



ETSI WG TM6
(ACCESS TRANSMISSION SYSTEMS ON METALLIC CABLES)

Permanent Document

TM6(01)21 – rev 6 (a6)

Living List for Spectral Management

SpM - part 2

creation of TR 101 830-2

This document is the living list of current issues connected with ETSI's spectral management report TR 101 830, part 2 (*Technical methods for performance evaluations*).

This work item is focussed on the creation of "Part 2", dedicated to calculation and measurement methods for evaluating what the performance of xDSL systems will be for various scenarios.

The target is to achieve working group approval by the end of the ETSI-TM6 meeting in November 2003. This means that the first version of SpM part 2 can be published by ETSI in the beginning of 2004. Issues that are (still) unsolved by that time, may be scheduled for a succeeding revision.

The issues related to the revision of "Part 1", or to the creation of "Part 3", are beyond the scope of this living list.

<i>Work Item Reference</i>	DTS/TM-06030
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Rapporteur/Editor (on behalf of KPN)	Rob F.M. van den Brink TNO Telecom PO Box 421 2260 AK Leidschendam The Netherlands	tel: +31 70 4462389 fax: +31 70 4463166 email: R.F.M.vandenBrink@telecom.tno.nl
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2. STUDY POINTS PART 2 (TECHNICAL METHODS FOR PERFORMANCE EVALUATIONS)

SP	Title	Owner	Status
2-1	<i>Spectral management aspects of non-stationary signals.</i>	<i>Reuven Franco (Tioga)</i>	Deleted
2-2	Basic model of input block	Ragnar Jonsson (Conexant)	Agreed
2-3	Basic model of 2-node cross talk	Rob van den Brink (KPN)	Agreed
2-4	Generic detection models (<i>PAM, CAP/QAM, shifted-shannon</i>)	Rob van den Brink (KPN)	Agreed
2-5	Transmitter/Disturber models - ADSL	Rosaria Persico (TI-labs)	prov agreed
2-6	Transmitter/Disturber models - SDSL	Rob van den Brink (KPN)	Agreed
2-7	Transmitter/Disturber models - HDSL-CAP/2	Rob van den Brink (KPN)	Agreed
2-8	Transmitter/Disturber models - HDSL-2B1Q	Rob van den Brink (KPN)	Prov Agreed
2-9	Performance model for ETSI compliant SDSL	Marc Kimpe (Adtran)	Agreed
2-10	Performance model for ETSI compliant HDSL-CAP	Rob van den Brink (KPN)	Agreed
2-11	Transmitter/Disturber models - ISDN-2B1Q	Rob van den Brink (KPN)	Agreed
2-12	Implementation loss values for PAM, CAP and DMT	Ragnar Jonsson (Conexant)	US
2-13	Method/Model for Cross talk Cumulative Distribution, etc.	Jack Douglass (Paradyne)	US
2-14	Method/Model for Impairment Combination for multiple disturbers	Jack Douglass (Paradyne)	US
2-15	Method/Model for Loop Cumulative Distribution + Occurrence	Jack Douglass (Paradyne)	US
2-16	Method/Model for Network Model Coverage Score	Jack Douglass (Paradyne)	US
2-17	Transmitter/Disturber models - ISDN-MMS43 (4B3T)	Marko Löffelholz (DTAG)	US
2-18	Generic detection model for DMT	Tomas Nordstrom (FTW)	US
2-19	Performance model for ETSI compliant ADSL (EC-variant)	Ragnar Jonsson (Conexant)	US
2-20	Disturber model for line shared ISDN noise	Marko Loeffelholz (DTAG)	US
2-21	Data collection of PSD measurements	Marcus Jonsson (TeliaSonera)	US
2-22			
2-23			

The current agreed procedure for changing the status of living list items is in Annex A of TM6 working methods.

Part 2 study points**SP 2-1. Spectral management rules for non-stationary signals.**

It was observed that the combined impairment from modems that are rapidly switching on and off over a period of time is much more destructive to ADSL than when these modems are continuously transmitting their signals. This is identified as "non stationary noise". The effect of non-stationary transmission in general on ADSL modems has not been fully understood. Is it a performance issue, related to the way a victim xDSL modem is implemented, or is it a spectral management issue that requires a way to bound the amount of non-stationary behaviour of signals that are injected into the Local Loop Wiring.

This study point is dedicated to the analysis of the impact of non-stationary cross talkers on legacy systems, and to find a way to model and bound the amount of non stationary noise.

Status: Deleted

Related Contributions:

- *002t24, Helsinki 2000, Impact of non-stationary cross talk on legacy ADSL modems - Orckit*
- *003t52, Vienna - Alcatel*
- *003t53, Vienna 2000, Stationarity requirements for spectral compatibility - Tioga*
- *004t25, TD26, TD35, TD53, Montreux 2000 - Alcatel*

SP 2-2. Basic model of input block.

Part 2 of SpM requires a range of calculation blocks, to enable performance evaluations. One of them is the evaluation of SNR, as interim result of an xDSL performance model (receiver). This study point explores possible improvements to the calculation blocks proposed in TD35 (021t35) of the Torino meeting, dedicated to the input block and the associated echo loss model.

Related Contributions:

- *021t35, Torino 2002 - Model of basic input block, within xDSL receivers - KPN*

SP 2-3. Basic model of 2-node cross talk.

Part 2 of SpM requires a range of calculation blocks, to enable performance evaluations. One of them is the evaluation of cross talk noise levels in a scenario, in the special case that all disturbers are virtually co-located at no more than 2 nodes. This study point explores possible improvements to the calculation block proposed in TD36 (021t36) of the Torino meeting.

Related Contributions:

- 021t36, Torino 2002 - Generic cross talk models for two-node co-location - KPN

SP 2-4. Generic Detection models. (PAM, CAP/QAM, Shifted Shannon)

Part 2 of SpM requires a range of calculation blocks, to enable performance evaluations. One of them is the evaluation of the performance (in terms of noise margin or max bitrate) when a received signal is deteriorated by noise. Models for PAM and CAP/QAM and a linecode independent ("Shifted Shannon") model have been proposed. This study point explores possible improvements of the proposed models.

Related Contributions:

- 022t35, Sophia 2002 - Generic detection models for performance modelling - KPN

SP 2-5. Transmitter/Disturber models for ADSL

Part 2 of SpM requires a range of calculation blocks, to enable performance evaluations. One of them is the evaluation of the expected signal levels of the "modem under study" as well as modems acting as disturber for the "modem under study". The PSD **masks** from "part 1" cover worst case values and are too pessimistic for this purpose and related to some resolution bandwidth. Performance modelling requires the definition of PSD **templates** representing expected values, being independent from any resolution bandwidth.

Related Contributions:

- 991t20, Villach 1999 - Revised noise models for SDSL - KPN
- 993t22, Edinburgh 1999 - Update of SDSL noise models, as requested by ETSI-TM6 - KPN
- 022t36, Sophia 2002 - Transmitter models for performance evaluations - KPN
- 022t22, Sophia 2002 - FSAN noise models are too pessimistic for SpM - Alcatel
- 022t23, Sophia 2002 - PSD of ADSL is too pessimistic in FSAN noise models - Alcatel
- 023t43, Praha 2002 - Defining Xtalk noise models by measuring ADSL transceivers - Alcatel
- 031t11, Sophia 2003 - Realistic noise model of ADSL for spectral management - Alcatel
- 031t23, Sophia 2003 - Transmitter models for ADSL modems - KPN/TNO
- 031w19, Sophia 2003 - Measurement of actual ADSL products - various vendors

SP 2-6. Transmitter/Disturber models for SDSL

Similar to SP 2-5, but dedicated to SDSL systems

- 991t20, Villach 1999 - Revised noise models for SDSL - KPN
- 993t22, Edinburgh 1999 - Update of SDSL noise models, as requested by ETSI-TM6 - KPN
- 022t36, Sophia 2002 - Transmitter models for performance evaluations - KPN
- 032t14, Reykjavik 2003 - Example of 2B1Q HDSL and SDSL PSDs - Siemens

SP 2-7. Transmitter/Disturber models for HDSL-CAP/2

Similar to SP 2-5, but dedicated to two-pair HDSL-CAP systems

- 991t20, Villach 1999 - Revised noise models for SDSL - KPN
- 993t22, Edinburgh 1999 - Update of SDSL noise models, as requested by ETSI-TM6 - KPN
- 022t36, Sophia 2002 - Transmitter models for performance evaluations - KPN

SP 2-8. Transmitter/Disturber models for HDSL-2B1Q

Similar to SP 2-5, but dedicated to HDSL-2B1Q systems

- 991t20, Villach 1999 - Revised noise models for SDSL - KPN
- 993t22, Edinburgh 1999 - Update of SDSL noise models, as requested by ETSI-TM6 - KPN
- 022t36, Sophia 2002 - Transmitter models for performance evaluations - KPN
- 031t20, Sophia 2003 - Example 2B1Q HDSL PSDs - Keymile
- 031t21, Sophia 2003 - Proposal on HDSL.2B1q/2 Transmitter signal models - KE

- 031t22, Sophia 2003 - Transmitter models for ISDN & HDSL-2B1Q modems - KPN/TNO
- 032t14, Reykjavik 2003 - Example of 2B1Q HDSL and SDSL PSDs - Siemens

SP 2-9. Performance model for ETSI compliant SDSL

Part 2 of SpM requires a range of calculation blocks, to enable performance evaluations. Among them are models that predict the performance (noise margin, or bitrate) of xDSL receivers, when the received signal is disturbed by noise. This study point is dedicated to models that predict 6 dB noise margin under all stress conditions specified by the ETSI SDSL standard, for various bitrates, noise models and testloops. Models of SDSL modems that outperform (or underperform) the ETSI standard requirements are beyond the scope of this study point.

- 023t32, Praha 2002 - Receiver performance model for ETSI compliant SDSL - KPN
- 024t37, Darmstadt 2002 - Parameters for SDSL performance model - Conexant / Adtran

SP 2-10. Performance model for ETSI compliant HDSL-CAP

Similar to SP 2-9, but dedicated to HDSL-CAP systems. This means predicting 0 dB noise margin under all stress conditions specified by the ETSI HDSL standard.

- 023t33, Praha 2002 - Receiver performance model for ETSI compliant HDSL/CAP - KPN

SP 2-11. Transmitter/Disturber models for ISDN-2B1Q

Similar to SP 2-5, but dedicated to ISDN-2B1Q systems. **Measurements are invited !!!!**

- 991t20, Villach 1999 - Revised noise models for SDSL - KPN
- 993t22, Edinburgh 1999 - Update of SDSL noise models, as requested by ETSI-TM6 - KPN
- 022t36, Sophia 2002 - Transmitter models for performance evaluations - KPN
- 031t22, Sophia 2003 - Transmitter models for ISDN & HDSL-2B1Q modems - KPN/TNO

SP 2-12. Implementation loss values for PAM, CAP and DMT

The SNR gap Γ , being used in various receiver performance models for xDSL modems, is a combination of various effects. This Γ parameter is usually split-up into the following three parts:

- Its theoretical value Γ_{linecode} , usually in the order of 9.8 dB, for the chosen line code (e.g. Γ_{PAM} , Γ_{CAP} or Γ_{DMT}).
- A theoretical coding gain $\Delta\Gamma_{\text{coding}}$, usually in the order of 3-5 dB, to indicate how much additional improvement is achieved by the chosen coding mechanism.
- The empirical implementation losses $\Delta\Gamma_{\text{impl}}$, usually 1.6 dB or more), indicating how much overall deterioration is caused by implementation dependent imperfections in echo cancellation, equalization, etc.

For SDSL this can be expressed as:

$$\text{SNR gap (linear): } \Gamma_{\text{SDSL}} = \Gamma_{\text{PAM}} / \Delta\Gamma_{\text{coding}} \times \Delta\Gamma_{\text{impl}}$$

$$\text{SNR gap (in dB): } \Gamma_{\text{SDSL_dB}} = \Gamma_{\text{PAM_dB}} - \Delta\Gamma_{\text{coding_dB}} + \Delta\Gamma_{\text{impl_dB}}$$

This study point is dedicated to split-up the SNR gap into the above mentioned components for all relevant xDSL modems (HDSL, ADSL, SDSL, VDSL, etc) by deriving the first two theoretical values, and by reconstructing the third empirical values. The resulting SNR gap shall be such that the receiver performance model can predict the performance values required by ETSI, under ETSI test conditions.

- 024t37, Darmstadt 2002 - Parameters for SDSL performance model - Conexant / Adtran

SP 2-13. Method/model for crosstalk cumulative distribution, etc

To extend current performance evaluation methods (based on scenarios with a fixed set of disturbers) to statistical network modelling (based on scenarios with likelihood of occurrence), various additional parametric models are to be developed. These models are generic models only, because the inclusion of empirical values for these parameters and/or the inclusion of other statistical data is beyond the scope of SpM-2.

This study point defines the measurement methods, procedures and calculations required to determine (a) the cross talk cumulative distribution, (b) the likelihood of occurrence (LOO) and (c) severity levels for cross talk.

Related Contributions

- 023t56, Praha 2002 - Suggested starting point for NMC Cross talk Models - Paradyne
- 024t39, Darmstadt 2002 - Calculating the probability of interferers ... - Paradyne

SP 2-14 Methods for Impairment Combinations for multiple disturbers

The objective of this study point is the same as described for SP 2-13, but this one is focussed on how to determine the Impairment Combinations (IC) for multiple types of cross talk.

SP 2-15 Methods for determining Loop Cumulative Distribution

To extend the interpretation of straight-forward reach calculation to the consequences of how many customers are enabled to demand for some service, various additional parametric models are to be developed that account for what percentage of customers live within a certain range. These models are country/region/cable specific, and therefore the models being studied are generic models only. This is because the inclusion of empirical values for these parameters and/or the inclusion of other statistical data is beyond the scope of SpM-2.

This study point is focussed on how to determine (a) the cumulative distribution, (b) the likelihood of occurrence (LOO) and (c) severity levels for Loops.

- 024t40, Darmstadt 2002 - A simple method of estimating the LOO of loop lengths - Paradyne
- 031t40, Sophia 2003 - Updated European crosstalk CDFs & example procedure - Paradyne
- 031t41, Sophia 2003 - Example for approximating European loop distribution - Paradyne

A proposed generic model for how many customers are located within distance L is based on (a) the knowledge of the distance that encloses 63% of the customers, (b) the knowledge on the slope of this customer count, around this 63% distance, and (c) the assumption that this curve follows a Weibull distribution at all other distances. This model for loop length L , has therefore 2 scenario dependent constants (L_0 and q_0), and equals:

$$\text{Cumulative distribution function: } F(L; L_0, q_0) = \left(1 - \exp\left(-\left(\frac{L}{L_0}\right)^{q_0}\right) \right)$$

$$\text{Probability density function: } f(L; L_0, q_0) = \left(\frac{q_0}{L_0}\right) \times \left(\frac{L}{L_0}\right)^{q_0} \times \exp\left(-\left(\frac{L}{L_0}\right)^{q_0}\right) = \frac{\partial F}{\partial L}$$

Constant L_0 represent the length covering 63% of all subscribers: $F(L_0) = (1 - 1/e)$. Constant q_0 represents the slope of $F(L)$ at that length and equals $q_0 = e \cdot L \cdot (dF/dL)$ at $L = L_0$.

SP 2-16 Methods for Determining Network Model Coverage (NMC) Score based on IC LOO and Loop LOO

The study point defines the measurement methods, procedures and calculations required to determine the Network model coverage score (NMC-score) based on IC LOO and Loop LOO

SP 2-17. Transmitter/Disturber models for ISDN-MMS43 (4B3T)

Similar to SP 2-11, but dedicated to ISDN-MMS43 systems. These systems are widely deployed in Germany. **Measurements are invited !!!!**

SP 2-18. Generic Detection model for DMT.

Part 2 of SpM requires a range of calculation blocks, including one (or more) detection model(s) dedicated to DMT in general. This study point explores possible improvements of the proposed model.

Related Contributions:

- 032t09, Reykjavik 2003 - Generic DMT detection model - KPN

SP 2-19. Performance models for ETSI compliant ADSL (EC-variant).

Part 2 of SpM requires a range of calculation blocks, including performance models that are specific for the EC variants of ADSL, including "ADSL over POTS" and "ADSL over ISDN". These specific

models are based on generic models for DMT detection and the receiver input. This study point explores possible improvements of the proposed models.

Related Contributions:

- 032t10, Reykjavik 2003 - Receiver performance model for "ADSL over POTS" (EC) - KPN
- 032t11, Reykjavik 2003 - Receiver performance model for "ADSL over ISDN" (EC) - KPN

SP 2-20 Disturber model for line shared ISDN noise

A model is required that enhance ADSL performance simulations by accounting for the additional noise generated by the ISDN system that share the same line. A simple approach may be a PSD description of line shared ISDN noise, but more advanced models (including splitter models) are not excluded from being studied.

Related Contributions:

- **????, DTAG has contributed in the past on this topic for defining ADSL noise; please provide me with the associated references - rapporteur.**

SP 2-21 Data collection of PSD measurements

Various contributions have provided PSD measurements on signals transmitted by modems. They indicate how good the various transmitter model can represent these modems. This study point is to collect this data in a computer readable format and to store this data on the ETSI server at some TM6 subdirectory. This is to enable all delegates to compare this data with possibly improved models.

The format shall be some tabular ascii format, and easily loadable by programs such as Matlab. The format is:

filename.psd	→	an ascii data file with numbers only, and without additional text each line contains two numbers, separated by one or more <tabs> the first number is the frequency in [Hz] (so no [kHz] or [MHz] !!!) the second number is the PSD value in [dBm/Hz] the frequency increases with the line number, each frequency value occurs only once
filename.txt	→	an ascii text file describing all relevant details about the data file

Text proposals, being candidate for inclusion into the Draft .

The text fragments below have been proposed for inclusion in the draft version of SpM part 2, but are still in the "under study" status. If agreement is achieved, they will be moved into the Draft

2 References

- [1] ETSI TS 102 080 (V1.3.2): "Transmission and Multiplexing (TM); Integrated Services Digital Network (ISDN) basic rate access; Digital transmission system on metallic local lines".
- [2] ETSI TS 101 135 (V1.5.3): "Transmission and Multiplexing (TM); High bit-rate Digital Subscriber Line (HDSL) transmission systems on metallic local lines; HDSL core specification and applications for combined ISDN-BA and 2 048 kbit/s transmission".
- [3] ETSI TS 101 524: "Transmission and Multiplexing (TM); Access transmission system on metallic access cables; Symmetrical single pair high bitrate Digital Subscriber Line (SDSL)".
- [4] ETSI TS 101 388, v1.3.1, (2002-05): "Transmission and Multiplexing (TM); Access transmission systems on metallic access cables; Asymmetric Digital Subscriber Line (ADSL) - European specific requirements", may 2002.

Text portion proposed for inclusion into clause 4

4.2 Cluster 2 Transmitter signal models

4.2.2 Transmitter signal model for "ISDN.MMS.43"

<This model is left for further study>

4.2.3 Transmitter signal model for "Proprietary.SymDSL.CAP.QAM"

<This model is left for further study>

4.3 Cluster 3 Transmitter signal models

4.3.1 Transmitter signal models for "HDSL.2B1Q"

The PSD templates for modeling the spectra of various "HDSL.2B1Q" transmitters is defined by the theoretical sinc-shape of PAM encoded signals, with additional filtering and a noise floor. The PSD template is the maximum of both power density curves, as summarized in table 1.

The coefficient q_N scales the total signal power of $P_1(f)$ to a value that equals P_0 . This value is dedicated to the used filter characteristics, but equals $q_N=1$ when no filtering is applied ($f_L \rightarrow 0, f_H \rightarrow \infty$). The source impedance equals 135Ω .

$P_1(f) = P_{HDSL} \times \frac{2 \times q_N}{f_X} \times \text{sinc}^2\left(\frac{f}{f_X}\right) \times \frac{1}{1 + \left(\frac{f}{f_H}\right)^{2 \cdot N_H}} \times \frac{1}{1 + \left(\frac{f_L}{f}\right)^2} \quad [W / Hz]$
$P_2(f) = \frac{10^{(P_{\text{floor_dBm}}/10)}}{1000} \quad [W / Hz]$
$P(f) = \max(P_1(f), P_2(f)) \quad [W / Hz]$
<p><u>Where:</u></p> $P_{HDSL} = \left(10^{P_{HDSL_dBm}/10}\right) / 1000 \text{ [W]}$ $R_S = 135 \text{ [\Omega]}$ $\text{sinc}(x) = \sin(\pi \cdot x) / (\pi \cdot x)$ <p><i>Default values for remaining parameters are summarized in table 1.</i></p>

Expression 1: PSD template for modeling "HDSL.2B1Q" signals.

Different HDSL implementations, may use different filter characteristics, and noise floor values. Table 1 summarizes *default* values for HDSL implementations, in case 3rd or 4th order Butterworth filtering has been applied. The default power level P_0 equals the maximum power allowed by the HDSL standard [2], since a nominal specification does not exist. The default noise floor P_{floor} equals the maximum PSD level that meets the out-of-band specification of the HDSL standard [2]. In case these default values are not appropriated for specific performance studies, other values may apply as well (provided that they are specified for these studies).

Type	Wire pair count	f_X [kHz]	f_H	f_L [kHz]	N_H	q_N	P_{HDSL_dBm} [dBm]	$P_{\text{floor_dBm}}$ [dBm/Hz]
HDSL.2B1Q/1	1	1160	$0.42 \times f_X$	3	3	1.4662	14	-121.5
HDSL.2B1Q/2	2	584	$0.50 \times f_X$	3	3	1.3501	14	-119
HDSL.2B1Q/3	3	392	$0.50 \times f_X$	3	3	1.3642	14	-117
HDSL.2B1Q/1	1	1160	<TBD>	3	4	<TBD>	14	-121.5
HDSL.2B1Q/2	2	584	$0.68 \times f_X$	3	4	1.1915	14	-119
HDSL.2B1Q/3	3	392	<TBD>	3	4	<TBD>	14	-117

Table 1: Default parameter values for the HDSL.2B1Q templates, as defined in expression 1. These default values are based on 3rd or 4th order Butterworth filtering.

4.3.2 Transmitter signal model for "HDSL.CAP"

<A model for HDSL.CAP/1 is still under study; only HDSL.CAP/2 has been agreed>

4.3.3 Transmitter signal model for "SDSL"

<This model has been agreed>

4.3.7 Transmitter signal model for "Proprietary.XXXXX"

<all proprietary models are left for further study>

4.4 Cluster 4 Transmitter signal models

4.4.1 Transmitter signal model for "ADSL over POTS" (EC)

The PSD template for modeling the "ADSL over POTS" transmit spectrum (EC variant) is defined in terms of break frequencies, as summarized in table 2. The associated values are constructed with straight lines between these break frequencies, when plotted against a *logarithmic* frequency scale and a *linear* dBm scale.

The break frequencies, (f_1 and f_2) and (f_3 and f_4), are dependent on the used DMT tones, (k_1 to k_2) and (k_3 to k_4), and they are to be specified first when using this PSD template. Default values are given for guidance only. The source impedance equals 100Ω .

NOTE: The FSAN Legacy template is based on a combination of the nominal PSD value for in-band frequencies, and the PSD mask for out-of-band frequencies, as specified in the ETSI ADSL standard.

ADSL over POTS		Up
		$100\ \Omega$
[Hz]		[dBm/Hz]
1		-97.5
3.99k		-97.5
4k		-92.5
25.875k		-38
138k		-38
307k		-90
1.221M		-90
1.630M		-110
30M		-110

FSAN LEGACY

ADSL over POTS		Down
		$100\ \Omega$
[Hz]		[dBm/Hz]
1		-97.5
3.99k		-97.5
4k		-92.5
25.875k		-40
1.104M		-40
3.093M		-90
4.545M		-110
30M		-110

ADSL over POTS (EC)	Up
DMT carriers [$k_1:k_2$]	[$k_1:k_2$]
f [Hz]	P [dBm/Hz]
1	-97.5
3.99k	-97.5
4 k	-92.5
$f_1 - 20k$	-92.5
f_1	-38
f_2	-38
$f_2 + 40k$	-90
1.221M	-90
1.630M	-110
30M	-110
$f_1 = (k_1 - 1/2) \times f_c$ $f_2 = (k_2 + 1/2) \times f_c$ $f_c = \Delta f = 4.3125\text{ kHz}$	

Default values: [$k_1 : k_2$] = [7:31]

KPN PROPOSAL

ADSL over POTS (EC)	Down
DMT carriers [$k_3:k_4$]	[$k_3:k_4$]
f [Hz]	P [dBm/Hz]
1	-97.5
3.99 k	-97.5
4 k	-92.5
$f_3 - 20k$	-92.5
f_3	-40
f_4	-40
$f_4 + 100k$	-90
3.093M	-90
4.545M	-110
30M	-110
$f_3 = (k_3 - 1/2) \times f_c$ $f_4 = (k_4 + 1/2) \times f_c$ $f_c = \Delta f = 4.3125\text{ kHz}$	

Default values: [$k_3 : k_4$] = [7:255]

ALCATEL PROPOSAL

ADSL over POTS Spec overlap		Up 100 Ω
[Hz]	[dBm/Hz]	
1	-101	
3.99k	-101	
4k	-96	
25.875k	-38	
138k	-38	
229.6k	-92.9	
686k	-100	
1.411M	-100	
1.630M	-110	
30M	-110	

ADSL over POTS Spec overlap		Down 100 Ω
[Hz]	[dBm/Hz]	
1	-101	
3.99k	-101	
4k	-96	
25.875k	-40	
1.104M	-40	
3.093M	?	
4.545M	?	
30M	?	

RAPPORTEURS PROPOSAL: ALCATEL/KPN MIXTURE

ADSL over POTS (EC) DMT carriers [k ₁ :k ₂]	Up
f [Hz]	P [dBm/Hz]
1	-101
3.99k	-101
4 k	-96
f ₁ - 5.5×f _c	-96
f ₁	-38
f ₂	-38
f ₂ + 21.5×f _c	-90
686 k	-100
1.411M	-100
1.630M	-110
5.275M	-112
30M	-112
$f_1 = (k_1 - 1/2) \times f_c$ $f_2 = (k_2 + 1/2) \times f_c$ $f_c = \Delta f = 4.3125 \text{ kHz}$	

ADSL over POTS (EC)	Down
DMT carriers [k ₃ :k ₄]	[k ₃ :k ₄]
f [Hz]	P [dBm/Hz]
1	-101
3.99 k	-101
4 k	-96
f ₃ - 5.5×f _c	-96
f ₃	-40
f ₄	-40
f ₄ + 23×f _c	-90
3.093M	-90
4.545M	-112
30M	-112
$f_3 = (k_3 - 1/2) \times f_c$ $f_4 = (k_4 + 1/2) \times f_c$ $f_c = \Delta f = 4.3125 \text{ kHz}$	

Default values: [k₁ : k₂] = [7:31]

Default values: [k₃ : k₄] = [7:255]

Table 2. PSD template values at break frequencies for modeling "ADSL over POTS"

4.4.2 Transmitter signal model for "ADSL.FDD over POTS"

The PSD template for modeling the "ADSL.FDD over POTS" transmit spectrum is defined in terms of break frequencies, as summarized in table 3. The associated values are constructed with straight lines between these break frequencies, when plotted against a *logarithmic* frequency scale and a *linear* dBm scale.

The break frequencies, (f₁ and f₂) and (f₃ and f₄), are dependent on the used DMT tones, (k₁ to k₂) and (k₃ to k₄), and they are to be specified first when using this PSD template. Default values are given for guidance only. The source impedance equals 100Ω.

NOTE: The FSAN legacy PSD template is based on a combination of the nominal PSD value for in-band frequencies, and the PSD mask for out-of-band frequencies, as specified in the ETSI ADSL standard.

FSAN LEGACY

ADSL.FDD over POTS		Up
		100 Ω
[Hz]		[dBm/Hz]
1		-97.5
3.99k		-97.5
4k		-92.5
25.875k		-38
138k		-38
307k		-90
1.221M		-90
1.630M		-110
30M		-110

ADSL.FDD over POTS		Down
		100 Ω
[Hz]		[dBm/Hz]
1		-97.5
3.99 k		-97.5
4 k		-92.5
80 k		-72.5
138.0 k		-44.2
138.1 k		-40
1.104 M		-40
3.093 M		-90
4.545 M		-110
30 M		-110

KPN PROPOSAL

ADSL.FDD over POTS		Up
DMT carriers [k₁:k₂]		[k₁:k₂]
f [Hz]		P [dBm/Hz]
1		-97.5
3.99 k		-97.5
4 k		-92.5
f ₁ -20k		-92.5
f ₁		-38
f ₂		-38
f ₂ +40k		-90
1.221M		-90
1.630M		-110
30M		-110
$f_1 = (k_1 - 1/2) \times f_c$		
$f_2 = (k_2 + 1/2) \times f_c$		
$f_c = \Delta f = 4.3125 \text{ kHz}$		

ADSL.FDD over POTS		Down
DMT carriers [k₃:k₄]		[k₃:k₄]
f [Hz]		P [dBm/Hz]
1		-97.5
3.99 k		-97.5
4 k		-92.5
f ₃ -40k		-92.5
f ₃		-40
f ₄		-40
f ₄ +100k		-90
3.093M		-90
4.545M		-110
30M		-110
$f_3 = (k_3 - 1/2) \times f_c$		
$f_4 = (k_4 + 1/2) \times f_c$		
$f_c = \Delta f = 4.3125 \text{ kHz}$		

Default values: [k₁ : k₂] = [7:30]

Default values: [k₃ : k₄] = [38:255]

ALCATEL PROPOSAL

ADSL over POTS		Up
Spec nonoverlap		100 Ω
[Hz]		[dBm/Hz]
0		-101
3.99k		-101
4k		-96
25.875k		-38
138k		-38
229.6k		-92.9
686k		-100
1.411M		-100
1.630M		-110
30M		-110

ADSL over POTS		Down
Spec nonoverlap		100 Ω
[Hz]		[dBm/Hz]
0		-101
3.99k		-101
4k		-96
80k		-76
138		-47.7
138		-40
1.104M		-40
3.093M		?
4.545M		?
30M		?

RAPORTEURS PROPOSAL: ALCATEL/KPN MIXTURE

ADSL.FDD over POTS DMT carriers [k ₁ :k ₂]		ADSL.FDD over POTS DMT carriers [k ₃ :k ₄]	
Up [k ₁ :k ₂]		Down [k ₃ :k ₄]	
f [Hz]	P [dBm/Hz]	f [Hz]	P [dBm/Hz]
0	-101	0	-101
3.99k	-101	3.99 k	-101
4 k	-96	4 k	-96
f ₁ - 5.5×f _c	-96	f ₃ - 10×f _c	-96
f ₁	-38	f ₃ - 0.5×f _c	-47.7
f ₂	-38	f ₃	-40
f ₂ + 10×f _c	-90	f ₄	-40
686 k	-100	f ₄ + 23×f _c	-90
1.411M	-100	3.093M	-90
		4.545M	-112
		30M	-112
$f_1 = (k_1 - 1/2) \times f_c$ $f_2 = (k_2 + 1/2) \times f_c$ $f_c = \Delta f = 4.3125 \text{ kHz}$		$f_3 = (k_3 - 1/2) \times f_c$ $f_4 = (k_4 + 1/2) \times f_c$ $f_c = \Delta f = 4.3125 \text{ kHz}$	
Default values: [k ₁ : k ₂] = [7:30]		Default values: [k ₃ : k ₄] = [38:255]	

Table 3. PSD template values at break frequencies for modelling "ADSL.FDD over POTS".
The default tone set enable a guard band between upstream and downstream PSD of 7 unused tones.

4.4.3 Transmitter signal model for "ADSL over ISDN" (EC)

The PSD template for modeling the "ADSL over ISDN" transmit spectrum (EC variant) is defined in terms of break frequencies, as summarized in table 4. The associated values are constructed with straight lines between these break frequencies, when plotted against a *logarithmic* frequency scale and a *linear* dBm scale.

The break frequencies, (f₁ and f₂) and (f₃ and f₄), are dependent on the used DMT tones, (k₁ to k₂) and (k₃ to k₄), and they are to be specified first when using this PSD template. Default values are given for guidance only. The source impedance equals 100Ω.

NOTE: The FSAN legacy PSD template is based on a combination of the nominal PSD value for in-band frequencies, and the PSD mask for out-of-band frequencies, as specified in the ETSI ADSL standard.

ADSL over ISDN		Up 100 Ω	
[Hz]	[dBm/Hz]	[Hz]	[dBm/Hz]
1	-90		
50k	-90		
80k	-81.8		
138k	-38		
276k	-38		
614k	-90		
1.221M	-90		
1.630M	-110		
30M	-110		

FSAN LEGACY

ADSL over ISDN		Down 100 Ω	
[Hz]	[dBm/Hz]	[Hz]	[dBm/Hz]
1	-90		
50k	-90		
80k	-81.8		
138k	-40		
1.104M	-40		
3.093M	-90		
4.545M	-110		
30M	-110		

KPN PROPOSAL

ADSL over ISDN (EC) DMT carriers [k ₁ :k ₂]	Up [k ₁ :k ₂]
f [Hz]	P [dBm/Hz]
1	-90
f ₁ -40k	-90
f ₁	-38
f ₂	-38
f ₂ +40k	-90
1.221M	-90
1.630M	-110
30M	-110
$f_1 = (k_1 - 1/2) \times f_c$ $f_2 = (k_2 + 1/2) \times f_c$ $f_c = \Delta f = 4.3125 \text{ kHz}$	

Default values: [k₁ : k₂] = [33:63]

ADSL over ISDN (EC) DMT carriers [k ₃ :k ₄]	Down [k ₃ :k ₄]
f [Hz]	P [dBm/Hz]
1	-90
f ₃ -40k	-90
f ₃	-40
f ₄	-40
f ₄ +100k	-90
3.093M	-90
4.545M	-110
30M	-110
$f_3 = (k_3 - 1/2) \times f_c$ $f_4 = (k_4 + 1/2) \times f_c$ $f_c = \Delta f = 4.3125 \text{ kHz}$	

Default values: [k₃ : k₄] = [33:255]

ALCATEL PROPOSAL

ADSL over ISDN Spec overlap	Up 100 Ω
[Hz]	[dBm/Hz]
0	-90
50k	-90
80k	-85.3
120k	-38
276k	-38
491k	-97.8
686k	-100
1.411M	-100
1.630M	-110
5.275M	-112
30M	-112

ADSL over ISDN Spec overlap	Down 100 Ω
[Hz]	[dBm/Hz]
0	-90
50k	-90
80k	-85.3
120k	-40
1.104M	-40
3.093M	?
4.545M	?
30M	?

RAPPORTEURS PROPOSAL: ALCATEL/KPN MIXTURE

ADSL over ISDN (EC) DMT carriers [k ₁ :k ₂]	Up [k ₁ :k ₂]
f [Hz]	P [dBm/Hz]
0	-90
50	-90
f ₁ - 10×f _c	-85.3
f ₁	-38
f ₂	-38
f ₂ + 4×f _c	-55
f ₂ + 11×f _c	-60
f ₂ + 17×f _c	-97.8
686	-100
1.411M	-100
1.630M	-110
5.275M	-112
30M	-112
$f_1 = (k_1 - 1/2) \times f_c$ $f_2 = (k_2 + 1/2) \times f_c$ $f_c = \Delta f = 4.3125 \text{ kHz}$	

Default values: [k₁ : k₂] = [33:63]

ADSL over ISDN (EC) DMT carriers [k ₃ :k ₄]	Down [k ₃ :k ₄]
f [Hz]	P [dBm/Hz]
0	-90
50 k	-90
f ₃ - 10×f _c	-85.3
f ₃	-40
f ₄	-40
f ₄ + 23×f _c	-90
3.093M	-90
4.545M	-112
30M	-112
$f_3 = (k_3 - 1/2) \times f_c$ $f_4 = (k_4 + 1/2) \times f_c$ $f_c = \Delta f = 4.3125 \text{ kHz}$	

Default values: [k₃ : k₄] = [33:255]

Table 4. PSD template values at break frequencies for modeling "ADSL over ISDN (EC)"

4.4.4 Transmitter signal model for "ADSL.FDD over ISDN"

The PSD template for modeling the "ADSL.FDD over ISDN" transmit spectrum is defined in terms of break frequencies, as summarized in table 5. The associated values are constructed with straight lines between these break frequencies, when plotted against a *logarithmic* frequency scale and a *linear* dBm scale.

The break frequencies, (f_1 and f_2) and (f_3 and f_4), are dependent on the used DMT tones, (k_1 to k_2) and (k_3 to k_4), and they are to be specified first when using this PSD template. Default values are given for guidance only. The source impedance equals 100Ω .

NOTE: The FSAN legacy PSD template is based on a combination of the nominal PSD value for in-band frequencies, and the PSD mask for out-of-band frequencies, as specified in the ETSI ADSL standard.

FSAN LEGACY

ADSL.FDD over ISDN Up 100 Ω		ADSL.FDD over ISDN Down 100 Ω	
[Hz]	[dBm/Hz]	[Hz]	[dBm/Hz]
0.001	-90	0.001	-90
50 k	-90	93.1	-90
80 k	-81.8	209	-62
120 k	-38	253.99	-48.5
276 k	-38	254	-40
614 k	-90	1104	-40
1.221 M	-90	3093	-90
1.630 M	-110	4545	-110
30 M	-110	30000	-110

KPN PROPOSAL

ADSL.FDD over ISDN DMT carriers [$k_1:k_2$] f [Hz]	Up [$k_1:k_2$] P [dBm/Hz]	ADSL.FDD over ISDN DMT carriers [$k_3:k_4$] f [Hz]	Down [$k_3:k_4$] P [dBm/Hz]
1	-90	1	-90
$f_1 - 40k$	-90	$f_3 - 40k$	-90
f_1	-38	f_3	-40
f_2	-38	f_4	-40
$f_2 + 40k$	-90	$f_4 + 100k$	-90
1.221M	-90	3.093M	-90
1.630M	-110	4.545M	-110
30M	-110	30M	-110
$f_1 = (k_1 - 1/2) \times f_c$ $f_2 = (k_2 + 1/2) \times f_c$ $f_c = \Delta f = 4.3125 \text{ kHz}$		$f_3 = (k_3 - 1/2) \times f_c$ $f_4 = (k_4 + 1/2) \times f_c$ $f_c = \Delta f = 4.3125 \text{ kHz}$	

Default values: [$k_1 : k_2$] = [33:56]

Default values: [$k_3 : k_4$] = [64:255]

ALCATEL PROPOSAL

ADSL over ISDN Spec nonoverlap Up 100 Ω		ADSL over ISDN Spec nonoverlap Down 100 Ω	
[Hz]	[dBm/Hz]	[Hz]	[dBm/Hz]
0	-90	0	-90
50k	-90	93.1k	-90
80k	-85.3	209k	-65.5
120k	-38	253.99	-52
276k	-38	254k	-40
491k	-97.8	1.104M	-40
686k	-100	3.093M	?
1.411M	-100	4.545M	?
1.630M	-110	30M	?
5.275M	-112		
30M	-112		

RAPPORTEURS PROPOSAL: ALCATEL/KPN MIXTURE

ADSL.FDD over ISDN DMT carriers [k ₁ :k ₂]		ADSL.FDD over ISDN DMT carriers [k ₃ :k ₄]	
Up [k ₁ :k ₂]		Down [k ₃ :k ₄]	
f [Hz]	P [dBm/Hz]	f [Hz]	P [dBm/Hz]
0	-90	0	-90
50	-90	f ₃ - 10×f _c	-90
f ₁ - 10×f _c	-85.3	f ₃ - 0.5×f _c	-52
f ₁	-38	f ₃	-40
f ₂	-38	f ₄	-40
f ₂ + 4×f _c	-55	f ₄ + 23×f _c	-90
f ₂ + 11×f _c	-60	3.093M	-90
f ₂ + 17×f _c	-97.8	4.545M	-112
686	-100	30M	-112
1.411M	-100		
1.630M	-110		
5.275M	-112		
30M	-112		
f ₁ = (k ₁ -1/2) × f _c f ₂ = (k ₂ +1/2) × f _c f _c = Δf = 4.3125 kHz		f ₃ = (k ₃ -1/2) × f _c f ₄ = (k ₄ +1/2) × f _c f _c = Δf = 4.3125 kHz	
Default values: [k ₁ : k ₂] = [33:56]		Default values: [k ₃ : k ₄] = [64:255]	

Table 5. PSD template values at break frequencies for modeling "ADSL.FDD over ISDN".
The default tone set enable a guard band between upstream and downstream PSD of 7 unused tones.

Text portions proposed for inclusion into clause 5

5 Generic receiver performance models for xDSL

5.2.4 Generic DMT detection model

The calculation of the margin *m* using the generic DMT detection model is equivalent with solving the equations in expression 2, for a given line rate *f_b*. The associated parameters are summarized in table 6, and function *bitload* is specified by the chosen bit-loading algorithm. The effective SNR is to be evaluated by using one of the input models described in clause 5.1. Depending on what offset format is used for the SNR expression, the calculated margin *m* will represent the noise margin *m_n* or the signal margin *m_s*.

$$\Delta b_k = \int_{(k-1/2) \cdot f_c}^{(k+1/2) \cdot f_c} \log_2 \left(1 + \frac{SNR_{ofs}(m, f)}{\Gamma} \right) \cdot df$$

$$f_b = f_s \times b = f_s \times \sum_{k \in \text{tones}} bitload(\Delta b_k)$$

Expression 2: Equation of the DMT-detection model, for solving the margin m for a given line rate f_b.

Bit-loading algorithm

The DMT carriers are all positioned at a multiple of the carrier frequency *f_c*, and each carrier may carry a fraction of the symbol by means of a few bits. The way this bit space is used to load each carrier with bits is implementation dependent.

Bit-loading algorithms do commonly use masking. Masking means skipping carriers for bit-loading when their bit space Δb_k is below some predefined minimum value Δb_{min} , and limiting the bit-loading to some pre-defined maximum when the bit space Δb_k exceeds some predefined maximum Δb_{max} . When data transport has been pushed to its limits (zero margin), the following bit-loading algorithms may apply, in addition to masking:

- *Fractional bit-loading* is a pure theoretical approach enabling to load even (non-integer) fractions of the bit space Δb_k on carrier k . This maximizes the use of the available capacity, but is unpractical to implement.

$(\Delta b_k < \Delta b_{\min})$	\Rightarrow	$bitload(\Delta b_k) \equiv 0$
$(\Delta b_k \geq \Delta b_{\min})$ and $(\Delta b_k < \Delta b_{\max})$	\Rightarrow	$bitload(\Delta b_k) \equiv \Delta b_k$
$(\Delta b_k > \Delta b_{\max})$	\Rightarrow	$bitload(\Delta b_k) \equiv \Delta b_{\max}$

- *Truncated bit-loading* is a more feasible in practice, and loads each carrier k to a number of bits equal to the largest non-negative integer *below* the bit space Δb_k .
- *Rounded bit-loading* is also feasible in practice, and loads each carrier k to a number of bits equal to the nearest non-negative integer of bit space Δb_k .
- *Gain adjusted bit-loading* is a sophisticated combination of rounded bit-loading and adjustment of powers to each of the tones, so that each individual bit space Δb_k approaches a rounded value (minimizes the loss of capacity), while the total transmit power is kept unchanged on average.

In various applications, it may be assumed that the capacity of well-designed *gain adjusted* bit-loading algorithms closely match those achieved by *fractional* bit-loading. For reasons of simplicity, and for making capacity calculations in this document less implementation dependent, the fractional bit-loading algorithm is used as default for DMT calculations all over this document, unless specified explicitly otherwise.

SNR-Gap

The (effective) SNR gap Γ , being used in the above expression 2, is a combination of various effects. This Γ parameter is often split-up into the following three parts:

- Its theoretical value Γ_{DMT} (in the order of 9.75 dB at BER = 10^{-7})
- A theoretical coding gain $\Delta\Gamma_{coding}$ (usually in the order of 3 - 5 dB), to indicate how much additional improvement is achieved by the chosen coding mechanism.
- An empirical adjustment for all *unidentified* implementation losses $\Delta\Gamma_{impl}$ (usually a few dB as well), indicating how much overall performance degradation is caused by implementation dependent imperfections (e.g. echo cancellation and equalization).

When Γ is split-up into the above three parts, its value shall be evaluated as follows:

$$\begin{aligned} \text{SNR gap (linear):} \quad \Gamma &= \Gamma_{DMT} \quad / \quad \Delta\Gamma_{coding} \quad \times \quad \Delta\Gamma_{impl} \\ \text{SNR gap (in dB):} \quad \Gamma_{dB} &= \Gamma_{DMT_dB} \quad - \quad \Delta\Gamma_{coding_dB} \quad + \quad \Delta\Gamma_{impl_dB} \end{aligned}$$

Involved parameters

Input quantities	linear	In dB	remarks
Signal to Noise Ratio	SNR	$10 \times \log_{10}(\text{SNR})$	Frequency dependent ratio of powers
Model Parameters	linear	In dB	remarks
SNR gap (effective)	Γ	$10 \times \log_{10}(\Gamma)$	$= \text{SNR}_{\text{req}} / (2^{2^b} - 1)$
SNR gap in parts:	Γ_{DMT} $\Delta\Gamma_{\text{coding}}$ $\Delta\Gamma_{\text{impl}}$	$10 \times \log_{10}(\Gamma_{\text{DMT}})$ $10 \times \log_{10}(\Delta\Gamma_{\text{coding}})$ $10 \times \log_{10}(\Delta\Gamma_{\text{impl}})$	Theoretical linecode value Coding gain Implementation loss
Symbol rate		f_s	The DMT symbol rate
Data rate		f_d	All payload bits that are to be transported in 1 sec
Line rate		f_b	= Date rate + overhead bitrate
Available set of tones		tones	Can be a subset of all possible tones. (e.g. tones = [7:255])
Carrier frequency (of tone k); $k \in \text{tones}$		$k \times f_c$	
Bits per symbol		b	$= f_b / f_s$ Bits of each symbol are spread out over all used carriers.
Bit-loading algorithm		<specify>	Can be one of: <ul style="list-style-type: none"> • Fractional • Truncated • Rounded • Gain adjusted
Minimum bit-loading		Δb_{min}	
Maximum bit-loading		Δb_{max}	
Output quantities			
Noise margin	m_n	$10 \times \log_{10}(m_n)$	
Signal margin	m_s	$10 \times \log_{10}(m_s)$	

Table 6: Parameters used for DMT detection models.

The various parameters in table 6, used within this generic detection model, have the following meaning:

- The SNR-gap (Γ) is a parameter indicative for how close the Shannon capacity limit can be approached.
- The line rate is usually higher then the data rate (0...30%) to transport overhead bits for error correction, signaling and framing.
- The symbol rate is usually significantly lower then the line rate since multiple bits per symbol are packed together, and spread-out over many carriers.
- The available tones are a list of integers that indicate what frequency band can be occupied by individual carriers. For instance all tones from tone 7 to tone 255.
- The carrier frequency is the frequency of the first non-zero carrier.
- The minimum and maximum bit-loading specify in what range the bit space of each carrier is loaded. Bit loading is skipped when the bit space is below Δb_{min} , and limited when the bitspace exceeds Δb_{max} .

Text portions proposed for inclusion into clause 6

6 Specific receiver performance models for xDSL

6.4 Receiver performance model for “ADSL over POTS” (EC)

This calculation model is capable for predicting the performance of an ETSI compliant “ADSL over POTS” modem. The reach predictions of this model are close to the ETSI reach requirements under the ETSI stress conditions as specified in the ETSI ADSL specification [4]. Deviations between the

predictions and requirements are less than 100m. The validity of the predicted performance holds for a wider range of stress conditions.

6.4.1 Building blocks of the receiver performance model

The receiver performance model for ETSI compliant “ADSL over POTS” is build-up from the following building blocks:

- A first order (linear) input model for the input block (without echo and equalization imperfections), specified in clause 5.1.1.
- The generic DMT detection model, specified in clause 5.2.4.
- The parameter values specified in table 7 of the succeeding clause.

6.4.2 Parameters of the receiver performance model

The parameter values, used in the receiver performance model for ETSI compliant “ADSL over POTS” modems, are summarized in table 7. Part of them are directly based on ADSL specifications. The remaining values are based on theory.

Model parameter		DMT		Remarks
		Upstream	Downstream	
SNR-Gap (effective)	Γ_{dB}	7.5 dB	7.5 dB	
SNR-Gap in parts	Γ_{DMT_dB} $\Delta\Gamma_{coding_dB}$ $\Delta\Gamma_{impl_dB}$	9.75 dB 4.25 dB 2.0 dB	9.75 dB 4.25 dB 2.0 dB	
Receiver noise	P_{RNO_dB}	(-135 dBm) -120 dBm	-135 dBm	
Symbol rate	f_s	4000 baud	4000 baud	
Data rate	f_d	64 ... 640 kb/s	64 ... 6144 kb/s	
Line rate	f_b	$f_{bl} = f_d + 16 \cdot f_s$ $f_{bh} = (f_d + 8 \cdot f_s) \cdot 1.13$ $f_b = \max(f_{bl}, f_{bh})$	$f_{bl} = f_d + 16 \cdot f_s$ $f_{bh} = (f_d + 8 \cdot f_s) \cdot 1.13$ $f_b = \max(f_{bl}, f_{bh})$	
Bits per symbol	b	f_b/b	f_b/b	
Available set of tones	tones	[7:31] = $[k_1 : k_2]$	[7:63, 65:255] = $[k_1 : k_2, k_3 : k_4]$ Tone 64 = pilot tone	DMT tone $k = 64$ does not convey any bits because it is reserved as pilot tone.
Carrier frequency of tone 1	f_c	4.3125 kHz	4.3125 kHz	
Bit-loading algorithm		Fractional	Fractional	See (clause 5.2.4)
Minimum bit-loading	Δb_{min}	2	2	Bits per carrier
Maximum bit-loading	Δb_{max}	15	15	Bits per carrier

Table 7: Values for the performance parameters extracted from the ETSI performance requirements under ESTI stress conditions.

6.5 Receiver performance model for “ADSL over POTS” (FDD)

<left for further study>

6.6 Receiver performance model for “ADSL over ISDN” (EC)

This calculation model is capable for predicting the performance of an ETSI compliant “ADSL over ISDN” modem. The reach predictions of this model are close to the ETSI reach requirements under the ETSI stress conditions as specified in the ETSI ADSL specification [4]. Deviations between the predictions and requirements are less than 80m. The validity of the predicted performance holds for a wider range of stress conditions.

6.6.1 Building blocks of the receiver performance model

The receiver performance model for ETSI compliant “ADSL over ISDN” is build-up from the following building blocks:

- A first order (linear) input model for the input block (without echo and equalization imperfections), specified in clause 5.1.1.
- The generic DMT detection model, specified in clause 5.2.4.
- The parameter values specified in table 8 of the succeeding clause.

6.6.2 Parameters of the receiver performance model

The parameter values, used in the receiver performance model for ETSI compliant “ADSL over ISDN” modems, are summarized in table 8. Part of them are directly based on ADSL specifications. The remaining values are based on theory.

Model parameter		DMT model		Remarks
		Upstream	Downstream	
SNR-Gap (effective)	Γ_{dB}	7.8 dB	7.5 dB	
SNR-Gap in parts	Γ_{DMT_dB}	9.75 dB	9.75 dB	
	$\Delta\Gamma_{coding_dB}$	4.25 dB	4.25 dB	
	$\Delta\Gamma_{impl_dB}$	2.3 dB	2.0 dB	
Receiver noise	P_{RNO_dB}	(-135 dBm) -120 dBm	-135 dBm	
Symbol rate	f_s	4000 baud	4000 baud	
Data rate	f_d	64 ... 640 kb/s	64 ... 6144 kb/s	
Line rate	f_b	$f_{bl} = f_d + 16 \cdot f_s$ $f_{bh} = (f_d + 8 \cdot f_s) \cdot 1.13$ $f_b = \max(f_{bl}, f_{bh})$	$f_{bl} = f_d + 16 \cdot f_s$ $f_{bh} = (f_d + 8 \cdot f_s) \cdot 1.13$ $f_b = \max(f_{bl}, f_{bh})$	
Bits per symbol	b	f_b / b	f_b / b	
Available set of tones	tones	[33:63] = $[k_1 : k_2]$	[33:95, 97:255] = $[k_1 : k_2, k_3 : k_4]$ Tone 96 = pilot tone	DMT tone k = 96 does not convey any bits because it is reserved as pilot tone.
Carrier frequency of tone 1	f_c	4.3125 kHz	4.3125 kHz	
Bit-loading algorithm		Fractional	Fractional	See (clause 5.2.4)
Minimum bit-loading	Δb_{min}	2	2	Bits per carrier
Maximum bit-loading	Δb_{max}	15	15	Bits per carrier

Table 8: Values for the performance parameters extracted from the ETSI performance requirements under ESTI stress conditions.

6.7 Receiver performance model for “ADSL over ISDN” (FDD)

<left for further study>

End of literal text proposals

Hidden definitions: