
3750 kHz	100 Ω	-5,7 dBm	100 kHz	-54,7 dBm/Hz	
5199,999 kHz	100 Ω	-6,2 dBm	100 kHz	-56,2 dBm/Hz	
5200 kHz	100 Ω	-33,5 dBm	100 kHz	-83,5 dBm/Hz	
5375 kHz	100 Ω	-60 dBm	100 kHz	-110 dBm/Hz	
6875 kHz	100 Ω	-60 dBm	100 kHz	-110 dBm/Hz	
7049,999 kHz	100 Ω	-60 dBm	100 kHz	-110 dBm/Hz	
7050 kHz	100 Ω	-60 dBm	100 kHz	-110 dBm/Hz	
8325 kHz	100 Ω	-60 dBm	100 kHz	-110 dBm/Hz	
8499,999 kHz	100 Ω	-33,5 dBm	100 kHz	-83,5 dBm/Hz	
8500 kHz	100 Ω	-8,3 dBm	100 kHz	-58,3 dBm/Hz	
10000 kHz	100 Ω	-9 dBm	100 kHz	-59 dBm/Hz	
11999,999 kHz	100 Ω	-10 dBm	100 kHz	-60 dBm/Hz	
12000 kHz	100 Ω	-33,5 dBm	100 kHz	-83,5 dBm/Hz	
12175 kHz	100 Ω	-60 dBm	100 kHz	-110 dBm/Hz	
14350 kHz	100 Ω	-60 dBm	100 kHz	-110 dBm/Hz	
14351 kHz	100 Ω	-60 dBm	100 kHz	-110 dBm/Hz	
14526 kHz	100 Ω	-60 dBm	100 kHz	-110 dBm/Hz	
30000 kHz	100 Ω	-60 dBm	100 kHz	-110 dBm/Hz	
12675 kHz	100 Ω	-52 dBm	1 MHz	-112 dBm/Hz	“Z”
14350 kHz	100 Ω	-52 dBm	1 MHz	-112 dBm/Hz	
14351 kHz	100 Ω	-52 dBm	1 MHz	-112 dBm/Hz	
14526 kHz	100 Ω	-52 dBm	1 MHz	-112 dBm/Hz	
30000 kHz	100 Ω	-52 dBm	1 MHz	-112 dBm/Hz	

NOTE 1: The PSD values between breakpoints shall be obtained by interpolation between adjacent breakpoints as follows:

- below *3575* kHz: on a dB / $\log_{10}(f)$ basis and
- above *3575* kHz: on a dB / f basis

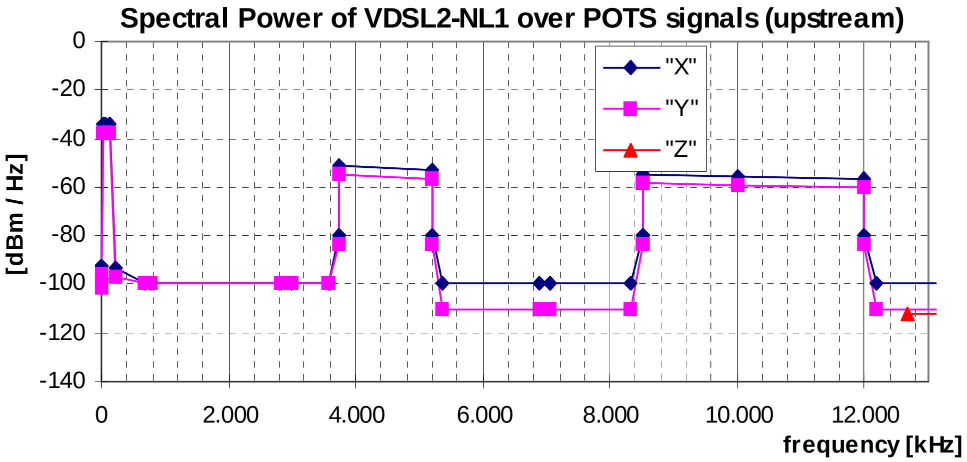

Figure 6: Spectral Power, for "VDSL2-NL1" signals, as specified in table 4.

3.1.6. Unbalance about earth (upstream and downstream)

To be compliant with this signal category, the balance of the signal that may flow through the LT-port or NT-port shall exceed minimum requirements, under the condition that the local loop wiring and its termination is well balanced. This can be verified by a Longitudinal Output Voltage (LOV) and a Longitudinal Conversion Loss (LCL) measurement at the source of that signal, as specified in clause 13.3.2 and 13.3.3. The minimum LOV and LCL requirements hold for what can be observed at the ports of the Local Loop Wiring, when the Local Loop Wiring is replaced by an artificial impedance network described in clause 13.3.2 and 13.3.3.

The differential termination impedance for LOV and LCL measurements shall be chosen equally to the design impedance $R_T = 100\ \Omega$ of the Signal Source under test.

The observed LOV shall have an rms voltage of below the value specified in table 5, measured in a *power* bandwidth B, centred over any frequency in the range from f_{min} to f_{max}, and averaged in any one second period. Compliance with this limitation is required with a longitudinal terminating impedance having value $Z_L(\omega) = R_L + 1 / (j\omega \times C_L)$ for all frequencies between f_{min} to f_{max}. Clause 13.3.2 defines an example measurement method for longitudinal output voltage.

The observed LCL shall be higher than the lower limits given in figure 7. The LCL values of the associated break frequencies of this figure are given in table 6. Clause 13.3.3 defines an example measurement method for longitudinal conversion loss. To be compliant with this signal category, this requirement shall be met for both the switched-on and switched-off mode of the signal source.

Reference: TS 101 270-1, clauses 8.3.3 and E.3.2 [2].

Table 5: Values for the LOV limits

	LOV	**B**	**f_{min}**	**f_{max}**	**R_L**	**C_L**
downstream	-46 dBV	10 kHz	5,1 kHz	1 825 kHz	100 Ω	150 nF
upstream	-46 dBV	10 kHz	5,1 kHz	210 kHz	100 Ω	150 nF

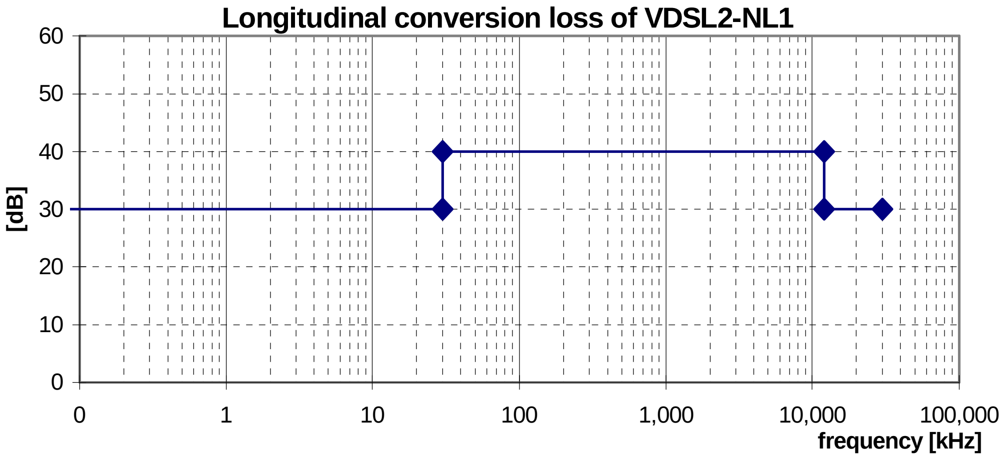

Figure 7: Minimum longitudinal conversion loss

Table 6: Frequencies and LCL values of the breakpoints of the LCL mask in figure 7.

Frequency	LCL
< 30 kHz	30 dB
30 kHz	40 dB
12 MHz	40 dB
12 MHz	30 dB
30 MHz	30 dB

END OF LITERAL TEXT PROPOSAL

4. Conclusion and proposal to ETSI-TM6

In this contribution, we presented a full signal description of VDSL2, tailored to the Dutch access network. This description is currently being proposed to a Dutch forum of xDSL operators, and it is expected that before the end of this year it will become the set of mandatory access rules for using the sub-loop in the Netherlands.

We propose the following:

- ETSI reopens a work item, dedicated to the revision of ETSI TR 101 830-1 (Spectral Management, part 1).
- To create a study point, dedicated to the inclusion of this “VDSL2-NL1” signal description in this revised SpM-1

By the inclusion of a “VDSL2-NL1” signal description in SpM-1, ETSI will by no means impose anybody to make use of these limits. Using it is purely an issue of national concern and national regulation.

Furthermore we invite other operators to propose similar VDSL2 signal descriptions, tailored to their own need, also for inclusion in SpM-1.

5. References

[1] ITU-T Recommendation G993.2: “Very High Speed Digital Subscriber Line 2 (VDSL2)”, Pre- published, Geneva, February 2006

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

[3] ETSI TS 101 388 (V1.3.1): "Transmission and Multiplexing (TM); Access transmission systems on metallic access cables; Asymmetric Digital Subscriber Line (ADSL) - European specific requirements [ITU-T Recommendation G.992.1 modified]".

[4] ITU-T Recommendation G.992.1: "Asymmetric digital subscriber line (ADSL) transceivers".