ETSI WG TM6
(ACCESS TRANSMISSION SYSTEMS ON METALLIC CABLES)

Permanent Document

TM6(01)21 – rev 10

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.
This draft has achieved "working group approval" during the ETSI-TM6 meeting of June 2004, meaning that an official AbC-procedure (Approval by Correspondence) will start in July. When the document passes this voting procedure, a first version of SpM part 2 will be published by ETSI somewhere in the fall of 2004. Issues that are (still) unsolved by that time are 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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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
	~~Transmitter/Disturber models - ADSL~~	Rosaria Persico (TI-labs)	split into 5.1+ 5.2
2-5.1	Transmitter/Disturber models - ADSL w/o DSslope@1.1MHz	Rosaria Persico (TI-labs)	Agreed
2-5.2	Study DS slope of ADSL template PSD at 1.1 MHz	Rosaria Persico (TI-labs)	US
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)*~~	deleted
2-13	~~*Method/Model for Cross talk Cumulative Distribution, etc.*~~	~~*Jack Douglass (Paradyne)*~~	deleted
2-14	~~*Method/Model for Impairment Combination for multiple disturbers*~~	~~*Jack Douglass (Paradyne)*~~	deleted
2-15	~~*Method/Model for Loop Cumulative Distribution + Occurrence*~~	~~*Jack Douglass (Paradyne)*~~	deleted
2-16	~~*Method/Model for Network Model Coverage Score*~~	~~*Jack Douglass (Paradyne)*~~	deleted
2-17	Transmitter/Disturber models - ISDN-MMS43 (4B3T)	Marko Löffelholz (DTAG)	US
2-18	Generic detection model for DMT	Tomas Nordstrom (FTW)	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	Tomas Nordström (FTW)	US
	~~Performance model for ETSI compliant ADSL.FDD over POTS~~	~~Krista Jacobsen (TI)~~	split into 23.1+23.2
2-23.1	Performance model for ADSL.FDD over POTS, w/o bitloading		agreed
2-23.2	Values for minimum and maximum bitloading	Rob van den Brink (TNO/KPN)	US
	~~Performance model for ETSI compliant ADSL.FDD over ISDN~~	Sigurd Schelstraete (ALC)	split into 24.1+24.2
2-23.1	Performance model for ADSL.FDD over ISDN, w/o bitloading		agreed
2-23.2	Values for minimum and maximum bitloading	Rob van den Brink (TNO/KPN)	US
2-25	Performance model for ADSL 2 and ADSL2+	Ragnar Jonsson (Conexant)	US
2-26	Modelling sidelobe pick-up in DMT Receivers	Ragnar Jonsson (Conexant)	US
2-27	Additions to the scope of SpM-2	Angus Carrick	Agreed
2-28	Text for how to simulate power back-off	Tomas Nordstrom (FTW)	Agreed
2-29	Transmitter/disturber model for ADSL2 annex J & M	Robert Baldemair (Ericsson)	Prov agreed
2-30	Text for preventing invalid bit-loading combinations	Tomas Nordstrom (FTW)	US
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*

This study point has been split-up into SP 2-5.1 and SP2-5.1, and is therefore closed

SP 2-5.1 Transmitter/Disturber models - ADSL without downstream slope @ 1.1MHz

Most of the details of the ADSL templates have been solved, except for a few numbers near 1.1 MHz. This study point is dedicated to the solved issues, and is therefore closed

SP 2-5.2 Transmitter/Disturber models - Downstream slope @ 1.1MHz of ADSL template

Most of the details of the ADSL templates have been solved, except for a few numbers near 1.1 MHz. This study point is dedicated to the numbers that are to define the downstream slope near 1.1 MHz.

- *041t33, Sophia 2004 - Unrealistic steep slopes in proposed ADSL SpM templates - Ericsson*
- *041t34, Sophia 2004 - Problems with current templates in ADSL2 J/M evaluations - Ericsson*

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*
- *041t05, Sophia 2004 - Measured ISDN.2B1Q transmitter PSD - Infineon*

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 <u>*generic*</u> 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: $$F(L;L_0,q_0)=\left(1-\exp\left(-\left(\tfrac{L}{L_0}\right)^{q_0}\right)\right)$$

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

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 $q_0= e\cdot L\cdot(\mathrm{d}F/\mathrm{d}L)$ 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*
- *041t24, Sophia 2004 - ISDN-4B3T PSD Measurements - 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*
- *041t27, Sophia 2004 - Revised modelling of "ADSL.FDD over POTS" (EC) - TNO/KPN*

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*
- *041t28, Sophia 2004 - Revised modelling of "ADS.FDDL over ISDN" (EC) - TNO/KPN*

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, including a model for input filtering that reduces the impact of sidelobe pick-up. The main issues are detailed in 041t22, and this studypoint is to develop the text that should be added to the description of the DMT performance 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*
- *041t22, Sophia 2004 - Sidelobe pick-up in ADSL DMT receivers - Alcatel*
- *041t23, Sophia 2004 - Modeling filtering in ADSL receivers - Alcatel*

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*

SP 2-28 Text for how to simulate power back-off
Power back-off is an essential aspect of modeling the behavior of transmitters, and practical implementations will cut-back this power in discrete steps (as specified in the relevant standards). Contribution 033w11 proposes to use for simulation purposes a smooth PCB function rather than the staircase PCB function described in the standard. Rational behind this proposal is to smoothen the bit-rate plots at low distances and enable so more accurate estimations of impact and deployment reaches. Contribution 041w23 shows that this approach leads indeed to smoother performance plots.
It was a common view within TM6 that the analysis of SpM-studies will deteriorate when implementation details like the staircase steps of PCB functions are incorporated as well. A simplified analysis with smooth function improves the analysis, even when this is less realistic.
This study point is dedicated to the precise wording and definition of the power back-of mechanism for SpM studies.
Related Contributions:

- *041w11, Sophia 2004 - Simulation Guide for ADSL and SDSL Power Back-Off - FTW*
- *041w23, Sophia 2004 - Comparison between smooth and staircase PCB - Ericsson*
- *042w08, Gent 2004 - Text, for power back-off in SDSL and ADSL transmitter - TNO*

SP 2-29. Transmitter/Disturber models for ADSL2 annex J&M
Similar to SP 2-5, but dedicated to ADSL2 annex J&M systems
Related Contributions:

- *041t34, Sophia 2004 - Problems with current templates in ADSL2 J/M evaluations - Ericsson*
- *041w12, Sophia 2004 - Proposed ADSL templates for Annex J/M - Ericsson*

SP 2-30. Text for preventing invalid bit-loading combinations
The current draft on SpM-2 has a note in clause 5.2.4, to warn against an invalid combination of loaded bits. This note is relevant, but not very helpful for those who are not highly skilled in the art of DMT simulations. This study point is to provide a more descriptive text.

- *042w10, Gent 2004 - Additional note for the generic DMT model on bit loading - TNO*

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 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)

ED. NOTE. The definition of a value fx, representing the steepness of the downstream slope near 1.1 MHz, has been left for further study.

Values like fx = 3093 kHz, based on the PSD mask specification in the standard, require a slope of at least –36 dB/octave. These values are seen as too pessimistic for a PSD template definition.

Values like fx = 1201 kHz, have been proposed as an alternative, and require a slope of at least –402 dB/octave. These values are seen as too optimistic and unrealistic.

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

ED. NOTE. The definition of a value f_x, representing the steepness of the downstream slope near 1.1 MHz, has been left for further study. See the editorial note in section 4.4.1 for further details

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

ED. NOTE. The definition of a value f_x, representing the steepness of the downstream slope near 1.1 MHz, has been left for further study. See the editorial note in section 4.4.1 for further details

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

ED. NOTE. The definition of a value f_x, representing the steepness of the downstream slope near 1.1 MHz, has been left for further study. See the editorial note in section 4.4.1 for further details

4.4.5 Transmitter signal model for "ADSL2/J" (All Digital Mode, FDD, annex J)

The PSD template for modeling the "ADSL2/J" 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 frequency Δf in this table refers to the sub-carrier spacing of the DMT tones of ADSL. The source impedance equals 100Ω.

ADSL2/J DMT carriers	***Up [1:k]***
f [Hz]	***P [dBm/Hz]***
0	-50
1.5 k	-50
3 k	PSD_1
f_1 =k×Δf	PSD_1
f_2	PSD_2
f_3	PSD_3
f_4	–97.8
686 k	-100
1.411M	-100
1.630M	-110
5.275M	-112
30M	-112
Δf = 4.3125 kHz	

ADSL2/J DMT carriers	***Down [64:255]***
f [Hz]	***P [dBm/Hz]***
0	-90
53.5×f_c = 230.72k	-90
63.0×f_c = 271.79k	-52
63.5×f_c = 273.84k	-40
255.5×f_c = 1101.84k	-40
f_x = <TBD>	-90
3.093M	-90
4.545M	-112
30M	-112
Δf = 4.3125 kHz	

Table 3. PSD template values at break frequencies for modeling "ADSL2/J". The values for f_1...f_4 and PSD_1…PSD_3 are specified in table 4.

US mask number (M)	Tone range [1...k]	f_1 [kHz]	f_2 [kHz]	f_3 [kHz]	f_4 [kHz]	PSD_1 [dBm/Hz]	PSD_2 [dBm/Hz]	PSD_3 [dBm/Hz]
1	1…32	32×Δf (≈140.16)	153.38	157.50	192.45	-38.0	-55.0	-60.0
2	1…36	36×Δf (≈157.41)	171.39	176.46	208.13	-38.5	-55.5	-60.5
3	1…40	40×Δf (≈174.66)	189.31	195.55	224.87	-39.0	-56.0	-61.0
4	1…44	44×Δf (≈191.91)	207.16	214.87	242.51	-39.4	-56.4	-61.4
5	1…48	48×Δf (≈209.16)	224.96	234.56	260.90	-39.8	-56.8	-61.8
6	1…52	52×Δf (≈226.41)	242.70	254.84	280.25	-40.1	-57.1	-62.1
7	1…56	56×Δf (≈243.66)	260.40	276.14	300.85	-40.4	-57.4	-62.4
8	1…60	60×Δf (≈260.91)	278.05	299.30	323.55	-40.7	-57.7	-62.7
9	1…63	63×Δf (≈273.84)	291.09	321.28	345.04	-41.0	-58.0	-63.0

Table 4. Parameter values for parameters used in table 3.

ED. NOTE. The definition of a value f_x, representing the steepness of the downstream slope near 1.1 MHz, has been left for further study. See the editorial note in section 4.4.1 for further details

Power back-off

<FOR FURTHER STUDY>

4.4.6 Transmitter signal model for "ADSL2/M" (over POTS, FDD, annex M)

The PSD template for modeling the "ADSL2/M" transmit spectrum is defined in terms of break frequencies, as summarized in table 5 and 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.

ADSL2/M DMT carriers	*Up [7:k]*
f [Hz]	*P [dBm/Hz]*
0	-101
3.99k	-101
4 k	-96
6.5×Δf (≈ 28.03k)	PSD_1
f_1 = k×Δf	PSD_1
f_2	PSD_2
f_3	PSD_3
f_4	–97.8
686 k	-100
1.411M	-100
1.630M	-110
5.275M	-112
30M	-112
Δf = 4.3125 kHz	

ADSL2/M DMT carriers	*Down [64:255]*
f [Hz]	*P [dBm/Hz]*
0	-90
53.5×f_c = 230.72k	-90
63.0×f_c = 271.79k	-52
63.5×f_c = 273.84k	-40
255.5×f_c = 1101.84k	-40
f_x = <TBD>	-90
3.093M	-90
4.545M	-112
30M	-112
Δf = 4.3125 kHz	

Table 5. PSD template values at break frequencies for modeling "ADSL2/M" . The values for f_1...f_4 and PSD_1…PSD_3 are specified in table 6.

US mask number (M)	Tone range [7…k]	f_1 [kHz]	f_2 [kHz]	f_3 [kHz]	f_4 [kHz]	PSD_1 [dBm/Hz]	PSD_2 [dBm/Hz]	PSD_3 [dBm/Hz]
1	7…32	32×Δf (≈140.16)	153.38	157.50	192.45	-38.0	-55.0	-60.0
2	7…36	36×Δf (≈157.41)	171.39	176.46	208.13	-38.5	-55.5	-60.5
3	7…40	40×Δf (≈174.66)	189.31	195.55	224.87	-39.0	-56.0	-61.0
4	7…44	44×Δf (≈191.91)	207.16	214.87	242.51	-39.4	-56.4	-61.4
5	7…48	48×Δf (≈209.16)	224.96	234.56	260.90	-39.8	-56.8	-61.8
6	7…52	52×Δf (≈226.41)	242.70	254.84	280.25	-40.1	-57.1	-62.1
7	7…56	56×Δf (≈243.66)	260.40	276.14	300.85	-40.4	-57.4	-62.4
8	7…60	60×Δf (≈260.91)	278.05	299.30	323.55	-40.7	-57.7	-62.7
9	7…63	63×Δf (≈273.84)	291.09	321.28	345.04	-41.0	-58.0	-63.0

Table 6. Parameter values for parameters used in table 5.

ED. NOTE. The definition of a value f_x, representing the steepness of the downstream slope near 1.1 MHz, has been left for further study. See the editorial note in section 4.4.1 for further details

Power back-off

<FOR FURTHER STUDY>

Text portions proposed for inclusion into clause 5

5 Generic receiver performance models for xDSL

5.1. Generic input models for effective SNR

5.1.2 Second order input model (with residual distortion)

ED NOTE The need for inclusion of the entire clause 5.1.2 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. An alternative way to model the same imperfections on maximum effective SNR is to reduce the number of the maximum bitloading

This input model assumes that two effects internally modify the SNR of the input signal:

- 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.

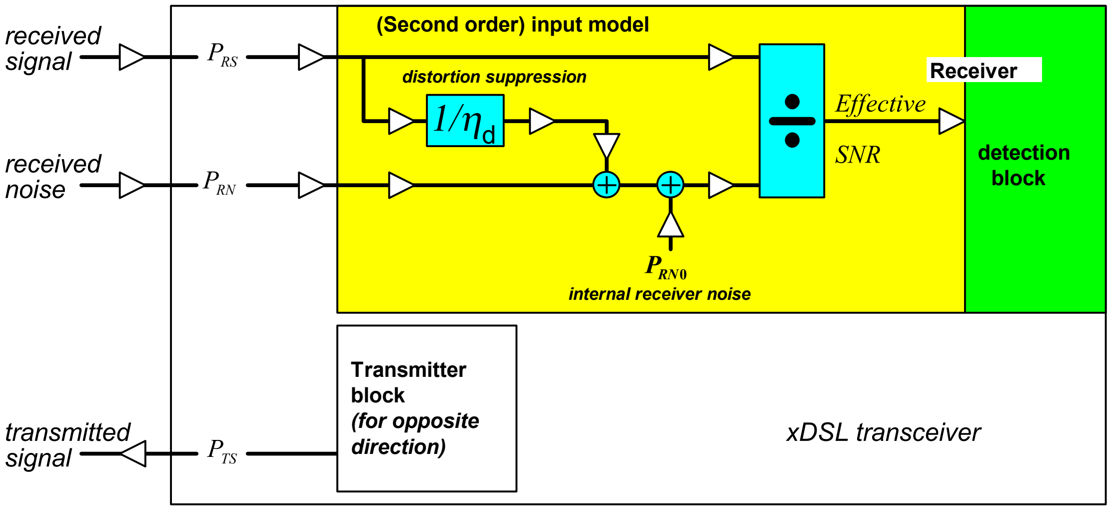

Figure 1: Flow diagram of a transceiver model that incorporates a linear second order input model for the determination of the effective SNR.

Expression 1 summarizes how to evaluate the effective SNR for this model, and it has been specified in plain and offset formats. Table 7 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 7: 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 two effects internally modify the SNR of the input signal:

- 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.

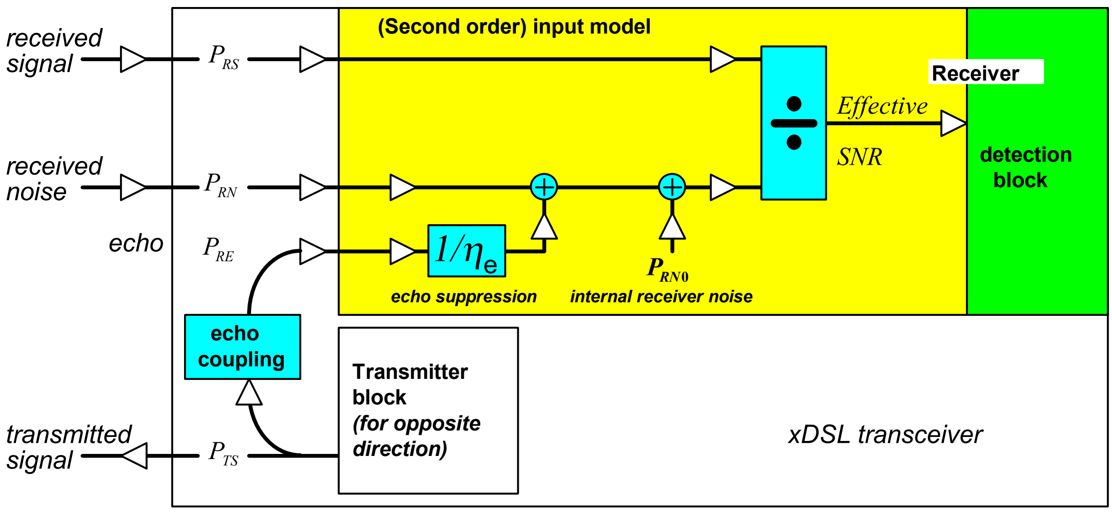

Figure 2: Flow diagram of a transceiver model that incorporates a linear second order input model for the determination of the effective SNR.

Expression 2 summarizes how to evaluate the effective SNR for this model, and it has been specified in plain and offset formats. Table 8 summarizes the involved parameters.

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

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 8: 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 three effects internally modify the SNR of the input signal:

- 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.

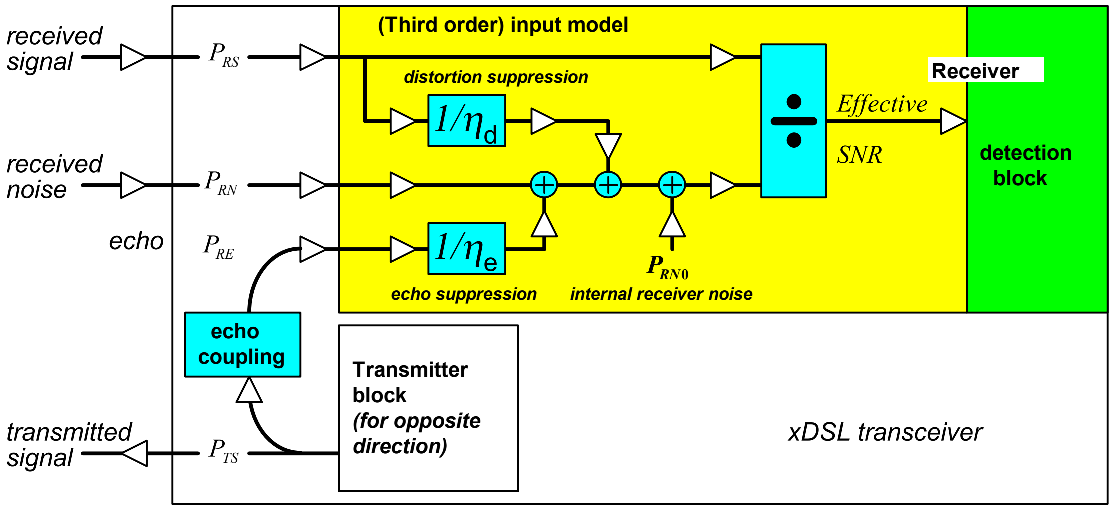

Figure 3: Flow diagram of a transceiver model that incorporates a linear third order input model for the determination of the effective SNR.

Expression 3 summarizes how to evaluate the effective SNR for this model, and it has been specified in plain and offset formats. Table 9 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: $SNR_{\mathrm{ofs,N}}(m, f) = \dfrac{P_{RS}}{P_{RN} \times m + P_{RN0} + P_{RE}/\eta_e^2 + P_{RS}/\eta_d^2}$

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

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

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"

NOTE The ADSL standard specifies the bitloading as integer values between 2 and 15, however the use of a model with "Fractional" bitloading enables the use of non-integer values to account for other receiver properties as well. This enables the modeling of other receiver characteristics, as if they were caused by the bitloading.

Using values for minimum bitloading between 1.5 and 2 may account for the power adjustment of individual levels that minimizes the loss of capacity. A value of 1.5 may be too optimistic and a value of 2 may be too pessimistic, and therefore this level has been left for further study.

Using values for maximum bitloading lower than 15 may account for imperfections in the equalizer causing an upper limit of the effective SNR at the detector. Practical implementations of ADSL that facilitate effective SNR values above 55 dB can take advantage of the full bitloading range (up to 15). The ETSI reach requirements, however, are based on bitrates for short loops (high SNR) that are significantly lower then expected from effective SNR values better then 55 dB. Therefore the value for this maximum bitloading has been left for further study.

ETSI compliant modems can pass the test when the effective SNR of the upstream receiver cannot exceed SNR values of 35 dB (or a maximum bitloading around 8 or 9).
(for more details, see 041t27).

When this model is used for simulation purposes, the chosen values for minimum and maximum bitloading shall be specified.

A possible way forward is the inclusion of more than one model: a model for "legacy ADSL" only following the minimum requirements of ETSI, and models for improved version(s) of ADSL (or ADSL2). On the other hand, such a legacy model can adversely effect the possibility to protect deployed ADSL systems.

6.7 Receiver performance model for "ADSL.FDD over ISDN"

NOTE The ADSL standard specifies the bitloading as integer values between 2 and 15, however the use of a model with "Fractional" bitloading enables the use of non-integer values to account for other receiver properties as well. This enables the modeling of other receiver characteristics, as if they were caused by the bitloading.

Using values for minimum bitloading between 1.5 and 2 may account for the power adjustment of individual levels that minimizes the loss of capacity. A value of 1.5 may be too optimistic and a value of 2 may be too pessimistic, and therefore this level has been left for further study.

Using values for maximum bitloading lower than 15 may account for imperfections in the equalizer causing an upper limit of the effective SNR at the detector. Practical implementations of ADSL that facilitate effective SNR values above 55 dB can take advantage of the full bitloading range (up to 15). The ETSI reach requirements, however, are based on bitrates for short loops (high SNR) that are significantly lower then expected from effective SNR values better then 55 dB. Therefore the value for this maximum bitloading has been left for further study.

ETSI compliant modems can pass the test when the effective SNR of the upstream receiver cannot exceed values of 34 dB (or a maximum bitloading around 8 or 9).
(for more details, see 041t28).

When this model is used for simulation purposes, the chosen values for minimum and maximum bitloading shall be specified.

A possible way forward is the inclusion of more than one model: a model for "legacy ADSL" only following the minimum requirements of ETSI, and models for improved version(s) of ADSL (or ADSL2). On the other hand, such a legacy model can adversely effect the possibility to protect deployed ADSL systems.

End of literal text proposals

Hidden definitions: