TITLE	**Update of SDSL noise models, as requested by ETSI-TM6**
PROJECT	SDSL

SOURCE: KPN/FSAN

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ABSTRACT As requested by ETSI-TM6, FSAN has updated the PSD assumptions on ISDN and HDSL-2B1Q disturbers, and updated the SDSL noise models accordingly. The result is a minor reduction of the noise.

1. Why an update of the noise models?

The current SDSL noise models [3,4], that are close to the agreed status within ETSI-TM6, are a realistic representation of the impairment in real access networks. The noise is a weighed power sum of several individual disturbers, and the PSD assumptions of each individual disturber have been specified in the contributions that have resulted in the noise models [1,2,3,4].

During the latest ETSI-TM6 meeting (Grenoble), it was raised that the PSD templates of the ISDN and HDSL-2B1Q disturbers are a few dB too pessimistic. This is because they were based on PSD-*masks*, as specified in ETSI standards, in stead of their *expected* PSD. As a result, the total transmit power of these disturbers is larger (up to 4 dB) than what is allowed for these systems. To have this updated, FSAN was requested by ETSI-TM6 to modify the PSD assumptions of the ISDN and HDSL-2B1Q disturbers, and to calculated the resulting PSD's of the SDSL noise model. This contribution describes the requested update, that results in a small reduction of the SDSL noise, as shown in figure 1 for model B.

Most of the proposed noise model is left unchanged, with respect to [3,4]. The appendix of this contribution lists all the used PSD templates in the construction of the SDSL noise models. These changes are combined with the unchanged portions of the noise model proposal to achieve a single reference for all FSAN assumptions on the SDSL noise.

Spin-off: "FSAN assumptions"
These individual disturber templates are used by FSAN members for simulating purposes, since they are the most representive PSDs for disturbing systems. To harmonize simulation, it is recommended to refer to the PSD templates in this contribution as the "*FSAN-assumptions on disturber PSD's*".

2. FSAN Proposal *(unchanged)*

Four scenario's have been identified to be applied to SDSL testing. Each scenario results in a length dependent PSD description of noise models, one to be injected at the LT-side, and another to be injected at the NT-side of the SDSL modem link under test.
The technology mix is summarised below. For combining the individual disturbers into a combine noise spectrum, the FSAN combination method shall be used, as described in [2] and [3] . The FSAN crosstalk sum for four individual PSD's equals (P in W/Hz):

$$P = (P_1^{Kn} + P_2^{Kn} + P_3^{Kn} + P_4^{Kn})^{1/Kn}, \quad \text{at } K_n=1/0.6$$

- ***Technology mix of model A (high penetration scenario)***

P_0	SDSL	+ 11.7 dB (occupying about 90 wire pairs)
P_1	ISDN/2B1Q	+ 11.7 dB (occupying about 90 wire pairs)
P_2	HDSL/2B1Q (2-pair)	+ 9.6 dB (occupying about 40 wire pairs)
P_3	ADSL over POTS	+ 11.7 dB (occupying about 90 wire pairs)
P_4	ADSL over ISDN	+ 11.7 dB (occupying about 90 wire pairs)

- ***Technology mix of model B (medium penetration scenario)***

P_0	SDSL	+ 7.1 dB (occupying about 15 wire pairs)
P_1	ISDN/2B1Q	+ 6.0 dB (occupying about 10 wire pairs)
P_2	HDSL/2B1Q (2-pair)	+ 3.6 dB (occupying about 4 wire pairs)
P_3	ADSL-lite	+ 6.0 dB (occupying about 10 wire pairs)
P_4	ADSL over ISDN	+ 4.2 dB (occupying about 5 wire pairs)

- ***Technology mix of model C (legacy scenario)***

P_0	SDSL	+ 7.1 dB (occupying about 15 wire pairs)
P_1	ISDN/2B1Q	+ 6.0 dB (occupying about 10 wire pairs)
P_2	HDSL/2B1Q (2-pair)	+ 3.6 dB (occupying about 4 wire pairs)
P_3	ADSL-lite	+ 6.0 dB (occupying about 10 wire pairs)
P_4	ADSL over ISDN	+ 4.2 dB (occupying about 5 wire pairs)
P_5	ISDN-PRI/HDB3	+ 3.6 dB (occupying about 4 wire pairs)

- ***Technology mix of model D (reference scenario)***

P_0	SDSL	+ 10.1 dB (occupying about 49 wire pairs)

NOTE 1 These numbers are a compromise found between several telcos and they **do not** reflect the actual environment in one specific network.

NOTE 2 The models approximate possible scenarios including ISDN/4B3T well enough. The difference of XA.LT.#, XA.NT.# between using ISDN/2B1Q and using ISDN/4B3T is negligible.

3. Calculated noise models *(minor change)*

Each noise model is subdivided into two parts: downstream noise at the LT-side and upstream noise at the NT-side. The noise models address the PSD levels of generator G1 and G2, as defined in Permanent Document TM6(98)10 [3], for upstream testing. The PSD of G1 and G2 are to be interchanged when testing the opposite direction.

[XA.LT.#]: are downstream PSD's of ***alien*** crosstalk noise. They are specified in Table 1, in terms of break frequencies. Their spectral profiles originate from a mix of disturbers, as described in section 2. These spectral profiles, filtered by the two crosstalk coupling functions as specified in Permanent Document TM6(98)10 [3], will represent their contribution to the FEXT, while testing downstream transmission, and to the NEXT while testing upstream transmission.

XA.LT.A [Hz]	*135 W* [dBm/Hz]	XA.LT.B [Hz]	*135 W* [dBm/Hz]	XA.LT.C [Hz]	*135 W* [dBm/Hz]	XA.LT.D [Hz]	*135 W* [dBm/Hz]
1	-20.0	1	-25.7	1	-25.7		
15 k	-20.0	15 k	-25.7	15 k	-25.7		
30 k	-21.5	30 k	-27.4	30 k	-27.4	*ALL*	*ZERO*
67 k	-27.0	45 k	-30.3	45 k	-30.3		
125 k	-27.0	70 k	-36.3	70 k	-36.3		
138 k	-25.7	127 k	-36.3	127 k	-36.3		
400 k	-26.1	138 k	-32.1	138 k	-32.1		
1104 k	-26.1	400 k	-32.5	400 k	-32.5		
2.5 M	-66.2	550 k	-32.5	550 k	-32.5		
4.55 M	-96.5	610 k	-34.8	610 k	-34.8		
30 M	-96.5	700 k	-35.4	700 k	-35.3		
		1104 k	-35.4	1104 k	-35.3		
		4.55 M	-103.0	1.85 M	-58.5		
		30 M	-103.0	22.4 M	-103.0		
				30 M	-103.0		

Table 1: Break frequencies of the "XA.LT.#" PSD masks that specify noise spectra as used in Permanent Document TM6(98)10 [3]. The PSD masks are constructed with straight lines between these break frequencies, when plotted against a *<u>logarithmic</u>* frequency scale and a *<u>linear</u>* dBm scale.

[XA.NT.#]: are upstream PSD's of ***alien*** crosstalk noise. They are specified in Table 2, in terms of break frequencies. Their spectral profiles originate from a mix of disturbers, as described in section 2. These spectral profiles, filtered by the two crosstalk coupling functions as specified in Permanent Document TM6(98)10 [3], will represent their contribution to the NEXT, while testing downstream transmission, and to the FEXT while testing upstream transmission.

XA.NT.A [Hz]	*135 W* [dBm/Hz]	XA.NT.B [Hz]	*135 W* [dBm/Hz]	XA.NT.C [Hz]	*135 W* [dBm/Hz]	XA.NT.D [Hz]	*135 W* [dBm/Hz]
1	-20.0	1	-25.7	1	-25.7		
15 k	-20.0	15 k	-25.7	15 k	-25.7		
60 k	-25.2	30 k	-26.8	30 k	-26.8	*ALL*	*ZERO*
276 k	-25.8	67 k	-31.2	67 k	-31.2		
500 k	-51.9	142 k	-31.2	142 k	-31.2		
570 k	-69.5	156 k	-32.7	156 k	-32.7		
600 k	-69.9	276 k	-33.2	276 k	-33.2		
650 k	-62.4	400 k	-46.0	335 k	-42.0		
763 k	-62.4	500 k	-57.9	450 k	-47.9		
1.0 M	-71.5	570 k	-75.7	750 k	-45.4		
2.75 M	-96.5	600 k	-76.0	1040 k	-45.5		
30 M	-96.5	650 k	-68.3	2.46 M	-63.6		
		763 k	-68.3	23.44 M	-103.0		
		1.0 M	-77.5	30 M	-103.0		
		2.8 M	-103.0				
		30 M	-103.0				

Table 2: Break frequencies of the "XA.NT.#" PSD masks that specify the alien noise spectra as used in Permanent Document TM6(98)10 [3]. The PSD masks are constructed with straight lines between these break frequencies, when plotted against a *<u>logarithmic</u>* frequency scale and a *<u>linear</u>* dBm scale.

Figure 1 illustrates how much difference can be observed for model B, between the old model [4] and the new model.

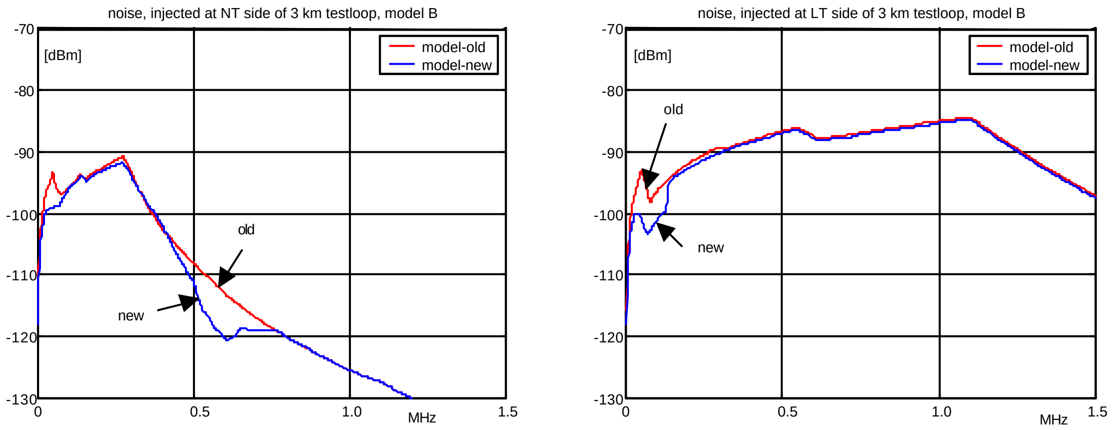

Figure 1. The difference in noise beteen the old model B and the new model B. Note that the noise definition in [3] makes the noise length dependent. These plots show their level as it can be observed at the NT- or LT-side of a testloop of 3 km.

4. Appendix (change in ISDN and HDSL-2B1Q)

The noise models of the individual NEXT-, FEXT-, background and white noise generators in the impairment generator, are based on the combined noise of different xDSL systems.

The individual disturbers can be described by simplified PSD templates, and the break frequencies of these templates are summarised in table 3 and 4. The PSD templates in table 3 are constructed with straight lines between these break frequencies, when plotted against a *logarithmic* frequency scale and a *linear* dBm scale.

ISDN 2B1Q	***135 W***
[Hz]	**[dBm/Hz]**
1	-31.8
15k	-31.8
30k	-33.5
45k	-36.6
60k	-42.2
75k	-55
85k	-55
100k	-48
114k	-48
300k	-69
301k	-79
500k	-90
1.4M	-90
3.637M	-120
30M	-120

ISDN 4B3T[1]	***See footnote 150W***
[Hz]	**[dBm/Hz]**
1	-30
50k	-30
300k	-67
301k	-74
1M	-74
4.043M	-120
30M	-120

HDSL 2B1Q	***2 pair 135 W***
[Hz]	**[dBm/Hz]**
1	-40.2
100k	-40.2
200k	-41.6
300k	-44.2
400k	-49.7
500k	-61.5
570k	-80
600k	-80
650k	-72
755k	-72
2.92M	-119
30M	-119

HDSL CAP	***2 pair 135 W***
[Hz]	**[dBm/Hz]**
1	-57
3.98k	-57
21.5k	-43
39.02k	-40
237.58k	-40
255.10k	-43
272.62k	-60
297.00k	-90
1.188M	-120
30M	-120

ADSL over POTS DMT	***Up 100 W***
[Hz]	**[dBm/Hz]**
1	-97.5
3.99k	-97.5
4k	-92.5
25.875k	-37.5
138k	-37.5
307k	-90
1.221M	-90
1.630M	-110
30M	-110

ADSL over POTS DMT	***Down 100 W***
[Hz]	**[dBm/Hz]**
1	-97.5
3.99k	-97.5
4k	-92.5
25.875k	-39.5
1.104M	-39.5
3.093M	-90
4.545M	-110
30M	-110

[1] This ISDN/3B4T PSD is based on the ***mask*** that is specified in ETSI standards, and not on a ***template*** for the expected average value. Using this PSD for performance simulation purposes may therefore cause results that are a bit pessimistic. This has no consequences to the SDSL noise models, since the ISDN/3B4T PSD is not used here. An update of this PSD, for simulation purposes in general, is for further study.

ADSL over ISDN DMT	***Up 100 W***
[Hz]	**[dBm/Hz]**
1	-90
50k	-90
80k	-81.9
138k	-37.5
276k	-37.5
614k	-90
1.221M	-90
1.630M	-110
30M	-110

ADSL over ISDN DMT	***Down 100 W***
[Hz]	**[dBm/Hz]**
1	-90
50k	-90
80k	-81.9
138k	-39.5
1.104M	-39.5
3.093M	-90
4.545M	-110
30M	-110

ADSL-lite DMT	***Up 100 W***
[Hz]	**[dBm/Hz]**
1	-97.5
3.99k	-97.5
4k	-92.5
25.875k	-37.5
138k	-37.5
307k	-90
1.221M	-90
1.630M	-110
30M	-110

ADSL-lite DMT	***down 100 W***
[Hz]	**[dBm/Hz]**
1	-97.5
3.99k	-97.5
4k	-92.5
80k	-72.5
138.0k	-44.2
138.1k	-39.5
552k	-39.5
956k	-65
1.800M	-65
2.290M	-90
3.093M	-90
4.545M	-110
30M	-110

Table 3: Break frequencies of the PSD masks of individual transmission systems. ADSL over ISDN refers to the case of ISDN-2B1Q. For reasons of simplicity, the brick walls at 4 kHz are modelled as step between 3.99 kHz to 4 kHz. Note that the PSD's of ISDN-BA (4B3T) and HDSL/2 (CAP) are included here for completeness, but are not used to calculate the noise models.

$$P(f) = \frac{2}{f_0} \cdot \frac{\mathrm{sinc}^2(f/f_0 - 1)}{1 + (f/f_{3dB})^{2 \cdot N}} \cdot P_0 \qquad [\mathrm{W/Hz}]$$

$P_0 = 12.4$ mW = 10.92 dBm; Rs=130 Ω;
$f_0 = 1.024$ MHz; $f_{3dB} = 1.024$ MHz; N=0.9
$\mathrm{sinc}(x) = \sin(\pi \cdot x) / (\pi \cdot x)$

Table 4: PSD mask of the ISDN-PRI (HDB3) system, as a function of the frequency.

5. References

[1] Rob van den Brink, KPN, *Proposal for SDSL performance tests*, ETSI-TM6 contribution TD27 (984t27a0), Vienna, Sept 1998.
[2] KPN/FSAN xDSL working group, *Revised noise models for SDSL*, ETSI-TM6 contribution TD20 (991t20a0), Villach, Feb 1999.
[3] Rob van den Brink, KPN, *Performance tests for SDSL and other long-range xDSL systems*, ETSI-TM6 permanent documents TM6(98)10, (980p10a0), Villach, Feb 1999.
[4] KPN/FSAN xDSL working group, *Self-crosstalk update of the SDSL noise models*, ETSI-TM6 contribution TD09 (992t09a0), Grenoble, May 1999.