ETSI WG TM6
(ACCESS TRANSMISSION SYSTEMS ON METALLIC CABLES)

Permanent Document

TM6(01)21 – rev 8 (a8) - DRAFT

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 June 2004. This means that the first version of SpM part 2 can be published by ETSI in the fall 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.

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Mark the new changes, valid since nov 24, 2003

2. STUDY POINTS PART 2 (TECHNICAL METHODS FOR PERFORMANCE EVALUATIONS)

SP	Title	Owner	Status
2-1	~~Spectral management aspects of non-stationary signals.~~	~~Reuven Franco (Tioga)~~	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 (*PAM, CAP/QAM, shifted-shannon*)	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)	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)	prov deleted
2-13	Method/Model for Cross talk Cumulative Distribution, etc.	Jack Douglass (Paradyne)	prov deleted
2-14	Method/Model for Impairment Combination for multiple disturbers	Jack Douglass (Paradyne)	prov. deleted
2-15	Method/Model for Loop Cumulative Distribution + Occurrence	Jack Douglass (Paradyne)	prov. deleted
2-16	Method/Model for Network Model Coverage Score	Jack Douglass (Paradyne)	prov deleted
2-17	Transmitter/Disturber models - ISDN-MMS43 (4B3T)	Marko Löffelholz (DTAG)	US
2-18	Generic detection model for DMT	Tomas Nordstrom (FTW)	Prov Agreed
2-19	Performance model for ETSI compliant ADSL (EC-variant)	Ragnar Jonsson (Conexant)	agreed
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	Improving the validity of receiver performance models	Krista Jacobsen (TI)	US
2-23	Performance model for ETSI compliant ADSL.FDD over POTS	Krista Jacobsen (TI)	US
2-24	Performance model for ETSI compliant ADSL.FDD over ISDN	Sigurd Schelstraete (ALC)	US
2-25	Performance model for ADSL 2 and ADSL2+	Krista Jacobsen (TI)	US
2-26	Modelling sidelobe pick-up in DMT Receivers	Sigurd Schelstraete (ALC)	US
2-27	Additions to the scope of SpM-2	Angus Carrick	Prov Agreed
2-28			
2-29			
2-30			
2-31			
2-32			
2-33			

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 then 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 line code 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*
- *034t38, Sophia 2003 - Transmitter models for ADSL - Alcatel*

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*
- *033t05, Sophia 2003 - Realistic template of HDSL.2B1Q/2 in out of band range - Swisscom*
- *033t06, Sophia 2003 - Measurements and model for HDSL.2B1Q/2 transceivers - Siemens*
- *034t41, Sophia 2003 - Measurements of out-of-band PSD of HDSL.2B1Q/2 - KE*

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 $\Gamma_{linecode}$, 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 Γ_{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 Γ_{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:

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

SNR gap (in dB): $\Gamma_{SDSL\_dB} = \Gamma_{PAM\_dB} - \Gamma_{coding\_dB} + \Gamma_{impl\_dB}$

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 op 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 op 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 ETSImating 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:

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

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

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. The current proposal addresses in-band frequencies. Out of band values, above 400 kHz are left for further study. Measurements are invited.

- *014t13, Sophia 2001 - Proposal for same pair ISDN template (4B3T) - DTAG*
- *033t17, Sophia 2003 - Proposal for an ISDN-MMS43 (4B3T) in-band template - T-Systems*

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*
- *034t23, Sophia 2003 - Generic detection model for DMT based modems - FTW*

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:
- *014t13, Sophia 2001 - Proposal for same pair ISDN template (4B3T) - DTAG*
- *033t18, Sophia 2003 - Disturber model for the line shared ISDN.4B3T noise - T-Systems*

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 (*ftp://docbase.etsi.org/tm/tm6/Inbox/PSD_data*). 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 ore 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 frequecny vallue occurs only once

filename.txt → an **ascii text file** describing all relevant details about the data file

SP 2-22 Improving the validity of receiver performance models
The validity of the current generic models for receivers is too limited to be usable for scenarios with high SNR. This limitation is highly relevant when simulating FDD modems (some ADSL variants or VDSL) because FDD modems are designed to maximize the SNR values due to the lack of spectral overlap. The high SNR aspect requires to model the imperfection of the equalization (causing inter symbol/carrier interference).

Another aspect of improvement is to add the need for a guard band between upstream and downstream by modelling the imperfections of the case echo cancellation (if any). A guard band of 7 DMT tones is quite common for the FDD variants of ADSL, and spectral management studies will

become too optimistic when the model (incorrectly) predicts an improvement of the performance when DMT tones in the guard band are activated.
This guard-band aspect may be too implementation-dependent and therefore undesirable to model. A possible way forward is leaving all echo cancellation out of the modelling, to accept a restricted validity of the ADSL model, and to make the tones in the guard band unavailable by explicit warning in the SpM standard
Related Contributions:

- *033t13, Sophia 2003 - Extending the validity of receiver performance models - KPN*
- *034t40, Sophia 2003 - Discussion of generic receiver model in SpM2 - Alcatel*
- *034t39, Sophia 2003 - Discussion of enhanced ADSL receiver model - Alcatel*

SP 2-23 Performance model for ETSI compliant ADSL.FDD over POTS
Same as SP-2-19, but dedicated to the FDD variant of ADSL over POTS. The model should predict the performance that can be benchmarked against the performance requirements in the ADSL standard.
Related Contributions:

- *033t14, Sophia 2003 - Receiver performance model for "ADSL.FDD over POTS" - KPN*
- *034t40, Sophia 2003 - Discussion of enhanced ADSL receiver model - Alcatel*

SP 2-24 Performance model for ETSI compliant ADSL.FDD over ISDN
Same as SP-2-19, but dedicated to the FDD variant of ADSL over ISDN. The model should predict the performance that can be benchmarked against the performance requirements in the ADSL standard.
Related Contributions:

- *033t15, Sophia 2003 - Receiver performance model for "ADSL.FDD over ISDN" - KPN*
- *034t40, Sophia 2003 - Discussion of enhanced ADSL receiver model - Alcatel*

SP 2-25 Performance model for ADSL2 and ADSL2+
New flavours of ADSL have been introduced in the ITU, and dedicated performance models are desired for SpM studies. A useful performance benchmark for ADSL2+ is unfortunately lacking, since there are currently no reach requirements in a standard that pushes these modem with extend spectrum to their true performance limits. Therefore this studypoint has also to address the way of preventing the inclusion of models in the SpM-2 standard that are predicting overoptimistic results
Related Contributions:

- *034t33, Sophia 2003 - Receiver models for G.992.3@A and G.992.5@A - TI*

SP 2-26 Modelling sidelobe pick-up in DMT Receivers
In order to improve the validity of performance models for DMT receivers, the impact of sidelobe pick-up in DMT receivers may be a useful addition to the model.
Related Contributions:

- *991t30, Villach 1999 - Adopting HDSL2 components in SDSL (Fig 1 & table 1)*
- *034w13, Sophia 2003 - Sidelobe pick-up in DMT receivers - Alcatel, Conexant*

SP 2-27 Additions to the scope of SpM-2
Text that clarifies that SpM-2 is not intended to set requirements to DSL equipment. The text proposed in 034w16 is probably adequate for the job.
Related Contributions:

- *034t37, Sophia 2003 - Clarification of the scope - Alcatel, Ericsson, Texas Instruments*
- *034w16, Sophia 2003 - Text proposal for scope of SpM-2 - ad hoc meeting*

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

Text portion proposed for addition to clause 1 (scope)

The models in this document are not intended to set requirements for DSL equipment. These requirements are contained in the relevant transceiver specifications. The models in this document are intended to provide a reasonable estimate of real-world performance but may not include every aspect of modem behaviour in real networks. Therefore real-world performance may not accurately match performance numbers calculated with these models.

Text portion proposed for addition to clause 2

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" (4B3T)

The PSD template for modeling the "ISDN.MMS.43" transmit spectrum (also known as ISDN.4B3T) is defined in terms of break frequencies, as summarized in table 1. The values are based on measurements on these modems. The associated values are constructed with straight lines between these break frequencies, when plotted against a *logarithmic* frequency scale and a *linear* dBm scale.

ISDN.MMS.43 (150 Ω)	
f [Hz]	**P [dBm/Hz]**
0	**<TBD>**
5 k	-40
22,5 k	-36
40 k	-37
65 k	-40
80 k	-43
100 k	-50
122,5 k	-62
154,5 k	-60
170 k	-61
185 k	-65
200 k	-69
215 k	-74
250 k	-82
300 k	-78
400 k	-67
<TBD>	**<TBD>**
30 M	**<TBD>**

Table 1: PSD template for modeling "ISDN.MMS.43" signals.

ED. NOTE. Due to the lack of measurements, the frequencies above 400 kHz are left for further study. The same applies for frequenies below 5 kHz. A way forward is to apply –40 dBm for the lower band, and to follow the PSD mask specification from ETSI TS 102 080 V1.3.2 (2000-05). In other words:

0,	–40
5 k	–40
…	…
400 k	-67
1 M	-67
5 M	-120
30 M	-120

4.2.3 Line-shared signal model for "ISDN.2B1Q"

<This model is left for further study>

4.2.4 Line-shared signal model for "ISDN.MMS.43" (4B3T)

The PSD template for modeling the filtered signal from an ISDN.MMS.43 transmitter, that has passed a low-pass splitter/filter for sharing the line with ADSL signals, is defined in table 2 in terms of break frequencies. It has been constructed from the transmitter PSD template, filtered by the low-pass transfer function representing the splitter/filter.

The values are based on measurements on these modems. The associated values are constructed with straight lines between these break frequencies, when plotted against a *logarithmic* frequency scale and a *linear* dBm scale.

Line-shared ISDN.MMS.43 (150 Ω)	
f [Hz]	**P [dBm/Hz]**
0	**<TBD>**
5 k	-48,7
22,5 k	-44,7
40 k	-45,3
65 k	-47,4
80 k	-50,1
100 k	-59,5
122,5 k	-108,5
154,5 k	-126,1
170 k	-127
185 k	-131
200 k	-135
215 k	-140
250 k	-148
300 k	-144
400 k	-133
1000 k	-133
5000 k	-186

Table 2: PSD template for modeling line shared "ISDN.MMS.43" signals.

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 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 frequency Δf in this table refers to the sub-carrier spacing of the DMT tones of ADSL.
The source impedance equals 100Ω.

~~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.*~~

~~**FSAN LEGACY**~~

~~*ADSL over POTS*~~	~~*Up 100 Ω*~~
~~**[Hz]**~~	~~**[dBm/Hz]**~~
~~0~~	~~-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 over POTS*~~	~~*Down 100 Ω*~~
~~**[Hz]**~~	~~**[dBm/Hz]**~~
~~0~~	~~-97.5~~
~~3.99k~~	~~-97.5~~
~~4k~~	~~-92.5~~
~~25.875k~~	~~-40~~
~~1.104M~~	~~-40~~
~~3.093M~~	~~-90~~
~~4.545M~~	~~-110~~
~~30M~~	~~-110~~

~~KPN PROPOSAL~~

~~ADSL over POTS (EC)~~ ~~DMT carriers [k_1:k_2]~~	~~Up~~ ~~[k_1:k_2]~~
~~f [Hz]~~	~~P [dBm/Hz]~~
~~0~~	~~-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~~
~~$f_1 = (k_1 - ½) \times f_c$~~ ~~$f_2 = (k_2 + ½) \times f_c$~~ ~~$f_c = \Delta f = 4.3125$ kHz~~	

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

~~ADSL over POTS (EC)~~ ~~DMT carriers [k_3:k_4]~~	~~Down~~ ~~[k_3:k_4]~~
~~f [Hz]~~	~~P [dBm/Hz]~~
~~0~~	~~-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~~
~~$f_3 = (k_3 - ½) \times f_c$~~ ~~$f_4 = (k_4 + ½) \times f_c$~~ ~~$f_c = \Delta f = 4.3125$ kHz~~	

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

~~ALCATEL PROPOSAL~~

~~ADSL over POTS~~ ***~~Spec overlap~~***	***~~Up~~*** ***~~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~~ ***~~Spec overlap~~***	***~~Down~~*** ***~~100 Ω~~***
~~[Hz]~~	~~[dBm/Hz]~~
~~0~~	~~-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 [k_1:k_2]
f [Hz]	P [dBm/Hz]
0	-101
3.99k	-101
4 k	-96
$f_1 - 5.5 \times f_c$	-96
f_1	-38
f_2	-38
$f_2 + 21.5 \times f_c$	-90
686 k	-100
1.411M	-100
1.630M	-110
5.275M	-112
30M	-112
$f_1 = (k_1 - ½) \times f_c$ $f_2 = (k_2 + ½) \times f_c$ $f_c = \Delta f$ = 4.3125 kHz	

ADSL over POTS (EC) DMT carriers [k_3:k_4]	Down [k_3:k_4]
f [Hz]	P [dBm/Hz]
0	-101
3.99 k	-101
4 k	-96
$f_3 - 5.5 \times f_c$	-96
f_3	-40
f_4	-40
$f_4 + 23 \times f_c$	-90
3.093M	-90
4.545M	-112
30M	-112
$f_3 = (k_3 - ½) \times f_c$ $f_4 = (k_4 + ½) \times f_c$ $f_c = \Delta f$ = 4.3125 kHz	

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

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

Proposal from nov 2003

ADSL over POTS (EC) DMT carriers [k_1:k_2]	Up [7:31]
f [Hz]	**P [dBm/Hz]**
0	-101
3.99k	-101
4 k	-96
$6.5 \times \Delta f$ (≈ 28.03)	-38
$31.5 \times \Delta f$ (≈ 1101.84)	-38
$53.0 \times \Delta f$ (≈ 228.56)	-90
686 k	-100
1.411M	-100
1.630M	-110
5.275M	-112
30M	-112
Δf = 4.3125 kHz	

ADSL over POTS (EC) DMT carriers [k_3:k_4]	Down [7:255]
f [Hz]	**P [dBm/Hz]**
0	-101
3.99 k	-101
4 k	-96
$6.5 \times \Delta f$ (≈ 28.03)	-40
$255.5 \times \Delta f$ (≈ 1101.84)	-40
$278.5 \times \Delta f$ (≈ 1201.03)	-90
3.093M	-90
4.545M	-112
30M	-112
Δf = 4.3125 kHz	

Table 3. 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 "ADSL.FDD over POTS" transmit spectra is defined in terms of break frequencies, as summarized in table 4 and 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 frequency Δf in this table refers to the sub-carrier spacing of the DMT tones of ADSL.

- Table 4 is to be used for modeling "guard band FDD modems", usually equipped with steep filtering for improving the separation between up and downstream signals. They leave 7 tones unused to enable this guard band.
- Table 5 is to be used for modeling "adjacent FDD modems", usually enhanced by echo cancellation for improving the separation between up and downstream signals. Because a guard band is not needed here, only 1 tone is left unused.

The source impedance equals 100Ω.

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 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 DMT carriers [k₁:k₂]	*Up [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
$f_1 = (k_1 - ½) \times f_c$ $f_2 = (k_2 + ½) \times f_c$ $f_c = \Delta f = 4.3125$ kHz	

Default values: $[k_1 : k_2] = [7:30]$

ADSL.FDD over POTS DMT carriers [k₃:k₄]	*Down [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
$f_3 = (k_3 - ½) \times f_c$ $f_4 = (k_4 + ½) \times f_c$ $f_c = \Delta f = 4.3125$ kHz	

Default values: $[k_3 : k_4] = [38:255]$

ALCATEL PROPOSAL

ADSL over POTS Spec nonoverlap	*Up 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 Spec nonoverlap	*Down 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	?

~~RAPPORTEURS PROPOSAL: ALCATEL/KPN MIXTURE~~

~~*ADSL.FDD over POTS DMT carriers [k_1:k_2]*~~	~~*Up [k_1:k_2]*~~
~~*f [Hz]*~~	~~*P [dBm/Hz]*~~
~~0~~	~~-101~~
~~3.99k~~	~~-101~~
~~4 k~~	~~-96~~
~~f_1 – 5.5×f_c~~	~~-96~~
~~f_1~~	~~-38~~
~~f_2~~	~~-38~~
~~f_2 + 10×f_c~~	~~-90~~
~~686 k~~	~~-100~~
~~1.411M~~	~~-100~~
~~1.630M~~	~~-110~~
~~5.275M~~	~~-112~~
~~30M~~	~~-112~~
~~f_1 = (k_1–½) × f_c~~ ~~f_2 = (k_2+½) × f_c~~ ~~f_c = Δf = 4.3125 kHz~~	

~~*ADSL.FDD over POTS DMT carriers [k_3:k_4]*~~	~~*Down [k_3:k_4]*~~
~~*f [Hz]*~~	~~*P [dBm/Hz]*~~
~~0~~	~~-101~~
~~3.99 k~~	~~-101~~
~~4 k~~	~~-96~~
~~f_3 – 10×f_c~~	~~-96~~
~~f_3 – 0.5×f_c~~	~~-47.7~~
~~f_3~~	~~-40~~
~~f_4~~	~~-40~~
~~f_4 + 23×f_c~~	~~-90~~
~~3.093M~~	~~-90~~
~~4.545M~~	~~-112~~
~~30M~~	~~-112~~
~~f_3 = (k_3–½) × f_c~~ ~~f_4 = (k_4+½) × f_c~~ ~~f_c = Δf = 4.3125 kHz~~	

~~Default values: [k_1 : k_2] = [7:30]~~

~~Default values: [k_3 : k_4] = [38:255]~~

Guard band FDD (using filters)

ADSL.FDD over POTS DMT carriers [k_1:k_2]	*Up* [7:30]
f [Hz]	*P [dBm/Hz]*
0	-101
3.99k	-101
4 k	-96
6.5×Δf (≈ 28.03)	-38
30.5×Δf (≈ 131.53)	-38
40.5×Δf (≈ 174.66)	-90
686 k	-100
1.411M	-100
1.630M	-110
5.275M	-112
30M	-112
Δf = 4.3125 kHz	

ADSL.FDD over POTS DMT carriers [k_3:k_4]	*Down* [38:255]
f [Hz]	*P [dBm/Hz]*
0	-101
3.99 k	-101
4 k	-96
27.5×Δf (≈ 118.59)	-96
37.0×Δf (≈ 159.56)	-47.7
37.5×Δf (≈ 161.72)	-40
255.5×Δf (≈ 1101.84)	-40
278.5×Δf (≈ 1201.03)	-90
3.093M	-90
4.545M	-112
30M	-112
Δf = 4.3125 kHz	

Table 4. PSD template values at break frequencies for modelling "ADSL.FDD over POTS", implemented as "guard band FDD" (with filtering). This PSD allocates 7 unused tones;

Adjacent FDD (using echo cancellation)

ADSL.FDD over POTS DMT carriers [k_1:k_2]	*Up* [7:31]
f [Hz]	*P [dBm/Hz]*
0	-101
3.99k	-101
4 k	-96
6.5×Δf (≈ 28.03)	-38
31.5×Δf (≈ 135.84)	-38
41.5×Δf (≈ 178.97)	-90
686 k	-100
1.411M	-100
1.630M	-110
5.275M	-112
30M	-112
Δf = 4.3125 kHz	

ADSL.FDD over POTS DMT carriers [k_3:k_4]	*Down* [33:255]
f [Hz]	*P [dBm/Hz]*
0	-101
3.99 k	-101
4 k	-96
22.5×Δf (≈ 97.03)	-96
32.0×Δf (≈ 138.00)	-47.7
32.5×Δf (≈ 140.16)	-40
255.5×Δf (≈ 1101.84)	-40
278.5×Δf (≈ 1201.03)	-90
3.093M	-90
4.545M	-112
30M	-112
Δf = 4.3125 kHz	

Table 5. PSD template values at break frequencies for modelling "ADSL.FDD over POTS", implemented as "adjacent FDD" (with echo canceling). This PSD allocates 1 unused tone, since a guard band is not required here.

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 6. 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 frequency Δf in this table refers to the sub-carrier spacing of the DMT tones of ADSL.
The source impedance equals 100Ω.

~~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 over ISDN	Up 100 Ω
[Hz]	[dBm/Hz]
0	-90
50k	-90
80k	-81.8
138k	-38
276k	-38
614k	-90
1.221M	-90
1.630M	-110
30M	-110

ADSL over ISDN	Down 100 Ω
[Hz]	[dBm/Hz]
0	-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]
0	-90
f_1-40k	-90
f_1	-38
f_2	-38
f_2+40k	-90
1.221M	-90
1.630M	-110
30M	-110
$f_1 = (k_1-½) \times f_c$ $f_2 = (k_2+½) \times f_c$ $f_c = \Delta f = 4.3125$ kHz	

ADSL over ISDN (EC) DMT carriers [k_3:k_4]	Down [k_3:k_4]
f [Hz]	P [dBm/Hz]
0	-90
f_3-40k	-90
f_3	-40
f_4	-40
f_4+100k	-90
3.093M	-90
4.545M	-110
30M	-110
$f_3 = (k_3-½) \times f_c$ $f_4 = (k_4+½) \times f_c$ $f_c = \Delta f = 4.3125$ kHz	

~~Default values: [k_1 : k_2] = [33:63]~~

~~Default values: [k_3 : k_4] = [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 [k₁:k₂]~~	~~Up [k₁:k₂]~~
~~f [Hz]~~	~~P [dBm/Hz]~~
~~0~~	~~-90~~
~~50~~	~~-90~~
~~$f_1 - 10\times f_c$~~	~~-85.3~~
~~f_1~~	~~-38~~
~~f_2~~	~~-38~~
~~$f_2 + 4\times f_c$~~	~~-55~~
~~$f_2 + 11\times f_c$~~	~~-60~~
~~$f_2 + 17\times f_c$~~	~~-97.8~~
~~686~~	~~-100~~
~~1.411M~~	~~-100~~
~~1.630M~~	~~-110~~
~~5.275M~~	~~-112~~
~~30M~~	~~-112~~
~~$f_1 = (k_1 - ½) \times f_c$; $f_2 = (k_2 + ½) \times f_c$; $f_c = \Delta f = 4.3125$ kHz~~	

~~ADSL over ISDN (EC) DMT carriers [k₃:k₄]~~	~~Down [k₃:k₄]~~
~~f [Hz]~~	~~P [dBm/Hz]~~
~~0~~	~~-90~~
~~50 k~~	~~-90~~
~~$f_3 - 10\times f_c$~~	~~-85.3~~
~~f_3~~	~~-40~~
~~f_4~~	~~-40~~
~~$f_4 + 23\times f_c$~~	~~-90~~
~~3.093M~~	~~-90~~
~~4.545M~~	~~-112~~
~~30M~~	~~-112~~
~~$f_3 = (k_3 - ½) \times f_c$; $f_4 = (k_4 + ½) \times f_c$; $f_c = \Delta f = 4.3125$ kHz~~	

~~Default values: $[k_1 : k_2] = [33:63]$~~

~~Default values: $[k_3 : k_4] = [33:255]$~~

Proposal from nov 2003

ADSL over ISDN (EC) DMT carriers [k₁:k₂]	*Up* [33:63]
f [Hz]	*P [dBm/Hz]*
0	-90
50	-90
22.5×Δf (≈ 97.03)	-85.3
32.5×Δf (≈ 140.16)	-38
63.5×Δf (≈ 273,84)	-38
67.5×Δf (≈ 291.09)	-55
74.5×Δf (≈ 321.28)	-60
80.5×Δf (≈ 347.16)	-97.8
686	-100
1.411M	-100
1.630M	-110
5.275M	-112
30M	-112
Δf = 4.3125 kHz	

ADSL over ISDN (EC) DMT carriers [k₃:k₄]	*Down* [33:255]
f [Hz]	*P [dBm/Hz]*
0	-90
50 k	-90
22.5×Δf (≈ 97.03)	-85.3
32.5×Δf (≈ 140.16)	-40
255.5×Δf (≈ 1101.84)	-40
278.5×Δf (≈ 1201.30)	-90
3.093M	-90
4.545M	-112
30M	-112
Δf = 4.3125 kHz	

Table 6. 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 "ADSL.FDD over ISDN" transmit spectra is defined in terms of break frequencies, as summarized in table 7 and 8. 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 frequency Δf in this table refers to the sub-carrier spacing of the DMT tones of ADSL.

- Table 7 is to be used for modeling "guard band FDD modems", usually enhanced by steep filtering for improving the separation between up and downstream signals. They leave 7 tones unused to enable this guard band.
- Table 8 is to be used for modeling "adjacent FDD modems", usually enhanced by echo cancellation for improving the separation between up and downstream signals. Because a guard band is not needed here, no tone is left unused.
-

The source impedance equals 100Ω.

~~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*~~
~~**[Hz]**~~	~~**[dBm/Hz]**~~
~~0~~	~~-90~~
~~50 k~~	~~-90~~
~~80 k~~	~~-81.8~~
~~120 k~~	~~-38~~
~~276 k~~	~~-38~~
~~614 k~~	~~-90~~
~~1.221 M~~	~~-90~~
~~1.630 M~~	~~-110~~
~~30 M~~	~~-110~~

~~*ADSL.FDD over ISDN*~~	~~*Down 100 Ω*~~
~~**[Hz]**~~	~~**[dBm/Hz]**~~
~~0~~	~~-90~~
~~93.1~~	~~-90~~
~~209~~	~~-62~~
~~253.99~~	~~-48.5~~
~~254~~	~~-40~~
~~1104~~	~~-40~~
~~3093~~	~~-90~~
~~4545~~	~~-110~~
~~30000~~	~~-110~~

~~**KPN PROPOSAL**~~

~~*ADSL.FDD over ISDN DMT carriers [k1:k2] f [Hz]*~~	~~*Up [k1:k2] P [dBm/Hz]*~~
~~0~~	~~-90~~
~~f_1-40k~~	~~-90~~
~~f_1~~	~~-38~~
~~f_2~~	~~-38~~
~~f_2+40k~~	~~-90~~
~~1.221M~~	~~-90~~
~~1.630M~~	~~-110~~
~~30M~~	~~-110~~
~~$f_1 = (k_1-½) \times f_e$ $f_2 = (k_2+½) \times f_e$ $f_e = \Delta f = 4.3125$ kHz~~	

~~*ADSL.FDD over ISDN DMT carriers [k3:k4] f [Hz]*~~	~~*Down [k3:k4] P [dBm/Hz]*~~
~~0~~	~~-90~~
~~f_3-40k~~	~~-90~~
~~f_3~~	~~-40~~
~~f_4~~	~~-40~~
~~f_4+100k~~	~~-90~~
~~3.093M~~	~~-90~~
~~4.545M~~	~~-110~~
~~30M~~	~~-110~~
~~$f_3 = (k_3-½) \times f_e$ $f_4 = (k_4+½) \times f_e$ $f_e = \Delta f = 4.3125$ 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~~
[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 nonoverlap~~	~~Down 100 Ω~~
[Hz]	[dBm/Hz]
0	-90
93.1k	-90
209k	-65.5
253.99	-52
254k	-40
1.104M	-40
3.093M	?
4.545M	?
30M	?

~~RAPPORTEURS PROPOSAL: ALCATEL/KPN MIXTURE~~

~~ADSL.FDD over ISDN DMT carriers [k_1:k_2]~~	~~Up [k_1:k_2]~~
f [Hz]	P [dBm/Hz]
0	-90
50	-90
$f_1 - 10\times f_c$	-85.3
f_1	-38
f_2	-38
$f_2 + 4\times f_c$	-55
$f_2 + 11\times f_c$	-60
$f_2 + 17\times f_c$	-97.8
686	-100
1.411M	-100
1.630M	-110
5.275M	-112
30M	-112
$f_1 = (k_1 - ½) \times f_c$ $f_2 = (k_2 + ½) \times f_c$ $f_c = \Delta f = 4.3125$ kHz	

~~ADSL.FDD over ISDN DMT carriers [k_3:k_4]~~	~~Down [k_3:k_4]~~
f [Hz]	P [dBm/Hz]
0	-90
$f_3 - 10\times f_c$	-90
$f_3 - 0.5\times f_c$	-52
f_3	-40
f_4	-40
$f_4 + 23\times f_c$	-90
3.093M	-90
4.545M	-112
30M	-112
$f_3 = (k_3 - ½) \times f_c$ $f_4 = (k_4 + ½) \times f_c$ $f_c = \Delta f = 4.3125$ kHz	

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

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

Guard band FDD (using filters)

ADSL.FDD over ISDN DMT carriers [k_1:k_2]	*Up [33:56]*
f [Hz]	*P [dBm/Hz]*
0	-90
50	-90
$22.5\times f_c = 97.03$	-85.3
$32.5\times f_c = 140.16$	-38
$56.5\times f_c = 243.66$	-38
$60.5\times f_c = 260.91$	-55
$67.5\times f_c = 291.09$	-60
$73.5\times f_c = 316.97$	-97.8
686	-100
1.411M	-100
1.630M	-110
5.275M	-112
30M	-112
$f_c = 4.3125$ kHz	

ADSL.FDD over ISDN DMT carriers [k_3:k_4]	*Down [64:255]*
f [Hz]	*P [dBm/Hz]*
0	-90
$53.5\times f_c = 230.72$	-90
$63.0\times f_c = 271.79$	-52
$63.5\times f_c = 273.84$	-40
$255.5\times f_c = 1101.84$	-40
$278.5\times f_c = 1201.03$	-90
3.093M	-90
4.545M	-112
30M	-112
$f_c = 4.3125$ kHz	

Table 7. PSD template values at break frequencies for modeling "ADSL.FDD over ISDN", implemented as "guard band FDD" (with filtering). This PSD allocates 7 unused tones.

adjacent FDD (using echo cancellation)

ADSL.FDD over ISDN DMT carriers [k_1:k_2]	Up [33:63]
f [Hz]	P [dBm/Hz]
0	-90
50	-90
22.5×f_c = 97.03	-85.3
32.5×f_c = 140.16	-38
63.5×f_c = 273.84	-38
67.5×f_c = 291.09	-55
74.5×f_c = 321.28	-60
80.5×f_c = 347.16	-97.8
686	-100
1.411M	-100
1.630M	-110
5.275M	-112
30M	-112
f_c = 4.3125 kHz	

ADSL.FDD over ISDN DMT carriers [k_3:k_4]	Down [64:255]
f [Hz]	P [dBm/Hz]
0	-90
53.5×f_c = 230.72	-90
63.0×f_c = 271.79	-52
63.5×f_c = 273.84	-40
255.5×f_c = 1101.84	-40
278.5×f_c = 1201.03	-90
3.093M	-90
4.545M	-112
30M	-112
f_c = 4.3125 kHz	

Table 8. PSD template values at break frequencies for modeling "ADSL.FDD over ISDN", implemented as "adjacent FDD" (with echo canceling). This PSD has no guard band.

Text portions proposed for inclusion into clause 5

5 Generic receiver performance models for xDSL

5.1. Generic input models for effective SNR

5.1.1 First order input model

5.1.2 Second order input model (with residual distortion)

This input model assumes that the SNR of the input signal is internally modified by two effects:

- an equivalent *receiver noise power* P_{RN0} that indicates how much noise is added by the receiver electronics.
- a *distortion suppression factor* η_d that indicates how effective equalization has been implemented. It represents the difference between transmitted signal and equalized received signal, and any non-zero difference behaves like noise.

Figure 1 shows the flow diagram of this model.

The relevance of including distortion suppression in this input model is mainly to extend the validity of the model to scenarios with relatively high SNR values. This is of particular interest when studying scenarios for FDD modems.

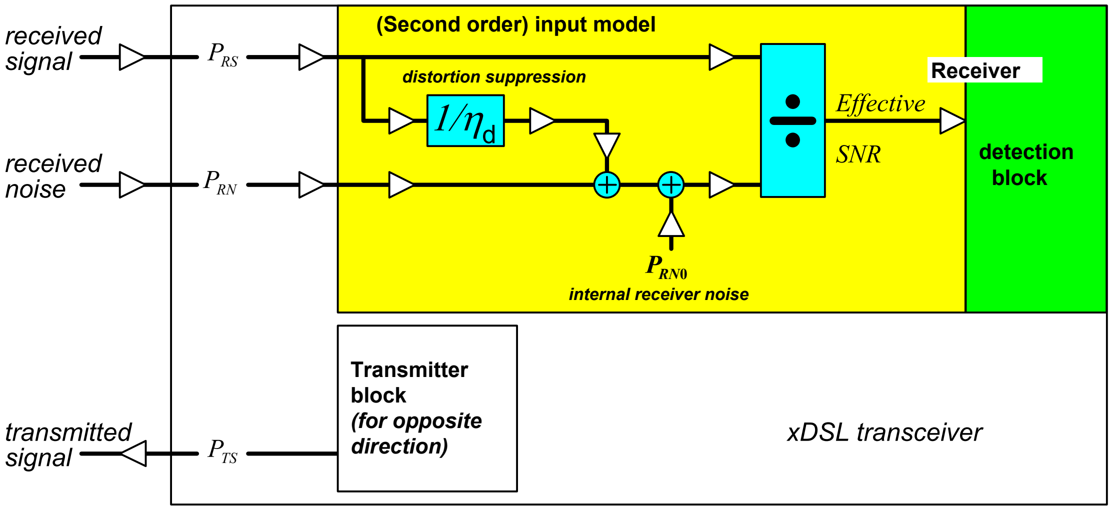


Figure 1: Flow diagram of a transceiver model that incorporates a linear second order input model for the determination of the effective SNR.

Expression 1 summarizes how to evaluate the effective SNR for this model, and it has been specified in plain and offset formats. Table 9 summarizes the involved parameters.

Plain format: $SNR(f) = \dfrac{P_{RS}}{P_{RN} + P_{RN0} + P_{RS}/\eta_d^2}$

Noise offset format: $SNR_{ofs,N}(m, f) = \dfrac{P_{RS}}{P_{RN} \times m + P_{RN0} + P_{RS}/\eta_d^2}$

Signal offset format: $SNR_{ofs,S}(m, f) = \dfrac{P_{RS}/m}{P_{RN} + P_{RN0} + P_{RS}/(\eta_d^2 \times m)}$

Expression 1: Effective SNR, in various formats for a second order input model accounting for residual distortion

INPUT QUANTITIES	linear	In dB	remarks
Received signal power	P_{RS}	$10\times\log_{10}(P_{RS})$	*Frequency dependent*
Received crosstalk noise	P_{RN}	$10\times\log_{10}(P_{RN})$	*External noise*
Received reflected power	P_{RE}	$10\times\log_{10}(P_{RE})$	*External noise*
Model Parameters			
Receiver noise power	P_{RN0}	$10\times\log_{10}(P_{RN0})$	*Internal noise*
Distortion suppression	η_d	$20\times\log_{10}(\eta_d)$	*Quality of equalizer*
Output quantities			
Signal to noise ratio (effective)	*SNR*	$10\times\log_{10}(SNR)$	*Frequency dependent*

Table 9: Involved parameters and quantities for a second order input model, accounting for residual distortion.

5.1.3. Second order input model (with residual echo)

ED NOTE The need for inclusion of the entire clause 5.1.3 is subject for further study, and the text below may be kept out of the draft if discussions within ETSI-TM6 on this topic have resulted in a conclusion

This input model assumes that the SNR of the input signal is internally modified by two effects:

- an equivalent *receiver noise power* P_{RN0} that indicates how much noise is added by the receiver electronics.
- an *echo suppression factor* η_e that indicates how effective echo cancellation is implemented.

Therefore this input model is enhanced with a simple but effective model of echo coupling as specified in clause 5.3. It models the echo coupling caused by the analogue hybrid used for "isolating" received and transmitted signal in a transceiver. When echo cancelation is on board, the echo can be suppressed additionally by a parameter η_e. Figure 2 shows the flow diagram of this model.

The relevance of including echo cancellation in this input model is mainly to cover the case that *lacks* echo cancellation, such as for FDD systems like ADSL and VDSL. Residual frequency overlap in the guard bands between up and downstream spectra may cause some deterioration of performance. By tweaking the value for echo suppression η_e, the amount of additional echo cancellation can be controlled.

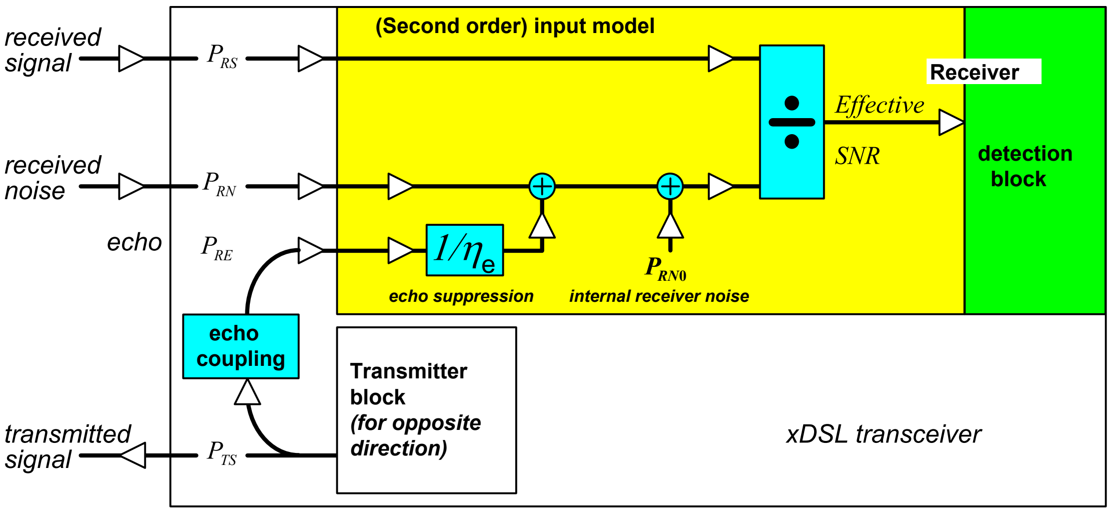


Figure 2: Flow diagram of a transceiver model that incorporates a linear second order input model for the determination of the effective SNR.

Expression 2 summarizes how to evaluate the effective SNR for this model, and it has been specified in plain and offset formats. Table 10 summarizes the involved parameters.

Plain format:	$SNR(f)$	=	$\dfrac{P_{RS}}{P_{RN} + P_{RN0} + P_{RE} / \eta_e^2}$
Noise offset format:	$SNR_{ofs,N}(m, f)$	=	$\dfrac{P_{RS}}{P_{RN} \times m + P_{RN0} + P_{RE} / \eta_e^2}$
Signal offset format:	$SNR_{ofs,S}(m, f)$	=	$\dfrac{P_{RS} / m}{P_{RN} + P_{RN0} + P_{RE} / \eta_e^2}$

Expression 2: Effective SNR, in various formats, for a second order input model accounting for residual echo

INPUT QUANTITIES	linear	In dB	remarks
Received signal power	P_{RS}	$10\times\log_{10}(P_{RS})$	*Frequency dependent*
Received crosstalk noise	P_{RN}	$10\times\log_{10}(P_{RN})$	*External noise*
Received reflected power	P_{RE}	$10\times\log_{10}(P_{RE})$	*External noise*
Model Parameters			
Receiver noise power	P_{RN0}	$10\times\log_{10}(P_{RN0})$	*Internal noise*
Echo suppression	η_e	$20\times\log_{10}(\eta_e)$	*Quality of echo canceller*
Output quantities			
Signal to noise ratio (effective)	*SNR*	$10\times\log_{10}(SNR)$	*Frequency dependent*

Table 10: Involved parameters and quantities for a second order input model accounting for residual echo

5.1.4. Third order input model (with residual distortion and echo)

ED NOTE The need for inclusion of the entire clause 5.1.4 is subject for further study, and the text below may be kept out of the draft if discussions within ETSI-TM6 on this topic have resulted in a conclusion

This input model assumes that the SNR of the input signal is internally modified by three effects:

- an equivalent *receiver noise power* P_{RN0} that indicates how much noise is added by the receiver electronics.
- an *echo suppression factor* η_e that indicates how effective echo cancellation is implemented.
- a *distortion suppression factor* η_d that indicates how effective equalization has been implemented. It represents the difference between transmitted signal and equalized received signal, and any non-zero difference behaves like noise.

This model is essentially the combination of the two previous (second order) models, and is shown in figure 3.

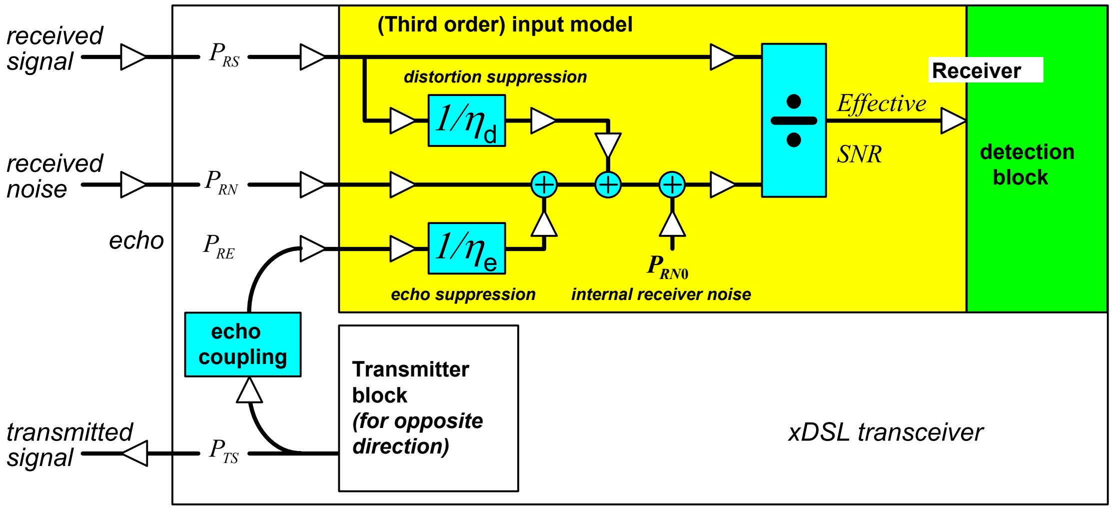


Figure 3: Flow diagram of a transceiver model that incorporates a linear third order input model for the determination of the effective SNR.

Expression 3 summarizes how to evaluate the effective SNR for this model, and it has been specified in plain and offset formats. Table 11 summarizes the involved parameters.

Plain format: $SNR(f) = \dfrac{P_{RS}}{P_{RN} + P_{RN0} + P_{RE}/\eta_e^2 + P_{RS}/\eta_d^2}$

Noise offset format: $SNR_{\text{ofs,N}}(m, f) = \dfrac{P_{RS}}{P_{RN} \times m + P_{RN0} + P_{RE}/\eta_e^2 + P_{RS}/\eta_d^2}$

Signal offset format: $SNR_{\text{ofs,S}}(m, f) = \dfrac{P_{RS}/m}{P_{RN} + P_{RN0} + P_{RE}/\eta_e^2 + P_{RS}/(\eta_d^2 \times m)}$

Expression 3: Effective SNR, in various formats for a third order input model

INPUT QUANTITIES	*linear*	*In dB*	*remarks*
Received signal power	P_{RS}	$10\times\log_{10}(P_{RS})$	*Frequency dependent*
Received crosstalk noise	P_{RN}	$10\times\log_{10}(P_{RN})$	*External noise*
Received reflected power	P_{RE}	$10\times\log_{10}(P_{RE})$	*External noise*
Model Parameters			
Receiver noise power	P_{RN0}	$10\times\log_{10}(P_{RN0})$	*Internal noise*
Echo suppression	η_e	$20\times\log_{10}(\eta_e)$	*Quality of echo canceller*
Distortion suppression	η_d	$20\times\log_{10}(\eta_d)$	*Quality of equalizer*
Output quantities			
Signal to noise ratio (effective)	*SNR*	$10\times\log_{10}(SNR)$	*Frequency dependent*

Table 11: Involved parameters and quantities for a third order input model.

5.2 Generic detection models

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 4, for a given line rate f_b (or given *data* line rate f_{bd}). The associated parameters are summarized in table 12, and function *load* 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 $SNR_{ofs}(m, f)$ is used to express this effective SNR for margins other then m=1 (equals zero dB), the solved margin *m* will result in the noise margin m_n or the signal margin m_s.

$$b_k = \log_2\left(1 + \frac{SNR_{ofs}(m, f)}{\Gamma}\right) \qquad [bit/symbol]$$

$$f_{bd} = f_{sd} \times b = f_{sd} \times \sum_{k \in tones} load(b_k) \qquad [bit/s]$$

$$f_b = f_{bd} + f_{bs} \qquad [bit/s]$$

Expression 4: Equations of the DMT-detection model, for solving the margin *m* for a given *data* line rate f_{bd}, and a given *data* symbol rate f_{sd}
The latter excludes all DMT symbols dedicated to synchronisation.

Bit-loading algorithm

The DMT sub-carriers are all positioned (centred) at a multiple of the sub-carrier frequency spacing Δf, and each sub-carrier theoretically may carry any (fractional) number of bits per symbol. The way this bit space is used to load each sub-carrier with bits is implementation dependent.

Bit-loading algorithms do commonly use masking. Masking means skipping carriers for loading when their bit space b_k is below some predefined minimum value b_{min}, and limiting the bit-loading to some pre-defined maximum when the bit space b_k exceeds some predefined maximum b_{max}. This masking process is summarized in expression 5.

$b_k < b_{min}$)	$\Rightarrow$	$load(b_k) \equiv 0$
$b_{min} \leq b_k \leq b_{max}$	$\Rightarrow$	$load(b_k) \equiv b_k$
$b_k > b_{max}$)	$\Rightarrow$	$load(b_k) \equiv b_{max}$

Expression 5: The bit space used in (fractional) bit-loading algorithms

When the data transport is operating on its limits (margin m=1, or zero dB), the following bit-loading algorithms may apply, in addition to masking:

- *Fractional bit-loading* (FBL), sometimes referred to as *water-filling* - is a pure theoretical approach enabling loading of any real number of bits per symbol in any sub-carrier k (including non-integer fractions). This maximizes the use of the available capacity, but is unpractical to implement.
- *Truncated bit-loading* (TBL) - is a more feasible algorithm in practice, and loads on each sub-carrier *k* a number of bits equal to the largest non-negative integer *below* the bit space b_k.
- *Rounded bit-loading* (RBL) - is also feasible in practice, and loads each sub-carrier *k* a number of bits equal to the nearest non-negative integer of bit space b_k.
- *Gain adjusted bit-loading* (GABL) - is a sophisticated combination of rounded bit-loading and adjustment of powers to each of the sub-carriers, so that each individual bit space b_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 algorithm. For the sake of simplicity, and for making capacity calculations in this document less implementation dependent, the fractional bit-loading algorithm with constraint number of bits per sub-carrier and symbol, as in expression 5, is used as default for DMT calculations all over this document, unless specified explicitly otherwise.

Note that when calculating the bit-loading, the used total power needs to be reduced by the amount of power spent on the cyclic extension.

> ED NOTE What is meant with this note? Can some additional explanation make it more explicit what should be done?

SNR-Gap

The (effective) SNR gap Γ, being used in the above expression 4, is a combination of various effects. This Γ parameter is often split-up into the following three parts:

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

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

SNR gap (linear): $\Gamma = \Gamma_{DMT} \;/\; \Gamma_{coding} \times \Gamma_{impl}$

SNR gap (in dB): $\Gamma_{\_dB} = \Gamma_{DMT\_dB} - \Gamma_{coding\_dB} + \Gamma_{impl\_dB}$

The margin value, which can be either noise margin or signal margin, is not included in the equations for SNR gap as it is contained in the offset SNR expression as described in clause 5.1.

Involved parameters

Input quantities	linear	In dB	remarks
Signal to Noise Ratio (effective value)	SNR	$10\times\log_{10}(SNR)$	Frequency dependent ratio of powers
Model Parameters	**linear**	**In dB**	**remarks**
SNR gap (effective)	Γ	$10\times\log_{10}(\Gamma)$	$= SNR_{req} / (2^{2\cdot b}-1)$
SNR gap in parts:	Γ_{DMT} Γ_{coding} Γ_{impl}	$10\times\log_{10}(\Gamma_{DMT})$ $10\times\log_{10}(\Gamma_{coding})$ $10\times\log_{10}(\Gamma_{impl})$	Modulation gap Coding gain Implementation loss
Symbol rate		f_s	Symbol rate, being the total number of *all* DMT symbols, transmitted in 1 second (Thus *data* symbols and *synch* symbols)
		f_{sd}	Symbol rate fragment, being the rate of *data* symbols only (without the overhead of synch symbols) that carry payloads bits
Line rate		f_b	Line rate, being the total number of *all* bits (for data, synch and other overhead) that is to be transported in 1 sec
		f_{bd}	Line rate fragment, caused by the bits in *data* symbols only
		f_{bs}	Line rate fragment, caused by the bits in *synch* symbols only
Data rate		f_d	All payload bits that are to be transported in 1 sec (also known as "net data bits")
Available set of tones		*tones*	Can be a subset of all possible tones. (e.g. tones = [7:255])
Center frequency location of tone k; k $\in$ tones		f_k	$f_k = k\times\Delta f$ Δf = 4.3125 kHz in all current DMT systems
Bits per data symbol		$b = \sum b_k$	$b = f_{bd} / f_{sd}$ The bits of each data symbol are spread out over all used tones, in fragments of b_k
Bit-loading algorithm		 FBL TBL RBL GABL	Can be one of: • Fractional bit-loading (a.k.a. water filling) • Truncated bit-loading • Rounded bit-loading • Gain adjusted bit-loading
Minimum bit loading		b_{min}	Minimum number of bits per sub-carrier and per datra symbol
Maximum bit loading		b_{max}	Maximum number of bits per sub-carrier and per data symbol
Output quantities			
Noise margin	m_n	$10\times\log_{10}(m_n)$	
Signal margin	m_s	$10\times\log_{10}(m_s)$	

Table 12: Parameters used for DMT detection models.

The various parameters in table 12, used within this generic detection model, have the following meaning:

- The SNR-gap (Γ) is a parameter that shows how far from the Shannon capacity limit a modem is performing at a certain bit error rate.

- The symbol rate f_s, in [baud] or [symbols/s], refers to *all* symbols being transmitted in one second. Most of them are so called *data* symbols, because they carrying bits for data transport, but after sending many data symbols, an additional *synch* symbol may be transmitted to keep the DMT transmission synchronized. The bits in each symbol are spread out over all involved DMT tones.
  The symbol rate is the sum of two fragments:
    - The *data* symbol rate f_{sd}, referring only to the rate of *data* symbols
    - The *synch* symbol rate f_{ss}, referring only to the rate of remaining *synch* symbols

  In ADSL, for example, one additional *synch* symbol is transmitted after sending 68 *data* symbols, and 4000 *data* symbols are transmitted in one second.
  In VDSL, for example, the *data* symbol rate and (total) symbol rate are equal as there is no extra synchronisation symbol as in ADSL.

- The line rate f_b [bits/s] refers to *all* bits being transmitted over the line in one second, including *all* overhead bits. Examples of overhead bits are bits for synchronization, all types of coding, the embedded operation channel, etc.
  Similar to the symbol rate, the line rate is the sum of two fragments:
  - The *data* line rate f_{bd}, refers to all bits in *data* symbols only, and covers payload bits as well as all overhead bits in a *data* symbol
  - The *synch* line rate f_{bs}, refers to all bits in the remaining *synch* symbols, and can be considered as 100% overhead for transporting payload bits.

  The bits in each symbol are spread out over the involved tones.

- The data rate f_d, in [bits/s], refers to the rate of *payload* bits only (also known as net data bits) that are to be transported by the DMT system. This rate does not include any transmission overhead, and is therefore lower then the line rate. Performance requirements are usually specified for these rates only, as for example the ETSI standard for ADSL [4].

- The available tones are specified by a list of integers, indicating what center frequencies are allocated to individual sub-carriers. For instance in ADSL it can contain any of the tones from tone 7 to tone 255.

- The center frequency of a sub-carrier k is $k \times \Delta f$, where Δf is the sub-carrier spacing.

- b_{min} and b_{max} are the minimum and maximum number of bits, respectively, used in the masking process of the bit loading.

5.3 Generic model for echo coupling

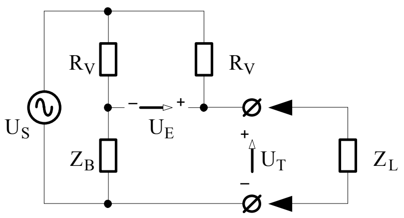
5.3.1 Linear echo coupling model

> ED. NOTE. This text was moved from clause 7.2, because it is more appropriated, and a slightly rephrased for clarity. The modeling of echo in general is subject of discussion within ETSI-TM6, and may be kept out completely of SpM-2 when TM6 has come to a conclusion.

.
This model describes a property of linear hybrids in transceivers, and models what portion of the transmitted signal reflects directly into the receiver. The hybrid is characterized by two parameters:

- R_V, representing the output impedance of the transceiver. Commonly used values are the design impedances of the modems under test, including as 100Ω for ADSL and 135Ω for SDSL.
- Z_B, representing the termination impedance that causes that the hybrid is perfectly balanced. This means that when the hybrid is terminated with this "balance impedance", no echo will flow into the receiver. For well-designed hybrids, this balance impedance is a "best guess" approximation of the "average" impedance of cables being used.

Figure 4 shows an equivalent circuit diagram of the above hybrid, represented as a Wheatstone bridge. The associated transfer function $H_E(j\omega)$ expresses what portion of the transmit signal will appear as echo.



$$H_E(j\omega) = \frac{U_E}{U_T} = 1 - \frac{Z_B}{R_V + Z_B} \times \frac{U_S}{U_T} = \frac{(Z_L - Z_B)\times R_V}{(R_V - Z_B)\times Z_L}$$

$$\frac{P_{RE}}{P_{TS}} = \left|H_E(j\omega)\right|^2$$

Figure 4: Flow diagram of the basic model for echo loss The identifiers P_{RE} and P_{TS} refer to power flow values used in figure Error! Bookmark not defined.**.**

When using this basic model for echo loss in a full simulation, value R_V can be made equal to the design impedance of the modem under test, and value Z_B can be made equal to the complex and frequency dependent input impedance of the cable, terminated at the other cable end with a load impedance equal to R_V. Values for R_V and Z_B are implementation specific.

Text portions proposed for inclusion into clause 6

6 Specific receiver performance models for xDSL

6.5 Receiver performance model for "ADSL.FDD over POTS"

ED NOTE: The text below is a first proposal, and has raised the discussion of echo suppression should be included in the model or not. Echo becomes highly relevant when FDD modems (without echo suppression) need a guard band to separate upstream and downstream spectra.

The advantage of modeling echo is that the range of scenarios for which the model is valid may increase. The drawback is that the differences between various implementations are too significant to represent it by a single model.

A possible way forward is remove all echo cancellation form the model, and to base a (simpler) model on the PSD templates of the "guard band FDD" variant of ADSL.FDD over POTS. The use of such a guard band was a basic assumption from vendors when the ADSL performance requirements were set. This guard band FDD variant can be benchmarked against the current ETSI requirements.

This calculation model is capable of predicting a performance that is benchmarked against the performance requirements of an ETSI compliant "ADSL.FDD over POTS" modem. The reach predicted by this model, under the stress conditions of the associated ETSI ADSL specification [4], is close to the minimum reach required by that ETSI specification. Deviations between the predicted reach and this "benchmark" reach are in most cases less then 150m. The validity of the predicted performance holds for a wider range of stress conditions.

6.5.1 Building blocks of the downstream receiver performance model

The downstream receiver performance model for ETSI compliant "ADSL.FDD over POTS" is build-up from the following building blocks:

- The generic linear input model, specified in clause 5.1.2. This is a second order model that accounts for two imperfections: internal receiver noise (P_{RN0}) and echo suppression (η_e).
- The generic DMT detection model, specified in clause 5.2.4.
- The echo-coupling model, specified in clause 5.3.1. This is a linear hybrid, which has R_V=100Ω as output impedance and Z_B = (120Ω) + (150Ω//47nF) + (750Ω//150nF) as balance impedance.
- The parameter values specified in table 13.

6.5.2 Building blocks of the upstream receiver performance model

The upstream receiver performance model for ETSI compliant "ADSL.FDD over POTS" is build-up from the following building blocks:

- The generic linear input model, specified in clause 5.1.4. This is a third order model that accounts for three imperfections: internal receiver noise (P_{RN0}), echo suppression (η_e) and distortion suppression (η_e).
- The generic DMT detection model, specified in clause 5.2.4.
- The echo-coupling model, specified in clause 5.3.1. This is a linear hybrid, which has R_V=100Ω as output impedance and Z_B = (120Ω) + (150Ω//47nF) + (750Ω//150nF) as balance impedance.
- The parameter values specified in table 13.

6.5.3 Parameters of the receiver performance model

The parameter values, used in the receiver performance model for ETSI compliant "ADSL.FDD over POTS" modems, are summarized in table 13. Parts of them are directly based on ADSL specifications. The remaining values are extracted from the ADSL performance requirements [4] or based on theory.

Model parameter		***DMT model***		
		Upstream	***Downstream***	***Remarks***
SNR-Gap (effective)	Γ_{dB}	9.3 dB	8.9 dB	
SNR-Gap in parts	Γ_{DMT_dB} Γ_{coding_dB} Γ_{impl_dB}	9.75 dB 4.25 dB 4.3 dB	9.75 dB 4.25 dB 3.9 dB	
Receiver noise	P_{RN0_dB}	–120 dBm	–140 dBm	
Distortion suppression	η_d	35 dB	N/A	*See clause 5.1.4*
Echo suppression	η_e	0 dB	0 dB	*See clause 5.1.4*
Echo model		Linear hybrid (see text)	Linear hybrid (see text)	*See clause 5.1.4*
Symbol rate	f_s f_{sd}	69/68 × 4000baud 4000 baud	69/68 × 4000 baud 4000 baud	*See clause 5.2.4*
Data rate	f_d	64 … 640 kb/s	64 … 6144 kb/s	
Line rate	f_{bd} f_b	$f_{bl} = f_d + 16 \times f_{sd}$ $f_{bh} = (f_d + 8 \times f_{sd}) \times 1.13$ $f_{bd} = max(f_{bl}, f_{bh})$ $f_b = 69/68 \times f_{db}$	$f_{bl} = f_d + 16 \times f_{sd}$ $f_{bh} = (f_d + 8 \times f_{sd}) \times 1.13$ $f_{bd} = max(f_{bl}, f_{bh})$ $f_b = 69/68 \times f_{db}$	*See clause 5.2.4*
Bits per symbol	b	f_{bd} / f_{sd}	f_{bd} / f_{sd}	
Available set of tones	*tones*	[7:30] = [k_1 : k_2] *Tone 31-37 are used as guard band*	[38:63, 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.*
Center frequency location of tone k; k ∈ tones	f_k	$f_k = k \times \Delta f$ Δf = 4.3125 kHz	$f_k = k \times \Delta f$ Δf = 4.3125 kHz	
Bit-loading algorithm		FBL	FBL	*See clause 5.3.4*
Minimum bit-loading	b_{min}	2	2	*Bits per sub-carrier*
Maximum bit-loading	b_{max}	15	15	*Bits per sub-carrier*

Table 13: Values for the performance parameters extracted from the ETSI performance requirements under ETSI stress conditions.

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

ED NOTE: The text below is a first proposal, and has raised the discussion of echo suppression should be included in the model or not. Echo becomes highly relevant when FDD modems (without echo suppression) need a guard band to separate upstream and downstream spectra.

The advantage of modeling echo is that the range of scenarios for which the model is valid may increase. The drawback is that the differences between various implementations are too significant to represent it by a single model.

A possible way forward is remove all echo cancellation form the model, and to base a (simpler) model on the PSD templates of the "guard band FDD" variant of ADSL.FDD over ISDN. The use of such a guard band was a basic assumption from vendors when the ADSL performance requirements were set. This guard band FDD variant can be benchmarked against the current ETSI requirements.

This calculation model is capable of predicting a performance that is benchmarked against the performance requirements of an ETSI compliant “ADSL.FDD over ISDN” modem. The reach predicted by this model, under the stress conditions of the associated ETSI ADSL specification [4], is close to the minimum reach required by that ETSI specification. Deviations between the predicted reach and this "benchmark" reach are in most cases less then 100m. The validity of the predicted performance holds for a wider range of stress conditions.

6.7.1 Building blocks of the downstream receiver performance model

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

- The generic linear input model, specified in clause 5.1.2. This is a second order model that accounts for two imperfections: internal receiver noise (P_{RN0}) and echo suppression (η_e).
- The generic DMT detection model, specified in clause 5.2.4.
- The echo-coupling model, specified in clause 5.3.1. This is a linear hybrid, which has R_V=100Ω as output impedance and Z_B = (120Ω) + (150Ω//47nF) + (750Ω//150nF) as balance impedance.
- The parameter values specified in table 14.

6.7.2 Building blocks of the upstream receiver performance model

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

- The generic linear input model, specified in clause 5.1.4. This is a third order model that accounts for three imperfections: internal receiver noise (P_{RN0}), echo suppression (η_e) and distortion suppression (η_e).
- The generic DMT detection model, specified in clause 5.2.4.
- The echo-coupling model, specified in clause 5.3.1. This is a linear hybrid, which has R_V=100Ω as output impedance and Z_B = (120Ω) + (150Ω//47nF) + (750Ω//150nF) as balance impedance.
- The parameter values specified in table 14.

6.7.3 Parameters of the receiver performance model

The parameter values, used in the receiver performance model for ETSI compliant “ADSL.FDD over ISDN” modems, are summarized in table 14. Parts of them are directly based on ADSL specifications. The remaining values are extracted from the ADSL performance requirements [4] or based on theory.

Model parameter		DMT model		
		Upstream	Downstream	Remarks
SNR-Gap (effective)	Γ_{dB}	9.6 dB	9.0 dB	
SNR-Gap in parts	Γ_{DMT_dB} Γ_{coding_dB} Γ_{impl_dB}	9.75 dB 4.25 dB 4.6 dB	9.75 dB 4.25 dB 4.0 dB	
Receiver noise	P_{RN0_dB}	–120 dBm	–140 dBm	
Distortion suppression	η_d	34 dB	N/A	*See clause 5.1.4*
Echo suppression	η_e	0 dB	0 dB	*See clause 5.1.4*
Echo model		Linear hybrid	Linear hybrid	*See clause 5.1.4*
Symbol rate	f_s f_{sd}	69/68 × 4000baud 4000 baud	69/68 × 4000 baud 4000 baud	*See clause 5.2.4*
Data rate	f_d	64 … 640 kb/s	64 … 6144 kb/s	
Line rate	f_{bd}	$f_{bl} = f_d + 16 \times f_{sd}$ $f_{bh} = (f_d + 8 \times f_{sd}) \times 1.13$ $f_{bd} = max(f_{bl}, f_{bh})$	$f_{bl} = f_d + 16 \times f_{sd}$ $f_{bh} = (f_d + 8 \times f_{sd}) \times 1.13$ $f_{bd} = max(f_{bl}, f_{bh})$	*See clause 5.2.4*
	f_b	$f_b = 69/68 \times f_{db}$	$f_b = 69/68 \times f_{db}$	
Bits per symbol	b	f_{bd} / f_{sd}	f_{bd} / f_{sd}	
Available set of tones	*tones*	[33:56] = [k_1 : k_2] *Tone 57-63 are used as guard band*	[64:95 , 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.*
Center frequency location of tone k; k ∈ tones	f_k	$f_k = k \times \Delta f$ Δf = 4.3125 kHz	$f_k = k \times \Delta f$ Δf = 4.3125 kHz	
Bit-loading algorithm		FBL	FBL	*See clause 5.2.4*
Minimum bit-loading	b_{min}	2	2	*Bits per sub-carrier*
Maximum bit-loading	b_{max}	15	15	*Bits per sub-carrier*

Table 14: Values for the performance parameters extracted from the ETSI performance requirements under ETSI stress conditions.

End of literal text proposals

Hidden definitions: