TITLE **Algorithmic approach for defining VDSL2 PSD templates for simulation purposes**

PROJECT SpM-2 (study point SP2-6, SP2-7 and SP2-8)

AUTHORS: Rob van den Brink, Bas van den Heuvel. Teun van der Veen - TNO

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

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

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STATUS for decision, and inclusion into SpM-2

ABSTRACT[1] The definition of VDSL2 transmitter models for VDSL2 by means of static PSD tables will easily result in an exploding number of tables. This contribution proposes another solution, by specifying VDSL2 transmitter models via an algorithmic approach using five independent building blocks. Such an approach combines the required flexibility with a limited number of PSD tables.

1. Problem to be solved

The primary purpose of the Spectral Management standard part 2, is to provide well defined (reproducible) assumptions for SpM studies. Reproducibility will improve when the models are kept as simple as possible, by allowing a fair compromise between simplicity and compliance with *all* details in a product standard.
Simple transmitter signal models, based on a simple description of the PSD templates by means of a table or formula, have proven adequate for many SpM studies. Examples are the transmitter models for ISDN, HDSL, SDSL and ADSL are involved.

In a first proposal to define adequate VDSL2 transmitter models, Swisscom [1] followed the same simple approach with tabular PSD templates. They defined fixed tables with PSD templates for three flavors of VDSL2: Profile 8b, 12a and 17. The tables were derived from tables in G.993.2, augmented with a “flat ceiling” to meet the appropriate power requirements for each profile.
The proposal in [1] was restricted to only three profiles, without any PSD shaping, and with a specific implementation of restricting the overall power (“flat ceiling”).

Although we have no problem with the actual PSD levels being proposed in [1], this approach is not suitable for expansion to cover other relevant VDSL2 templates as well. Such an approach will easily result in an ***exploding number of tables*** when more combinations are to be added in this way. In addition, the tables in [1] cannot be reused when shaping is applied. The shaping will also influence the amount by which the overall power has to be restricted, so each shape requires its own table. Therefore we believe that SpM-2 should model the VDSL2 PSD templates in a more advanced manner. This contribution proposes a framework for such a solution.

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

2. Proposed algorithmic approach

The complexity of VDSL2 (many flavors, many kinds of PSD shaping/PBO in downstream and upstream, power restrictions) requires a break-down of the specification of a PSD template for a particular scenario. Figure 1 illustrates a possible way to break down a VDSL2 transmitter model into five individual building blocks:

- A fixed "baseline PSD template", described in a tabular way based on G.993.2
- A "PSD band remover" that can remove VDSL bands like U0, U1 and/or U2 by a relatively simple parametric formula.
- A "PSD shaper" that modifies the shape of the template by a parametric formula, guided by the victim spectrum to be protected..
- A "PSD notcher" that can "punch" notches in a shaped PSD, to prevent egress levels that are too high in radio bands of interest. This is also a simple parametric formula.
- A "PSD restrictor" that modifies a PSD to prevent power levels above some maximum.

We will discuss these building blocks one by one.

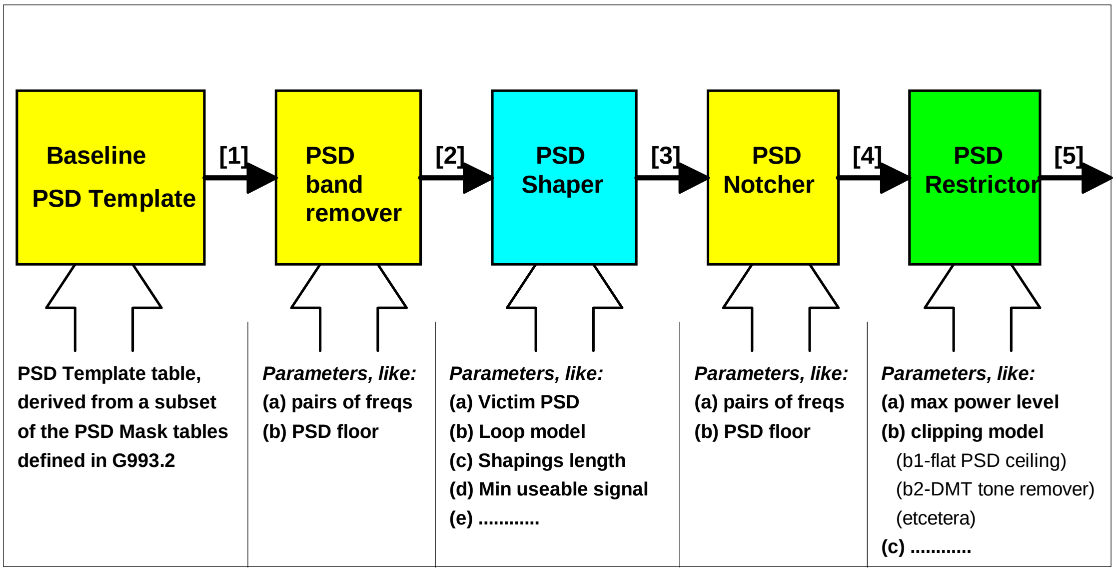

***Figure 1**: Building blocks of a VDSL2 transmitter model, to define a wide range of PSD templates with only a few PSD tables and formulas.*

Building block for "Baseline PSD templates"

The description of the baseline PSD template is static and tabular in nature. The templates are derived from G993.2 masks, corrected for 3.5dB difference between mask and template, and corrected for PSD constraints in 1MHz resolution bands.
Such a derivation is to be guided by a compromise between simplicity and following ITU details. The fact that the "PSD band remover" is implemented as a separated building block will significantly reduce the number of required PSD tables.

Building block for "PSD band remover"

The description of this building block is typically algorithmic in nature. It may remove different bands simultaneously, by replacing in-band PSD levels by a specified floor PSD. Typical parameters are:

- Pairs of (f_{min}, f_{max}) to indicate the boundaries of bands to be removed.
- A floor PSD (may be frequency dependent) to specify the remaining PSD levels within removed bands.

It is expected that the combination of the first two building blocks can generate more PSD combinations than are currently covered by the many PSD tables summarized in G993.2.

Building block for "PSD Shaper"
The description of this building block is typically algorithmic in nature, roughly following the way it is formulated in G997.1. A difference is that shaping is to be applied in this building block to PSD *templates* and not to PSD *masks*. The algorithm is expected to be rather complicated.
To model DPBO aspects in downstream signals, the following parameters may apply:

- The PSD template of a victim signal (level at central office) that is to be protected by proper shaping. It is typically an ADSL2plus downstream signal, that may distinct between the "annex-A" and "annex-B" variants for both the overlapping and non-overlapping spectra. This template is related to DPBO_EPSD specified in G997.1.
- A pair of (f_{min}, f_{max}) to indicate the band in which shaping is applied to the VDSL spectrum. These are typically the **DPBO_FMIN** and **DPBO_FMAX** parameters specified in G997.1.
- The loop model is another "parameter", such as for instance a polynomial curve (like the e-side cable model "**DPBO_ESCM**" used in G997.1, using parameters like A,B,C), or even more advanced models like "TP100" or "TP150" specified by ETSI as VDSL test loop.
- The shaping length can be another parameter, which can be the actual loop-length between central office and cabinet, or something shorter. This is typically the **DPBO_ESEL** parameter specified in G997.1, representing the so called "E-Side Electrical Length" (in dB).
- The minimum useable victim signal can be a fifth parameter, which can even change with the shaping length. Its value is essential to determine up to what frequency the VDSL2 PSD has to be shaped to protect the victim PSD. This is typically the **DPBO_MUS** parameter specified in G.997.1, and calles "Minimum Useable Signal".
- More parameters can be applied, when appropriate.

To model UPBO aspects in upstream signals, another algorithm and set of parameters are required. All details are left for further study, but the concept remains the same as for downstream.

Building block for "PSD notcher"
The description of this building block is also algorithmic in nature, and has great similarity with the "PSD band remover". However it is applied behind the PSD shaper to prevent unnecessary notching of signal levels that are already sufficiently reduced by shaping.

- Pairs of (f_{min}, f_{max}) to indicate the boundaries of bands to be removed
- A floor PSD (typically -80 dBm/Hz, but may be frequency dependent) to specify the remaining PSD level of removed bands.

Building block for "PSD Restrictor"
The description of this building block is also algorithmic in nature. It is to prevent that the aggregate signal power, associated with a shaped PSD template, exceeds the maximum values specified in G993.2. The algorithm is typically iterative in nature.
Different modem implementations may require different models for this building block:

- One model can be a "flat PSD ceiling" model. As soon as the PSD template level exceeds some maximum, it will be "clipped" to that level. This maximum may be found for a specific PSD shape by an iterative algorithm, to facilitate that it is not effective when not required.
- Another model could be a "DMT tone remover", a mechanism based on suppressing several DMT tones in the lower frequency band to meet the maximum power limit.

When required, more alternative models may be defined here, but concept remains the same.

3. Differences with the PSD mask definitions for SpM-1

The above mentioned algorithmic approach illustrates the complexity of modeling VDSL2 transmitters. Since such a model is about PSD templates and not about PSD masks, it can take advantage of some simplification by ignoring details about the slope near a "brick wall". In spite of that, the remaining complexity makes the use of an advanced simulation tool for SpM studies a "must".

Such a complexity, however, is unacceptable for specifying signal limits for a particular access rules. in a particular access network or country. Especially in disputes on violating mandatory access rules, the specification of signal limits should be kept as simple as possible.

This is exactly the domain of the SpM-1 standard: to assist local authorities with adequate descriptions that are informative from an ETSI point of view. Therefore the SpM-1 standard should specify signal ***masks*** by means of PSD tables, while the SpM-2 can do a more advanced job be specifying an infinite number of signal ***templates*** by means of an algorithmic approach. Fortunately, many signals with different PSD templates may fit beneath that same PSD mask, so the explosion in number of PSD tables is not an issue for SpM-1.

4. Conclusions and proposal

- Specifying models for VDSL2 transmitters by means of fixed PSD template tables, as proposed in [1], is not a favorable approach. It will easily result in an ***exploding number of tables*** when more combinations are to be added in this way.
- We propose to specify models for VDSL2 transmitters by means of five independent building blocks, as shown in figure 1. Such an algorithmic approach combines flexibility with a limited number of PSD tables.
- It should be possible to solve four of the five building blocks in a relatively simple way: for “Baseline PSD templates”, “PSD band remover”, “PSD notcher” and “PSD restrictor”. The description of the building block “PSD shaper” may require more study.
- The split-up of the problem in the current three study points (SP2-6, SP2-7 and SP2-8) is inconvenient, with respect to the proposed algorithmic approach. It is recommended to treat them as one for the time being. When detailed proposals TM6 may decide to replace them into two other study points: one about the shaper (G997.1 issues), and another about the rest (G993.2 issues).

5. References

[1] Andreas Thöny, Philippe Repond, *Text proposal on 998 VDSL2 PSD Templates for profiles 8b, 12a and 17a*, Swisscom, ETSI TM6 contribution 063t11, sept 2006.