TITLE **PSD masks for VDSL, and corresponding templates**

PROJECT VDSL

SOURCE:

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ABSTRACT This document contains a proposal for both peak and nominal PSD masks for VDSL, based on the principles on which consensus was reached. It also contains informative descriptions of the corresponding PSD templates. Furthermore, controversial aspects of the PSD definitions have been identified for further study.

1. Introduction

For a proper definition of the transmit PSD for VDSL, a merging is required of the VDSL band allocation plan [2] and the older requirements on the PSD in [1]. In [4] and [5] detailed proposals for this merging have been given.

Discussion has focused on the level of the in-band PSD values and on whether the PSD masks should be interpreted as peak masks or as nominal masks[6][7][8][9]. After a lot of debate, consensus has been reached on the principles behind the PSD mask requirements. This contribution describes these guiding principles, and contains a text proposal and values for all the normative PSD masks. It also contains text for an informative Annex that contains tables for the corresponding PSD templates and plots of the templates and the peak masks.

During discussion on the TM6 exploder of previous versions of this contribution, a consensus on the complete PSD description proved to be unreachable at this time. The controversial issues have been identified and summed up in this contribution. These issues are for further study, and we suggest to add these issues to the VDSL living list.

2. Defining PSD masks

2.1. Definitions

The current draft text for the VDSL part 1 specification [3] contains both 'PSD limits' and 'nominal PSD values'. The precise meaning of these terms is unclear, as well as their status (normative/informative). To avoid confusion, the following terminology is proposed for inclusion in the standard:

- A *peak PSD mask* is a normative requirement, specifying maximum signal levels in ≤10 kHz power bandwidth.
- A *nominal PSD mask* is a normative requirement, specifying maximum signal levels in well-defined power bandwidths, significantly wider then 10 kHz (The power bandwidth is a 100 kHz sliding window for in-band frequencies and a 1 MHz sliding window for out-of-band frequencies).
- A *PSD template* is intended to be used for
    - o performance simulation (informative use of the template);
    - o simplifying the definition of self noise (normative use of the template)

  The PSD template is expected to be close to an appropriate[1] combination of the nominal and peak PSD mask requirements.

The PSD masks specify the maximum narrow-band signal power (NBSP) into a resistive load impedance R=135Ω. The narrow band signal power is defined as the average power **P** of a sending signal into a resistive load **R**, filtered by a band filter centred at a specified frequency. The corresponding PSD value is obtained by dividing the power **P** by the *power* bandwidth **B** of the band filter.

The power bandwidth is different from the commonly used -3 dB resolution bandwidth, since it fully accounts for the shape of the transfer function H(f) of frequency selective filters while measuring narrow band power. The power bandwidth of a frequency selective filter centered at f_c is defined by:

$$B_{power}(f_c) = \frac{1}{|H_{\max}|^2} \int_0^\infty |H(f, f_c)|^2 \, . \, df \text{ , with } H_{\max} = \max(|H(f)|) .$$

2.2. Construction guide lines

As a result of much discussion within ETSI TM6, consensus has been reached on the following points:

- A reduction will be made with respect to the number of different PSDs.
- There will be both peak and nominal requirements for the VDSL PSDs.
- In-band, the peak and nominal PSD masks will differ by 2 dB.
- For the M1 case, the in-band peak mask values will be 1 dB above the existing PSD values.
- For the M2 case, the in-band peak mask values will be 2 dB above the existing PSD values.

Section 3 describes how the peak and nominal masks have been constructed on the basis of these guiding principles.

Section 4 describes a list of those issues on which no consensus could be reached during e-mail correspondence on the ETSI TM6 reflector. These issues are marked as 'for further study'. We suggest to add these issues to the VDSL living list.

[1] *Typically, the template will coincide with the nominal mask for in-band frequencies, and should not violate any of the specified masks.*

3. Construction of the masks

3.1. Problems with a simple approach

In the construction of masks and templates, it is tempting to make the following simplifications (this approach is close to the T1E1.4 approach):

- Take the template equal to the nominal PSD mask.
- Have a fixed difference (e.g. 2 dB) between peak PSD mask and nominal PSD mask everywhere.

However, such a simplified approach leads to a number of undesired consequences:

1. There will be a significant inconsistency between templates and nominal masks
2. This inconsistency leads to templates that are inappropriate
   a. for self-noise generation in performance tests,
   b. for performance simulation.
3. The nominal mask will be too restrictive.

3.1.1. Why is there inconsistency?

Suppose that a signal is generated, and that its PSD equals the PSD template as contained in the proposed annex. When the shape of this PSD is measured with a spectrum analyzer, the measured shape will never be equal to PSD template, because the spectrum analyzer has to measure with a finite resolution bandwidth. Figure 1 and Figure 2 illustrate what shape will be measured into 100 kHz resolution band[2], near a steep edge of a spectrum. It clearly shows that near steep edges, the measured nominal values and template values will differ significantly! So if the PSD is equal to the PSD template, that PSD will violate the nominal mask requirements in case that the nominal mask is made equal to that template.

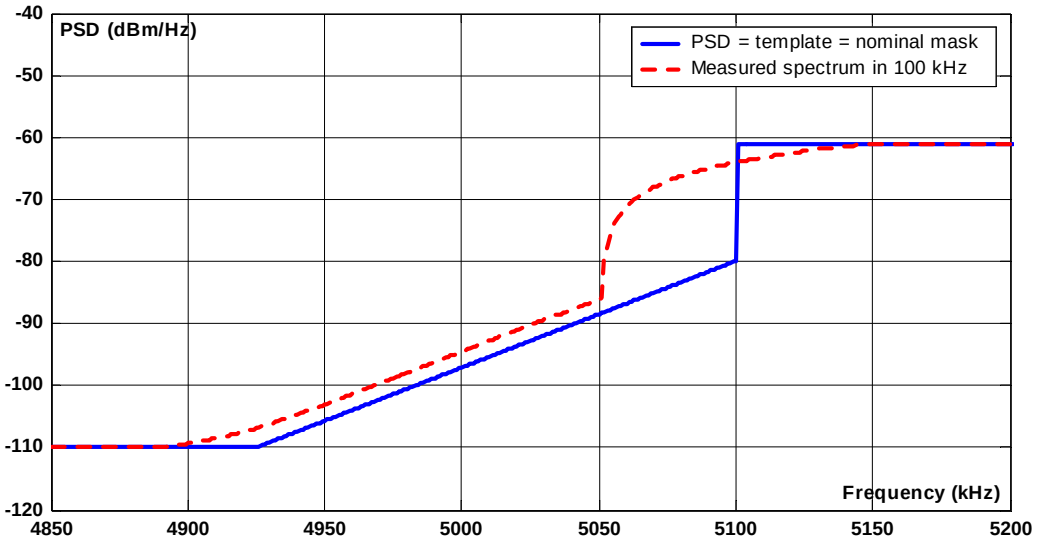


Figure 1: Example showing that taking the template equal to the nominal PSD mask (around transition frequencies) leads to violations of the nominal mask. The red/dotted curve shows how a measurement with 100 kHz power bandwidth of the PSD would look like.

[2] This effect has nothing to do with the way that the spectrum at 100 kHz power bandwidth is measured. The effect also occurs if the method of averaging a number of 10 kHz measurements is used.

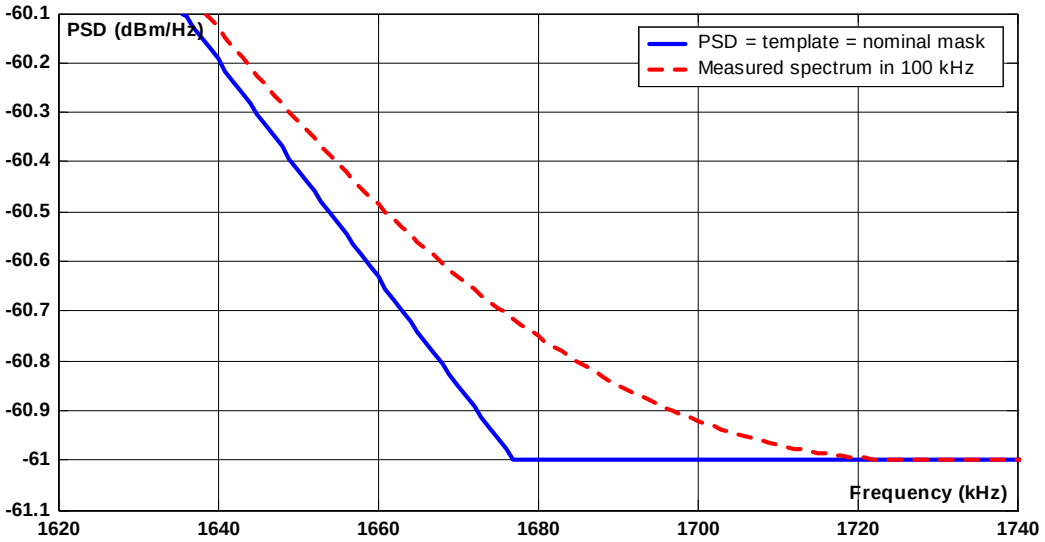


Figure 2: Example showing that taking the template equal to the nominal PSD mask (at the in-band lower corner point in the first downstream band in the M1 FTTEx case) leads to violations of the mask. The red/dotted curve shows how a measurement with 100 kHz power bandwidth of the PSD would look like.

3.1.2. Why does the inconsistency lead to inappropriate templates?

It is conceivable (for simplicity's sake) to agree to take the templates equal to the nominal PSD masks and accept the inconsistency that was described above. However, the consequence of this would be that we agree to use templates that are pessimistic for self-noise evaluation and optimistic for performance evaluation. This is because the nominal PSD mask will prevent an actual VDSL transmitter to emit the PSD values of the template.

3.1.3. Why is the nominal mask too restrictive?

Suppose that the nominal PSD mask is taken to be 2 dB below the peak PSD mask everywhere. Because of the effects described above, this has the consequence that more stringent PSD requirements would be imposed on to the modem than what would be naively expected on the basis of this nominal mask. The PSD that can be emitted by an actual VDSL transmitter would need to be significantly below this nominal mask at a number of points.

3.2. The solution

In view of the problems and complications that are caused by the simplistic approach described above, the approach followed in this contribution will be as follows:

1. Define the (normative) peak PSD mask, based on the agreed views.
2. Define (informative) PSD templates as 'peak PSD mask – 2dB' (for the in-band frequencies)
3. Construct the (normative) nominal mask from the templates such that the nominal masks and the templates are consistent.

This approach does not have the disadvantages of the simple approach sketched above. The approach is described in detail in the next sections.

3.2.1. The peak PSD mask (normative)

As starting point the existing PSD values have been used: these values were obtained [4] by merging directly the VDSL band allocation plan [2] and the older requirements on the PSD in [1]. In the rest of this paper, these PSD values will be referred to as 'the existing PSD'

A (normative) peak PSD mask (≤10 kHz power bandwidth) has been constructed as follows:

1. For the M1 cases, the in-band peak mask values are 1 dB above the existing PSD.
2. For the M2 cases, the in-band peak mask values are 2 dB above the existing PSD.
3. For the ADSL band in the FTTEx case, the in-band peak mask value is taken to be –38 – $D(f)$ dBm/Hz. The precise value of $D(f)$ is TBD, but the idea is to define $D(f)$ such that the total transmit power under the template (envelope power) equals 14.5 dBm (see the section 4: 'For further study')
4. At the rest of the frequency range (out-of-band and transition bands), the peak mask values are kept equal to the existing PSD for both M1 and M2 masks.

3.2.2. The PSD template (informative)

An (informative) PSD template has been constructed (see the text proposal for an informative Annex).

- For in-band frequencies, the PSD template is 2 dB below the corresponding PSD mask.
- For the transition and the out-of-band frequencies, the PSD template is equal to the peak PSD masks[3], with one alteration: the PSD template takes into account the 1 MHz wide band constraints of [2] (which effectively apply for frequencies from 4 MHz and upwards).

3.2.3. The nominal PSD mask (normative)

A (normative) nominal PSD mask has been constructed based on the PSD template that was constructed above. Basically, at those frequencies where the nominal PSD mask is defined, the nominal PSD mask is taken equal to the PSD template. Thus, the nominal PSD mask consists of a number of segments.

1. For in-band frequencies, the power bandwidth of the window shall be 100 kHz.
2. For out-of-band frequencies the power bandwidth of the window shall be 1 MHz
3. At both in-band and out-of-band frequencies (at those frequencies where the original 1MHz wideband constraints of [2] were applicable), the nominal mask equals the PSD template, with one exception (see below).
4. For the transition frequencies, the nominal PSD mask is not defined.

Exception:
For the FTTEx masks there is a small complication at the frequency corner point of 1677 kHz (M1 case) resp. 1394 kHz (M2 case). The problem is illustrated by Figure 2: due to 'power leakage' the measured spectrum in 100 kHz at that point will be a few tenths of a dB higher than the corresponding template value. Therefore, the nominal PSD mask has an extra allowance of 0.5 dB with respect to the PSD template at this point[4].

[3] Strictly speaking, such a template would violate the peak PSD mask at the (steep) transition frequencies. This very small inconsistency is neglected.
[4] At the in-band slopes themselves, this 'power leakage' effect also leads to measured PSD values (in 100 kHz power bandwidth) that are slightly higher than those of the PSD template. Since the difference is maximally 0.05 dB, this effect is neglected.

4. For further study

A number of issues have been found to be controversial, and are left for further study.

4.1. The optional band (25 kHz – 138 kHz)

There is consensus that the optional band should be available for both upstream (U0) and downstream (D0) use. We leave the specification of the optional band for further study, because of the following reasons:

- For FTTCab, we have doubts that the level should be –60 dBm/Hz, as this would be very different from the allowed values above 138 kHz.
- The implications of/on the total power constraint are not clear.
- The roll-off behaviour of this band is not clear.

4.2. Implementation of the total power limitation

It is an explicit operator requirement [9] that the PSD template describe realistic VDSL signals, and that PSD templates should be 'backed-up' by corresponding (nominal) PSD masks. To guarantee that the PSD templates and masks indeed correspond to realistic VDSL signals, they should take into account the constraints on the wideband transmit power.

Without alterations, the downstream FTTEx masks would allow a total power of roughly 21 dBm, much more power than allowed by the current total power constraint of 14.5 dBm. This leads to unwanted degrees of freedom in using the spectrum.

The total power constraint is implemented as follows. For the FTTEx cases concerned, the template is lowered in the ADSL band. The level in this band is set at –40 – $D(f)$ dBm/Hz, where $D(f)$ is chosen such that the total transmit power under the template (envelope power) equals 14.5 dBm.

There is no consensus on how to choose $D(f)$. The following lists some possibilities:

- Set $D=0$ (i.e. remove $D(f)$ from the specification altogether). This leads to non-realistic templates and nominal masks, which do not satisfy the operator requirement on having realistic PSD templates and nominal masks.
- Select a constant value for $D(f)$ in the ADSL band. Choose this level such that the total transmit power under the template (envelope power) equals 14.5 dBm. This approach is in line with the procedure sketched in [11]. The value of D will differ for the various cases of the FTTEx systems; the fixed values for D are provided in the text proposal for information.
- It is possible to select other shapes of $D(f)$, e.g. corresponding to the case that only the upper part of the first downstream band is used.

4.3. The total transmit power

There is the widely supported opinion that the standard should not limit the potential capabilities of VDSL by setting a too stringent upper limit for the total power. Unfortunately, a proposal to allow an optional value of 21 dBm total downstream transmit power [10] was not accepted by TM6.

Since, this contribution did not want to address any controversial issue, the PSD and template values provided by this contribution build on what has been officially agreed so far within TM6 (14.5 dBm was PA, 21 dBm is under discussion).

If an (optional) value for the transmit power of 21 dBm (or 17.5 dBm) would be allowed, the value of $D(f)$ for the FTTEx masks and templates would have to be recalculated to match this total power. This is also the case if a 21 dBm option would be allowed for systems that only use the first downstream band.

4.4. The roll-off behaviour of FTTCab in the ADSL band

In the present proposal, the roll-off of the VDSL signal in the ADSL regime is taken according to the original part 1 specification. Possibly, this roll-off is too relaxed, which might cause spectral compatibility problems. The need for steeper roll-off behaviour is for further study.

Related to this is the issue whether the –90 dBm/Hz value in this regime from 225 to 552 kHz should be replaced by –89 dBm/Hz (for M1) resp. –88 dBm/Hz (for M2)

4.5. Definition of peak mask and nominal mask

There seem to be different views on how to define PSD masks and/or how to determine compliancy to these masks. Any possible controversial parts of the definition are put in a separate annex, and are for further study.

4.6. Further rationalisation of PSDs

Because of the way the PSDs have been constructed from the requirements of part 1 and part 2 of the existing VDSL specification, there are some artefacts still present in the current proposal. The removal of these artefacts is for further study. These artefacts are:

- The nominal masks consist of segments using a power bandwidth of 100 kHz (in-band) and segments to use 1 MHz (out-of-band). It could be considered to use a power bandwidth of 100 kHz for all segments. Which is in line with the proposal made in [12].
- In the out-of-band part of the downstream masks, there is an artificial jump at 4 MHz. This is caused by the fact that the original (part 2) 1 MHz wideband constraint changes at this frequency. It could be considered to remove this artefact, by extending the frequency range of this nominal requirement downwards to 3175 kHz resp. 3925 kHz.

5. Text proposals for normative text

*[*** Editorial comment: This text should be added to the 'definitions' section in section 3.1 of* [1] ****]*

********** BEGIN OF TEXT PROPOSAL **********

TERMINOLOGY

Peak PSD mask: a normative requirement of a transmitted signal, specifying maximum PSD levels in a resolution band with well defined 'narrow' power bandwidth. This band is considered sufficiently narrow for approximating the underlying PSD from band filtered signal power measurements. Therefore the shape of the resolution band is commonly left unspecified (e.g. gaussian shaped or rectangular shaped).

Nominal PSD mask: a normative requirement of a transmitted signal, specifying maximum PSD levels in a resolution band, with a well defined 'wide' shape: a near rectangular window. Because of this well defined window shape the power bandwidth is implicitly defined as well. This window is considered sufficiently wide for approximating the 'average' of the underlying PSD.

PSD template: a simplified PSD description of a transmitted signal, being considered as a fair representation of the signal spectrum. A PSD template is intended for use in:

- performance simulations (informative use of template);
- simplified definitions of self noise during performance measurement (normative use of the template).

Power bandwidth: a number specifying the width of an equivalent rectangular shaped bandwidth filter that represents an arbitrary shaped bandwidth filter in such a way that both filters yields the same power output when filtering white noise. This power bandwidth is often different from the commonly used –3dB bandwidth of bandfilters.

********** END OF TEXT PROPOSAL **********

Editorial comment: This text should replace the sections 'PSD limits' etc in section 8.2.5.2 in [3]
********** BEGIN OF TEXT PROPOSAL **********

8.?? PSD limits

The peak PSD masks and the nominal PSD masks (see section 3.1) defined in this document are defined as follows: all requirements specify the maximum narrow-band signal power (NBSP) into a resistive load impedance *R=135 W*. The narrow band signal power is defined as the average power **P** of a sending signal, filtered by a band filter centred at a specified frequency. The corresponding PSD value is obtained by dividing the power **P** by the *power* bandwidth **B** of the band filter. See Annex ? for further details on specifying PSD masks and verifying compliance.

The following tables shall be used as upper bounds for the Narrow Band Spectral Power respectively the PSD when joining the points using straight lines on a graph with a logarithmic frequency scale (Hz) and a linear power scale (dBm resp. dBm/Hz). The 'A' section of the table contains the peak PSD mask. The 'B' section of the table contains the nominal PSD mask.

> NOTE: Each table contains six distinct frequency ranges, each limited by two *edge frequencies* f_{start} and f_{stop}. For such a frequency range, the maximum NBSP (in a power bandwidth B) shall be below NBSP(f) for all $f_{start}+B/2 < f < f_{stop} - B/2$.

8.????? Upstream masks (Main band plan)

	P.M1			
	Freq (kHz)	Signal Level (dBm) P	Power Bandwidth (kHz) B	Power Density (dBm/Hz) P/B
A	0	-67.5	1	-97.5
	4	-67.5	1	-97.5
	4	-70	10	-110
	225	-70	10	-110
	226	-60	10	-100
	2825	-60	10	-100
	3000	-40	10	-80
	3001	-19	10	-59
	5099	-19	10	-59
	5100	-40	10	-80
	5275	-60	10	-100
	6875	-60	10	-100
	7050	-40	10	-80
	7051	-19	10	-59
	10000	-19	10	-59
	11999	-29	10	-69
	12000	-40	10	-80
	12175	-60	10	-100
	30000	-60	10	-100
B	3000	-11	100	-61
	5100	-11	100	-61
	5275	-52	1000	-112
	6875	-52	1000	-112
	7050	-11	100	-61
	10000	-11	100	-61
	12000	-21	100	-71
	12175	-52	1000	-112
	30000	-52	1000	-112

	P.M2			
	Freq (kHz)	Signal Level (dBm) P	Power Bandwidth (kHz) B	Power Density (dBm/Hz) P/B
	0	-67.5	1	-97.5
	4	-67.5	1	-97.5
	4	-70	10	-110
	225	-70	10	-110
	226	-60	10	-100
	2825	-60	10	-100
	3000	-40	10	-80
	3001	-12.8	10	-52.8
	5099	-15.1	10	-55.1
	5100	-40	10	-80
	5275	-60	10	-100
	6875	-60	10	-100
	7050	-40	10	-80
	7051	-16.5	10	-56.5
	10000	-18	10	-58
	11999	-18	10	-58
	12000	-40	10	-80
	12175	-60	10	-100
	30000	-60	10	-100
	3000	-4.8	100	-54.8
	5100	-7.1	100	-57.1
	5275	-52	1000	-112
	6875	-52	1000	-112
	7050	-8.5	100	-58.5
	10000	-10	100	-60
	12000	-10	100	-60
	12175	-52	1000	-112
	30000	-52	1000	-112

8.????? Downstream masks for FTTCab (Main band plan)

	Pcab.M1				Pcab.M2			
	Freq (kHz)	Signal Level (dBm) P	Power Bandwidth (kHz) B	Power Density (dBm/Hz) P/B	Freq (kHz)	Signal Level (dBm) P	Power Bandwidth (kHz) B	Power Density (dBm/Hz) P/B
A	0	-67.5	1	-97.5	0	-67.5	1	-97.5
	4	-67.5	1	-97.5	4	-67.5	1	-97.5
	4	-70	10	-110	4	-70	10	-110
	225	-70	10	-110	225	-70	10	-110
(*)	226	-50	10	-90	226	-50	10	-90
(*)	552	-50	10	-90	552	-50	10	-90
(*)	1104	-19	10	-59	1104	-18	10	-58
					1394	-8	10	-48
	2999	-19	10	-59	2999	-12.8	10	-52.8
	3000	-40	10	-80	3000	-40	10	-80
	3175	-60	10	-100	3175	-60	10	-100
	4925	-60	10	-100	4925	-60	10	-100
	5100	-40	10	-80	5100	-40	10	-80
	5101	-19	10	-59	5101	-15.1	10	-55.1
	7049	-19	10	-59	7049	-16.5	10	-56.5
	7050	-40	10	-80	7050	-40	10	-80
	7225	-60	10	-100	7225	-60	10	-100
	30000	-60	10	-100	30000	-60	10	-100
B	1104	-11	100	-61	1104	-10	100	-60
					1394	0	100	-50
	3000	-11	100	-61	3000	-4.8	100	-54.8
	4000	-50	1000	-110	4000	-50	1000	-110
	4925	50	1000	-110	4925	50	1000	-110
	5100	-11	100	-61	5100	-7.1	100	-57.1
	7050	-11	100	-61	7050	-8.5	100	-58.5
	7225	-52	1000	-112	7225	-52	1000	-112
	30000	-52	1000	-112	30000	-52	1000	-112

NOTE: The grey area in the table (marked with "*") corresponds to the roll-off of the VDSL signal in the ADSL regime. Possibly, this roll-off is too relaxed, which might cause spectral compatibility problems. The need for steeper roll-off behaviour is for further study. Therefore, the numbers in the grey area may change in the future.

8.????? Downstream masks for FTTEx (Main band plan)

	Pex.P1.M1			
	Freq (kHz)	Signal Level (dBm) P	Power Bandwidth (kHz) B	Power Density (dBm/Hz) P/B
A	0	-67.5	1	-97.5
	4	-67.5	1	-97.5
	4	-50	10	-90
	138	-50	10	-90
	139	-19	10	-59
	217	-19	10	-59
	276	2-Δ	10	-38-Δ
	1104	2-Δ	10	-38-Δ
	1677	-19	10	-59
	2999	-19	10	-59
	3000	-40	10	-80
	3175	-60	10	-100
	4925	-60	10	-100
	5100	-40	10	-80
	5101	-19	10	-59
	7049	-19	10	-59
	7050	-40	10	-80
	7225	-60	10	-100
	30000	-60	10	-100
B	276	10-Δ	100	-40-Δ
	1104	10-Δ	100	-40-Δ
	1677	-11+0.5	100	-61+0.5
	1750	-11	100	-61
	3000	-11	100	-61
	4000	-50	1000	-110
	4925	50	1000	-110
	5100	-11	100	-61
	7050	-11	100	-61
	7225	-52	1000	-112
	30000	-52	1000	-112

Pex.P1.M2			
Freq (kHz)	Signal Level (dBm) P	Power Bandwidth (kHz) B	Power Density (dBm/Hz) P/B
0	-67.5	1	-97.5
4	-67.5	1	-97.5
4	-50	10	-90
138	-50	10	-90
139	-18	10	-58
217	-18	10	-58
276	2-Δ	10	-38-Δ
1104	2-Δ	10	-38-Δ
1394	-8	10	-48
2999	-12.8	10	-52.8
3000	-40	10	-80
3175	-60	10	-100
4925	-60	10	-100
5100	-40	10	-80
5101	-15.1	10	-55.1
7049	-16.5	10	-56.5
7050	-40	10	-80
7225	-60	10	-100
30000	-60	10	-100
276	10-Δ	100	-40-Δ
1104	10-Δ	100	-40-Δ
1394	0+0.5	100	-50+0.5
3000	-4.8	100	-54.8
4000	-50	1000	-110
4925	50	1000	-110
5100	-7.1	100	-57.1
7050	-8.5	100	-58.5
7225	-52	1000	-112
30000	-52	1000	-112

	Pex.P2.M1			
	Freq (kHz)	Signal Level (dBm) P	Power Bandwidth (kHz) B	Power Density (dBm/Hz) P/B
A	0	-67.5	1	-97.5
	4	-67.5	1	-97.5
	4	-50	10	-90
	138	-50	10	-90
	139	2-Δ	10	-38-Δ
	1104	2-Δ	10	-38-Δ
	1677	-19	10	-59
	2999	-19	10	-59
	3000	-40	10	-80
	3175	-60	10	-100
	4925	-60	10	-100
	5100	-40	10	-80
	5101	-19	10	-59
	7049	-19	10	-59
	7050	-40	10	-80
	7225	-60	10	-100
	30000	-60	10	-100
B	138	10-Δ	100	-40-Δ
	1104	10-Δ	100	-40-Δ
	1677	-11+0.5	100	-61+0.5
	1750	-11	100	-61
	3000	-11	100	-61
	4000	-50	1000	-110
	4925	50	1000	-110
	5100	-11	100	-61
	7050	-11	100	-61
	7225	-52	1000	-112
	30000	-52	1000	-112

Pex.P2.M2			
Freq (kHz)	Signal Level (dBm) P	Power Bandwidth (kHz) B	Power Density (dBm/Hz) P/B
0	-67.5	1	-97.5
4	-67.5	1	-97.5
4	-50	10	-90
138	-50	10	-90
139	2-Δ	10	-38-Δ
1104	2-Δ	10	-38-Δ
1394	-8	10	-48
2999	-12.8	10	-52.8
3000	-40	10	-80
3175	-60	10	-100
4925	-60	10	-100
5100	-40	10	-80
5101	-15.1	10	-55.1
7049	-16.5	10	-56.5
7050	-40	10	-80
7225	-60	10	-100
30000	-60	10	-100
138	10-Δ	100	-40-Δ
1104	10-Δ	100	-40-Δ
1394	0+0.5	100	-50+0.5
3000	-4.8	100	-54.8
4000	-50	1000	-110
4925	50	1000	-110
5100	-7.1	100	-57.1
7050	-8.5	100	-58.5
7225	-52	1000	-112
30000	-52	1000	-112

NOTE: Δ can be a fixed value or can be frequency dependent over the ADSL band. The precise values are for further study. Proposed constant values that implement the 14.5 dBm total power constraint are in the table below:

Profile	**PSD reduction D (dB) For systems using both DS bands**	**PSD reduction D (dB) For systems using only the first DS band**
Pex.P1.M1	5.9	5.6
Pex.P1.M2	8.4	7.5
Pex.P2.M1	6.4	6.1
Pex.P2.M2	8.8	8.0

8.????? Upstream masks (Optional regional specific plan)

	P.M1				P.M2			
	Freq (kHz)	Signal Level (dBm) P	Power Bandwidth (kHz) B	Power Density (dBm/Hz) P/B	Freq (kHz)	Signal Level (dBm) P	Power Bandwidth (kHz) B	Power Density (dBm/Hz) P/B
A	0	-67.5	1	-97.5	0	-67.5	1	-97.5
	4	-67.5	1	-97.5	4	-67.5	1	-97.5
	4	-70	10	-110	4	-70	10	-110
	225	-70	10	-110	225	-70	10	-110
	226	-60	10	-100	226	-60	10	-100
	3575	-60	10	-100	3575	-60	10	-100
	3750	-40	10	-80	3750	-40	10	-80
	3751	-19	10	-59	3751	-13.7	10	-53.7
	5199	-19	10	-59	5199	-15.2	10	-55.2
	5200	-40	10	-80	5200	-40	10	-80
	5375	-60	10	-100	5375	-60	10	-100
	8325	-60	10	-100	8325	-60	10	-100
	8500	-40	10	-80	8500	-40	10	-80
	8501	-19	10	-59	8501	-17.3	10	-57.3
	10000	-19	10	-59	10000	-18	10	-58
	11999	-29	10	-69	11999	-18	10	-58
	12000	-40	10	-80	12000	-40	10	-80
	12175	-60	10	-100	12175	-60	10	-100
	30000	-60	10	-100	30000	-60	10	-100
B	3750	-11	100	-61	3750	-5.7	100	-55.7
	5200	-11	100	-61	5200	-7.2	100	-57.2
	5375	-52	1000	-112	5375	-52	1000	-112
	8325	-52	1000	-112	8325	-52	1000	-112
	8500	-11	100	-61	8500	-9.3	100	-59.3
	10000	-11	100	-61	10000	-10	100	-60
	12000	-21	100	-71	12000	-10	100	-60
	12175	-52	1000	-112	12175	-52	1000	-112
	30000	-52	1000	-112	30000	-52	1000	-112

8.????? Downstream masks for FTTCab (Optional regional specific plan)

	Pcab.M1				Pcab.M2			
	Freq (kHz)	Signal Level (dBm) P	Power Bandwidth (kHz) B	Power Density (dBm/Hz) P/B	Freq (kHz)	Signal Level (dBm) P	Power Bandwidth (kHz) B	Power Density (dBm/Hz) P/B
A	0	-67.5	1	-97.5	0	-67.5	1	-97.5
	4	-67.5	1	-97.5	4	-67.5	1	-97.5
	4	-70	10	-110	4	-70	10	-110
	225	-70	10	-110	225	-70	10	-110
(*)	226	-50	10	-90	226	-50	10	-90
(*)	552	-50	10	-90	552	-50	10	-90
(*)	1104	-19	10	-59	1104	-18	10	-58
					1394	-8	10	-48
	3749	-19	10	-59	3749	-13.7	10	-53.7
	3750	-40	10	-80	3750	-40	10	-80
	3925	-60	10	-100	3925	-60	10	-100
	5025	-60	10	-100	5025	-60	10	-100
	5200	-40	10	-80	5200	-40	10	-80
	5201	-19	10	-59	5201	-15.2	10	-55.2
	8499	-19	10	-59	8499	-17.3	10	-57.3
	8500	-40	10	-80	8500	-40	10	-80
	8675	-60	10	-100	8675	-60	10	-100
	30000	-60	10	-100	30000	-60	10	-100
B	1104	-11	100	-61	1104	-10	100	-60
					1394	0	100	-50
	3750	-11	100	-61	3750	-5.7	100	-55.7
	4000	-50	1000	-110	4000	-50	1000	-110
	5025	-50	1000	-110	5025	-50	1000	-110
	5200	-11	100	-61	5200	-7.2	100	-57.2
	8500	-11	100	-61	8500	-9.3	100	-59.3
	8675	-52	1000	-112	8675	-52	1000	-112
	30000	-52	1000	-112	30000	-52	1000	-112

NOTE: The grey area in the table (marked with "*") corresponds to the roll-off of the VDSL signal in the ADSL regime. Possibly, this roll-off is too relaxed, which might cause spectral compatibility problems. The need for steeper roll-off behaviour is for further study. Therefore, the numbers in the grey area may change in the future.

8.????? Downstream masks for FTTEx (Optional regional specific plan)

	Pex.P1.M1			
	Freq (kHz)	Signal Level (dBm) P	Power Bandwidth (kHz) B	Power Density (dBm/Hz) P/B
A	0	-67.5	1	-97.5
	4	-67.5	1	-97.5
	4	-50	10	-90
	138	-50	10	-90
	139	-19	10	-59
	217	-19	10	-59
	276	2-Δ	10	-38-Δ
	1104	2-Δ	10	-38-Δ
	1677	-19	10	-59
	3749	-19	10	-59
	3750	-40	10	-80
	3925	-60	10	-100
	5025	-60	10	-100
	5200	-40	10	-80
	5201	-19	10	-59
	8499	-19	10	-59
	8500	-40	10	-80
	8675	-60	10	-100
	30000	-60	10	-100
B	276	10-Δ	100	-40-Δ
	1104	10-Δ	100	-40-Δ
	1677	-11+0.5	100	-61+0.5
	1750	-11	100	-61
	3750	-11	100	-61
	4000	-50	1000	-110
	5025	-50	1000	-110
	5200	-11	100	-61
	8500	-11	100	-61
	8675	-52	1000	-112
	30000	-52	1000	-112

	Pex.P1.M2			
	Freq (kHz)	Signal Level (dBm) P	Power Bandwidth (kHz) B	Power Density (dBm/Hz) P/B
A	0	-67.5	1	-97.5
	4	-67.5	1	-97.5
	4	-50	10	-90
	138	-50	10	-90
	139	-18	10	-58
	217	-18	10	-58
	276	2-Δ	10	-38-Δ
	1104	2-Δ	10	-38-Δ
	1394	-8	10	-48
	3749	-13.7	10	-53.7
	3750	-40	10	-80
	3925	-60	10	-100
	5025	-60	10	-100
	5200	-40	10	-80
	5201	-15.2	10	-55.2
	8499	-17.3	10	-57.3
	8500	-40	10	-80
	8675	-60	10	-100
	30000	-60	10	-100
B	276	10-Δ	100	-40-Δ
	1104	10-Δ	100	-40-Δ
	1394	0+0.5	100	-50+0.5
	3750	-5.7	100	-55.7
	4000	-50	1000	-110
	5025	-50	1000	-110
	5200	-7.2	100	-57.2
	8500	-9.3	100	-59.3
	8675	-52	1000	-112
	30000	-52	1000	-112

	Pex.P2.M1			
	Freq (kHz)	Signal Level (dBm) P	Power Bandwidth (kHz) B	Power Density (dBm/Hz) P/B
A	0	-67.5	1	-97.5
	4	-67.5	1	-97.5
	4	-50	10	-90
	138	-50	10	-90
	139	2-Δ	10	-38-Δ
	1104	2-Δ	10	-38-Δ
	1677	-19	10	-59
	3749	-19	10	-59
	3750	-40	10	-80
	3925	-60	10	-100
	5025	-60	10	-100
	5200	-40	10	-80
	5201	-19	10	-59
	8499	-19	10	-59
	8500	-40	10	-80
	8675	-60	10	-100
	30000	-60	10	-100
B	138	10-Δ	100	-40-Δ
	1104	10-Δ	100	-40-Δ
	1677	-11+0.5	100	-61+0.5
	1750	-11	100	-61
	3750	-11	100	-61
	4000	-50	1000	-110
	5025	-50	1000	-110
	5200	-11	100	-61
	8500	-11	100	-61
	8675	-52	1000	-112
	30000	-52	1000	-112

Pex.P2.M2			
Freq (kHz)	Signal Level (dBm) P	Power Bandwidth (kHz) B	Power Density (dBm/Hz) P/B
0	-67.5	1	-97.5
4	-67.5	1	-97.5
4	-50	10	-90
138	-50	10	-90
139	2-Δ	10	-38-Δ
1104	2-Δ	10	-38-Δ
1394	-8	10	-48
3749	-13.7	10	-53.7
3750	-40	10	-80
3925	-60	10	-100
5025	-60	10	-100
5200	-40	10	-80
5201	-15.2	10	-55.2
8499	-17.3	10	-57.3
8500	-40	10	-80
8675	-60	10	-100
30000	-60	10	-100
138	10-Δ	100	-40-Δ
1104	10-Δ	100	-40-Δ
1394	0+0.5	100	-50+0.5
3750	-5.7	100	-55.7
4000	-50	1000	-110
5025	-50	1000	-110
5200	-7.2	100	-57.2
8500	-9.3	100	-59.3
8675	-52	1000	-112
30000	-52	1000	-112

NOTE: Δ can be a fixed value or can be frequency dependent over the ADSL band. The precise values are for further study. Proposed constant values that implement the 14.5 dBm total power constraint are in the table below:

Profile	**PSD reduction D (dB) For systems using both DS bands**	**PSD reduction D (dB) For systems using only the first DS band**
Pex.P1.M1	6.2	5.7
Pex.P1.M2	10	8.2
Pex.P2.M1	6.7	6.2
Pex.P2.M2	10	8.7

********** END OF TEXT PROPOSAL **********

6. Text proposal for informative Annexes

********** BEGIN OF TEXT PROPOSAL **********

ANNEX ??: Specifying PSD masks

The peak PSD masks and the nominal PSD masks (see section 3.1) defined in this document are defined as follows: all requirements specify the maximum narrow-band signal power (NBSP) into a resistive load impedance *R=135 W*. The narrow band signal power is defined as the average power **P** of a sending signal into a resistive load **R**, filtered by a band filter centred at a specified frequency. The corresponding PSD value is obtained by dividing the power **P** by the *power* bandwidth **B** of the band filter.

The power bandwidth is different from the commonly used -3 dB resolution bandwidth, since it fully accounts for the shape of the transfer function H(f) of frequency selective filters while measuring narrow band power. The power bandwidth of a frequency selective filter centered at f_c is defined by:

$$B_{power}(f_c) = \frac{1}{|H_{\max}|^2} \int_0^{\infty} |H(f, f_c)|^2 \, . \, df \text{ , with } H_{\max} = \max(|H(f)|)$$

To check compliancy to the 100 kHz and 1 MHz sliding window constraints of the nominal PSD mask, the narrowband (peak) PSD measurements may be averaged within the appropriate sliding window.

NOTE: A MORE DETAILED PRESCRIPTION OF THE MEASURING METHODS IS LEFT FOR FURTHER STUDY.

********** END OF TEXT PROPOSAL **********

********** BEGIN OF TEXT PROPOSAL **********

Annex ??(Informative) PSD templates

This annex contains the tables with the PSD templates for the VDSL signals. It also contains plots of these templates, and compares these templates to the corresponding peak mask.

The main band plan

P.M1	
Freq (kHz)	Power density (dBm/Hz)
0	-97.5
4	-97.5
5	-110
225	-110
226	-100
2825	-100
3000	-80
3001	-61
5099	-61
5100	-80
5275	-112
6875	-112
7050	-80
7051	-61
11999	-61
12000	-80
12175	-112
30000	-112

P.M2	
Freq (kHz)	Power density (dBm/Hz)
0	-97.5
4	-97.5
5	-110
225	-110
226	-100
2825	-100
3000	-80
3001	-54.8
5099	-57.1
5100	-80
5275	-112
6875	-112
7050	-80
7051	-60
11999	-60
12000	-80
12175	-112
30000	-112

Pcab.M1	
Freq (kHz)	Power density (dBm/Hz)
0	-97.5
4	-97.5
5	-110
225	-110
226	-90
552	-90
1104	-61
2999	-61
3000	-80
3175	-100
3999	-100
4000	-110
4925	-110
5100	-80
5101	-61
7049	-61
7050	-80
7225	-112
30000	-112

Pcab.M2	
Freq (kHz)	Power density (dBm/Hz)
0	-97.5
4	-97.5
5	-110
225	-110
226	-90
552	-90
1104	-60
1394	-50
2999	-54.8
3000	-80
3175	-100
3999	-100
4000	-110
4925	-110
5100	-80
5101	-57.1
7049	-58.5
7050	-80
7225	-112
30000	-112

Pex.P1.M1	
Freq (kHz)	Power density (dBm/Hz)
0	-97.5
4	-97.5
5	-90
138	-90
139	-59
217	-59
276	-40-Δ
1104	-40-Δ
1677	-61
2999	-61
3000	-80
3175	-100
3999	-100
4000	-110
4925	-110
5100	-80
5101	-61
7049	-61
7050	-80
7225	-112
30000	-112

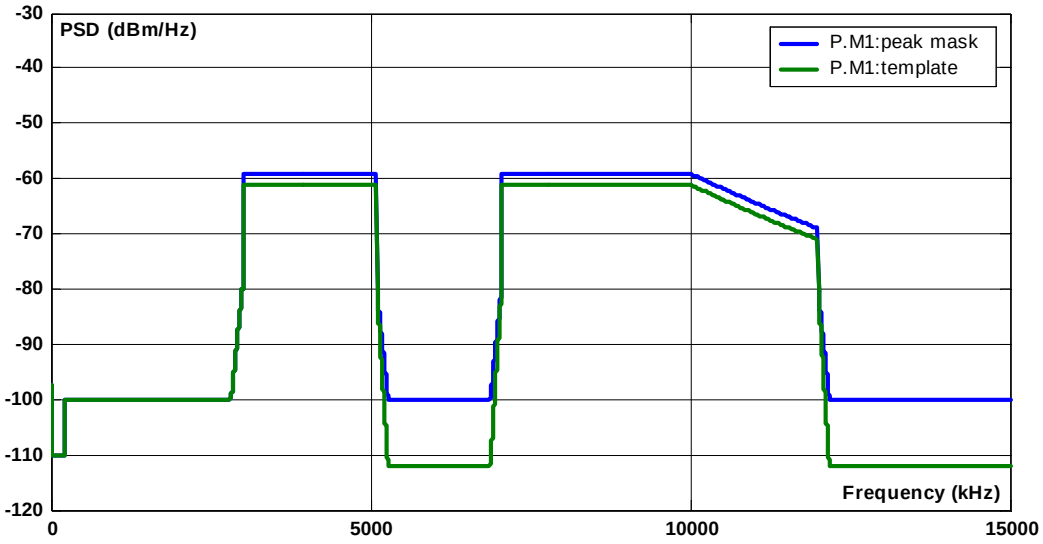
Pex.P1.M2	
Freq (kHz)	Power density (dBm/Hz)
0	-97.5
4	-97.5
5	-90
138	-90
139	-58
217	-58
276	-40-Δ
1104	-40-Δ
1394	-50
2999	-54.8
3000	-80
3175	-100
3999	-100
4000	-110
4925	-110
5100	-80
5101	-57.1
7049	-58.5
7050	-80
7225	-112
30000	-112

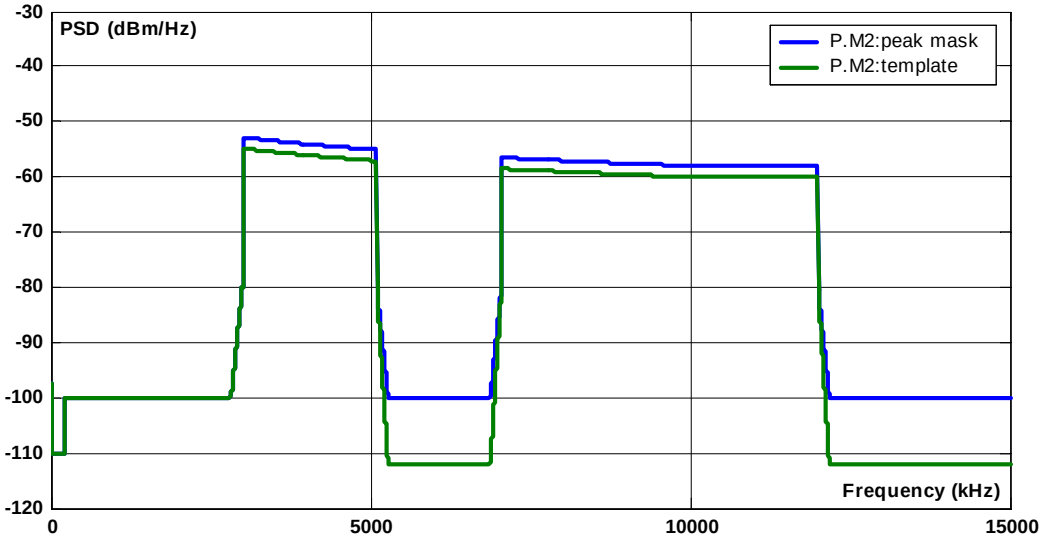
Pex.P2.M1	
Freq (kHz)	Power density (dBm/Hz)
0	-97.5
4	-97.5
5	-90
138	-90
139	-40-Δ
1104	-40-Δ
1677	-61
2999	-61
3000	-80
3175	-100
3999	-100
4000	-110
4925	-110
5100	-80
5101	-61
7049	-61
7050	-80
7225	-112
30000	-112

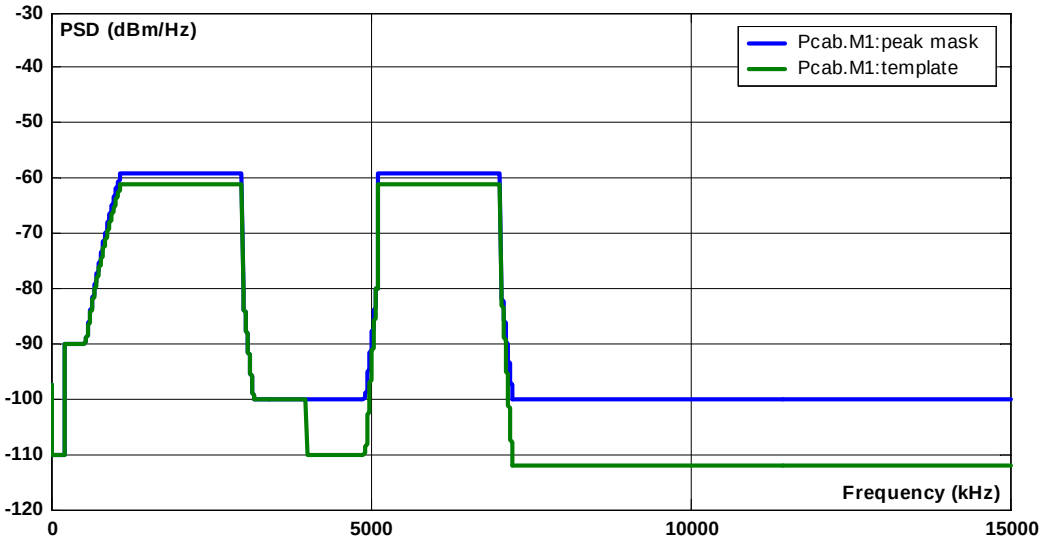
Pex.P2.M2	
Freq (kHz)	Power density (dBm/Hz)
0	-97.5
4	-97.5
5	-90
138	-90
139	-40-Δ
1104	-40-Δ
1394	-50
2999	-54.8
3000	-80
3175	-100
3999	-100
4000	-110
4925	-110
5100	-80
5101	-57.1
7049	-58.5
7050	-80
7225	-112
30000	-112

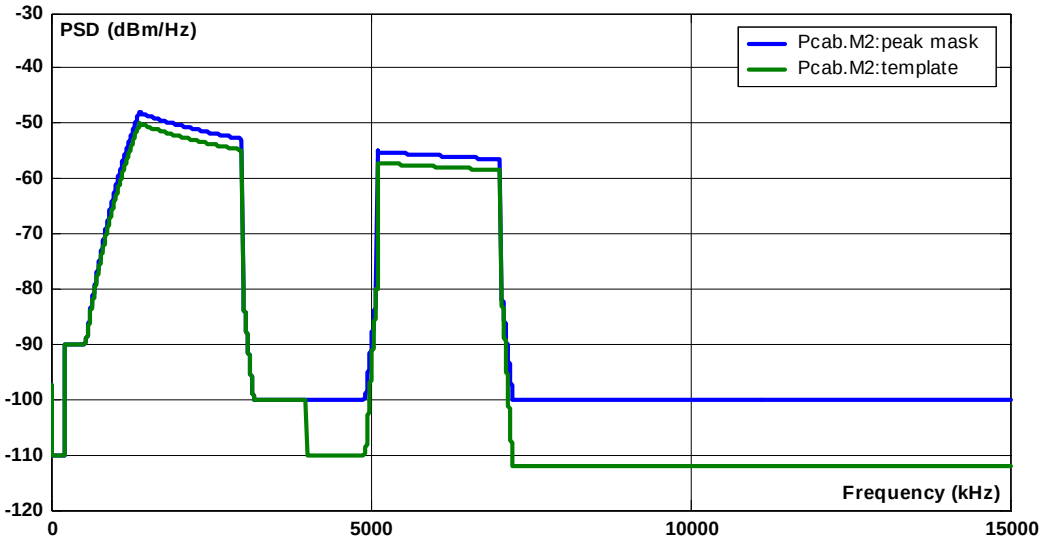
Profile	**PSD reduction** D **(dB)**	**First band Power (dBm @ 135** W**)**	**Second band Power (dBm @ 135** W**)**	**Total Power (dBm @ 135** W**)**
P.M1	N/a	2.2	4.7	6.6
P.M2	N/a	7.2	7.4	10.3
Pcab.M1	N/a	2.0	1.9	5.0
Pcab.M2	N/a	10.1	5.1	11.3
Pex.P1.M1	5.9	14.2	1.9	14.5
Pex.P1.M2	8.4	14.0	5.1	14.5
Pex.P2.M1	6.4	14.2	1.9	14.5
Pex.P2.M2	8.8	14.0	5.1	14.5
Pex.P1.M1	5.6	14.5	N/a	14.5
Pex.P1.M2	7.5	14.5	N/a	14.5
Pex.P2.M1	6.1	14.5	N/a	14.5
Pex.P2.M2	8.0	14.5	N/a	14.5

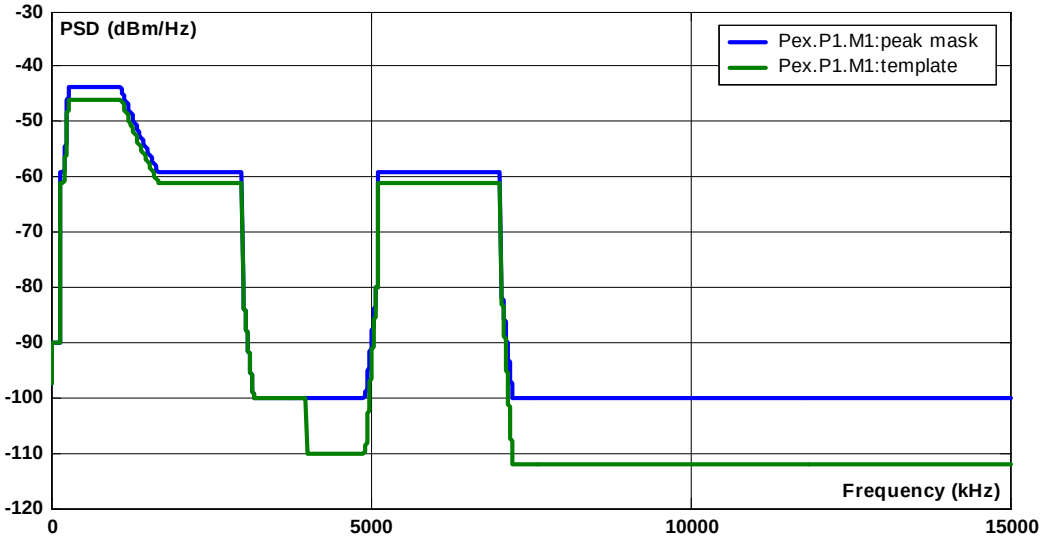
Table TBD: Total transmit power of each of the PSD templates.The values in grey apply to systems that only use the first downstream band

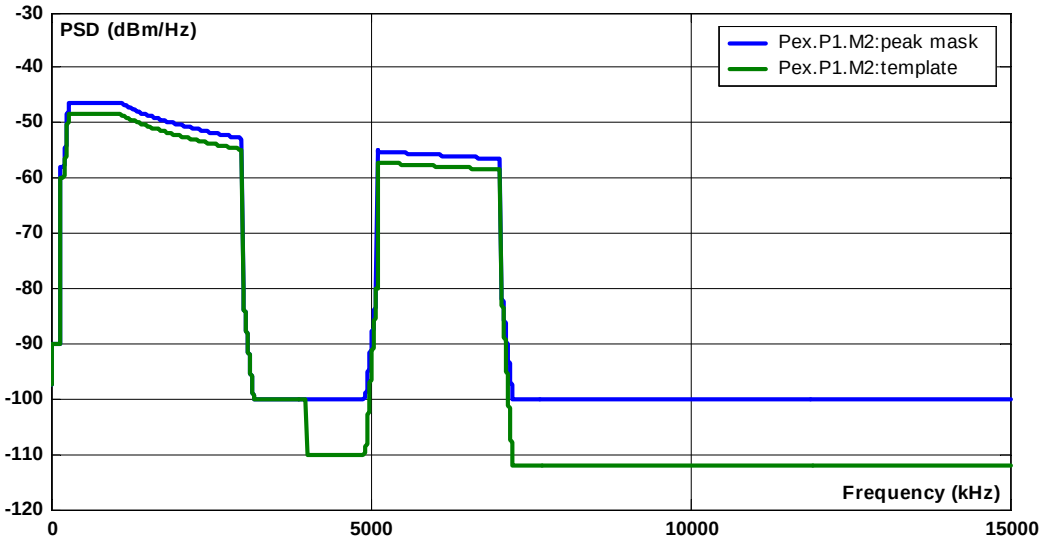

PSD (dBm/Hz)
P.M1:peak mask
P.M1:template
-30
-40
-50
-60
-70
-80
-90
-100
-110
-120
0
5000
10000
15000
Frequency (kHz)

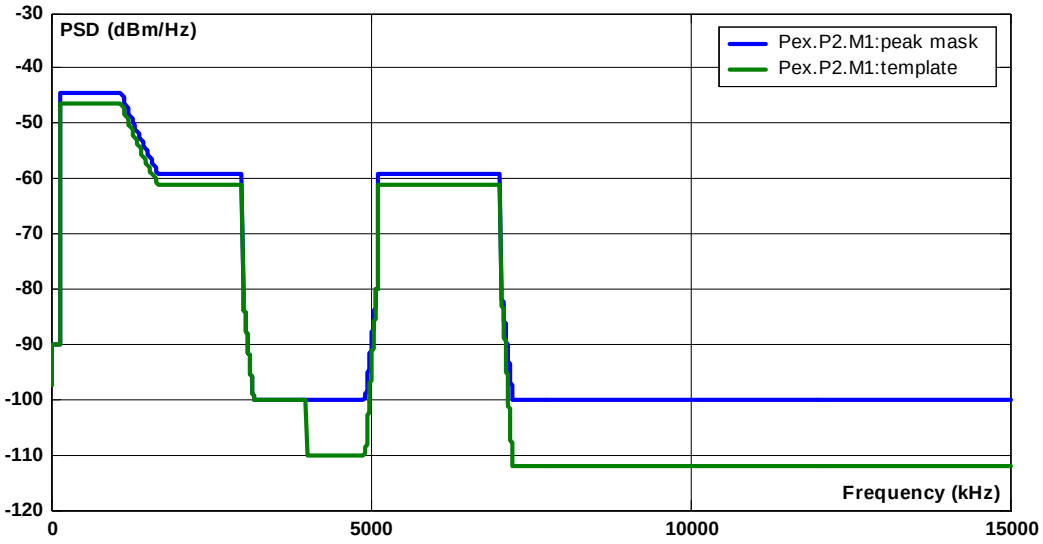

PSD (dBm/Hz)
P.M2:peak mask
P.M2:template
-30
-40
-50
-60
-70
-80
-90
-100
-110
-120
0
5000
10000
15000
Frequency (kHz)

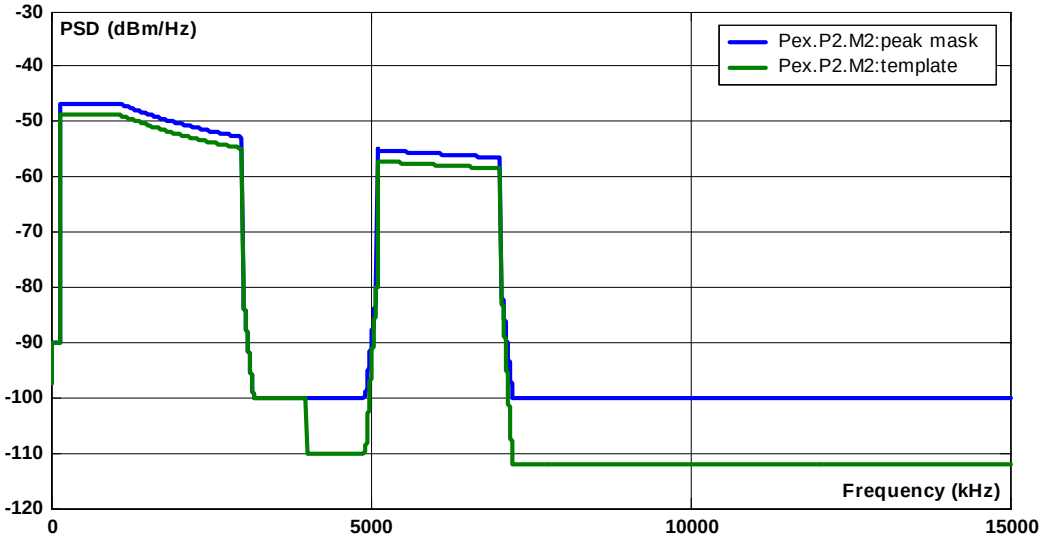

PSD (dBm/Hz)
Pcab.M1:peak mask
Pcab.M1:template
-30
-40
-50
-60
-70
-80
-90
-100
-110
-120
0
5000
10000
15000
Frequency (kHz)


PSD (dBm/Hz)
Pcab.M2:peak mask
Pcab.M2:template
-30
-40
-50
-60
-70
-80
-90
-100
-110
-120
0
5000
10000
15000
Frequency (kHz)


PSD (dBm/Hz)
Pex.P1.M1:peak mask
Pex.P1.M1:template
-30
-40
-50
-60
-70
-80
-90
-100
-110
-120
0
5000
10000
15000
Frequency (kHz)


PSD (dBm/Hz)
Pex.P1.M2:peak mask
Pex.P1.M2:template
-30
-40
-50
-60
-70
-80
-90
-100
-110
-120
0
5000
10000
15000
Frequency (kHz)


PSD (dBm/Hz)
-30
-40
-50
-60
-70
-80
-90
-100
-110
-120
0
5000
10000
15000
Frequency (kHz)
Pex.P2.M1:peak mask
Pex.P2.M1:template


PSD (dBm/Hz)
-30
-40
-50
-60
-70
-80
-90
-100
-110
-120
0
5000
10000
15000
Frequency (kHz)
Pex.P2.M2:peak mask
Pex.P2.M2:template

The optional regional specific band plan

P.M1	
Freq (kHz)	Power density (dBm/Hz)
0	-97.5
4	-97.5
5	-110
225	-110
226	-100
3575	-100
3750	-80
3751	-61
5199	-61
5200	-80
5375	-112
8325	-112
8500	-80
8501	-61
11999	-61
12000	-80
12175	-112
30000	-112

P.M2	
Freq (kHz)	Power density (dBm/Hz)
0	-97.5
4	-97.5
5	-110
225	-110
226	-100
3575	-100
3750	-80
3751	-55.7
5199	-57.2
5200	-80
5375	-112
8325	-112
8500	-80
8501	-60
11999	-60
12000	-80
12175	-112
30000	-112

Pcab.M1	
Freq (kHz)	Power density (dBm/Hz)
0	-97.5
4	-97.5
5	-110
226	-110
225	-90
552	-90
1104	-61
3749	-61
3750	-80
3925	-100
3999	-100
4000	-110
5025	-110
5200	-80
5201	-61
8499	-61
8500	-80
8675	-112
30000	-112

Pcab.M2	
Freq (kHz)	Power density (dBm/Hz)
0	-97.5
4	-97.5
5	-110
225	-110
226	-90
552	-90
1104	-60
1394	-50
3749	-55.7
3750	-80
3925	-100
3999	-100
4000	-110
5025	-110
5200	-80
5201	-57.2
8499	-59.3
8500	-80
8675	-112
30000	-112

Pex.P1.M1	
Freq (kHz)	Power density (dBm/Hz)
0	-97.5
4	-97.5
5	-90
138	-90
139	-59
217	-59
276	-40-Δ
1104	-40-Δ
1677	-61
3749	-61
3750	-80
3925	-100
3999	-100
4000	-110
5025	-110
5200	-80
5201	-61
8499	-61
8500	-80
8675	-112
30000	-112

Pex.P1.M2	
Freq (kHz)	Power density (dBm/Hz)
0	-97.5
4	-97.5
5	-90
138	-90
139	-58
217	-58
276	-40-Δ
1104	-40-Δ
1394	-50
3749	-55.7
3750	-80
3925	-100
3999	-100
4000	-110
5025	-110
5200	-80
5201	-57.2
8499	-59.3
8500	-80
8675	-112
30000	-112

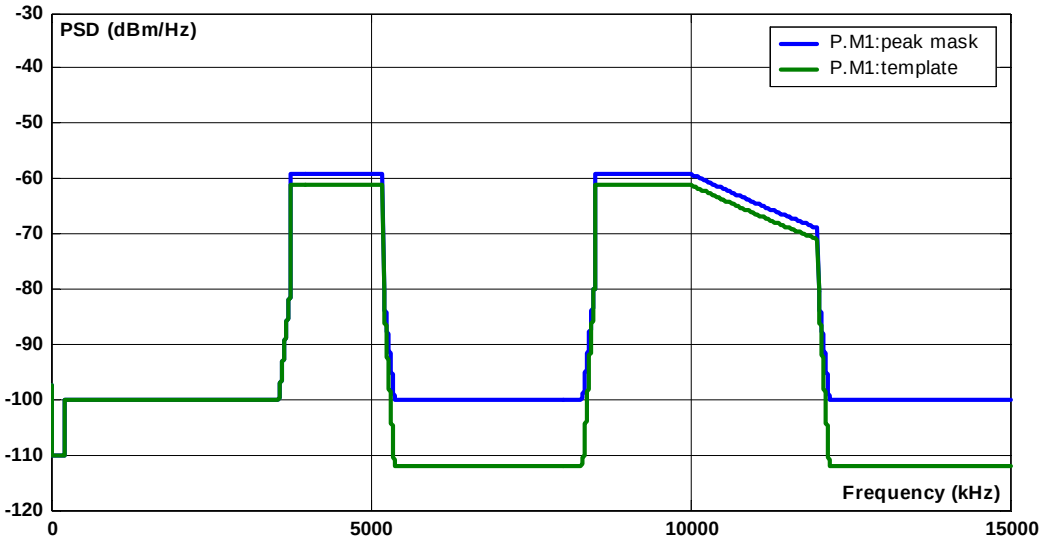
Pex.P2.M1	
Freq (kHz)	Power density (dBm/Hz)
0	-97.5
4	-97.5
5	-90
138	-90
139	-40-Δ
1104	-40-Δ
1677	-61
3749	-61
3750	-80
3925	-100
3999	-100
4000	-110
5025	-110
5200	-80
5201	-61
8499	-61
8500	-80
8675	-112
30000	-112

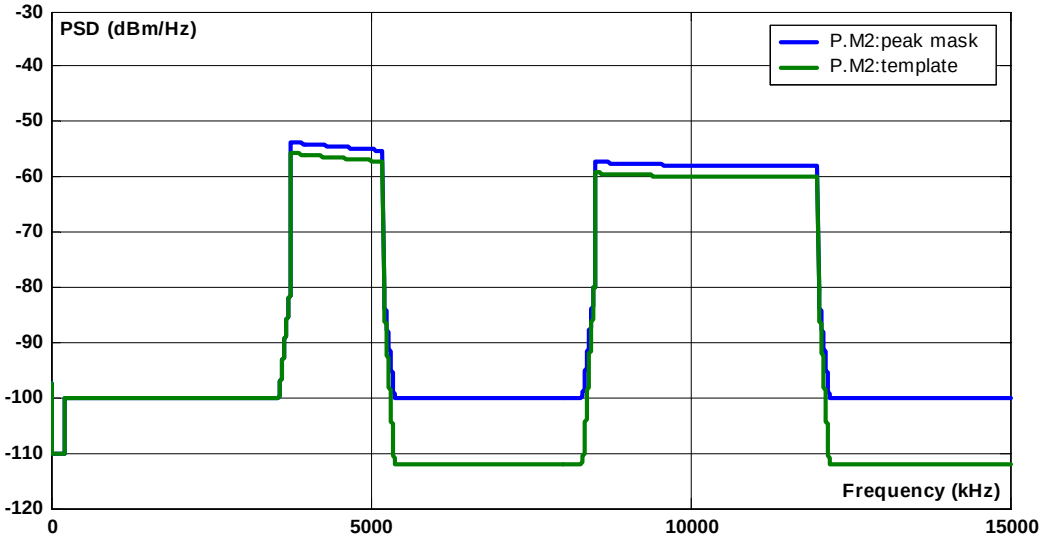
Pex.P2.M2	
Freq (kHz)	Power density (dBm/Hz)
0	-97.5
4	-97.5
5	-90
138	-90
139	-40-Δ
1104	-40-Δ
1394	-50
3749	-55.7
3750	-80
3925	-100
3999	-100
4000	-110
5025	-110
5200	-80
5201	-57.2
8499	-59.3
8500	-80
8675	-112
30000	-112

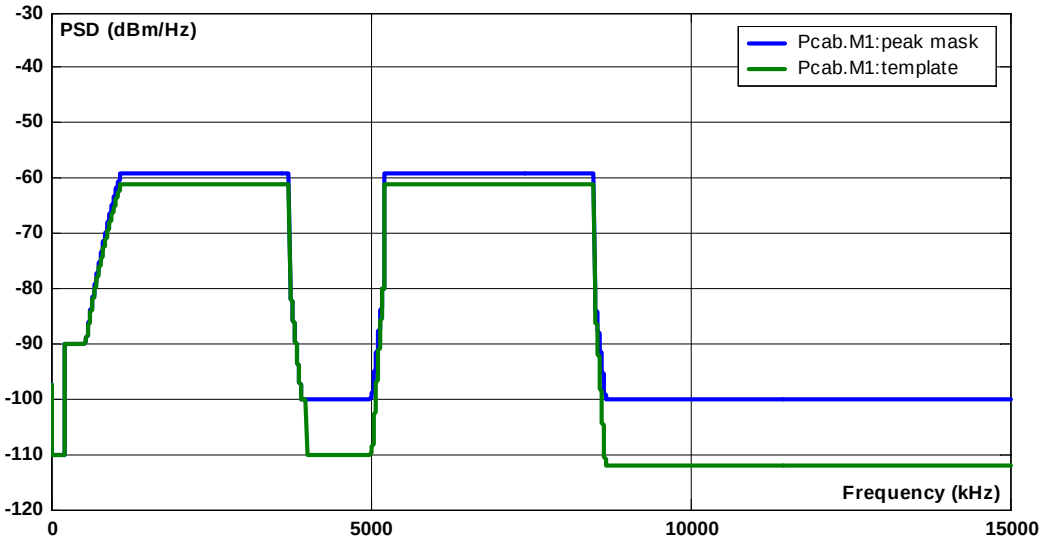
Profile	**PSD reduction D (dB)**	**First band Power (dBm @ 135 W)**	**Second band Power (dBm @ 135 W)**	**Total Power (dBm @ 135 W)**
P.M1	N/a	0.6	2.5	4.7
P.M2	N/a	5.1	5.6	8.4
Pcab.M1	N/a	3.4	4.2	6.8
Pcab.M2	N/a	11.2	6.9	12.5
Pex.P1.M1	6.2	14.1	4.2	14.5
Pex.P1.M2	10	13.7	6.9	14.5
Pex.P2.M1	6.7	14.1	4.2	14.5
Pex.P2.M2	10	13.9	6.9	14.7[5]
Pex.P1.M1	5.7	14.5	N/a	14.5
Pex.P1.M2	8.2	14.5	N/a	14.5
Pex.P2.M1	6.2	14.5	N/a	14.5
Pex.P2.M2	8.7	14.5	N/a	14.5

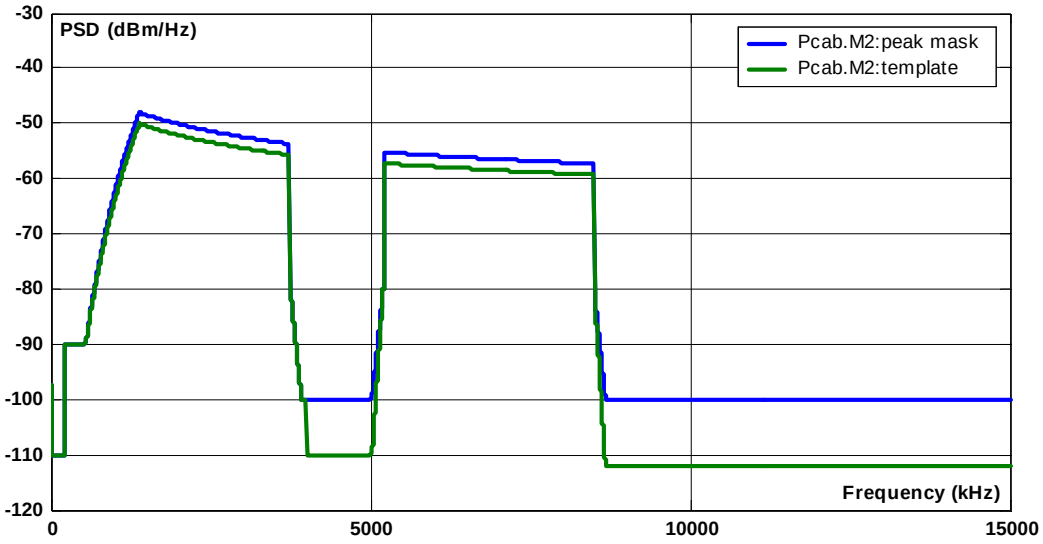
Table TBD: Total transmit power of each of the PSD templates. The values in grey apply to systems that only use the first downstream band

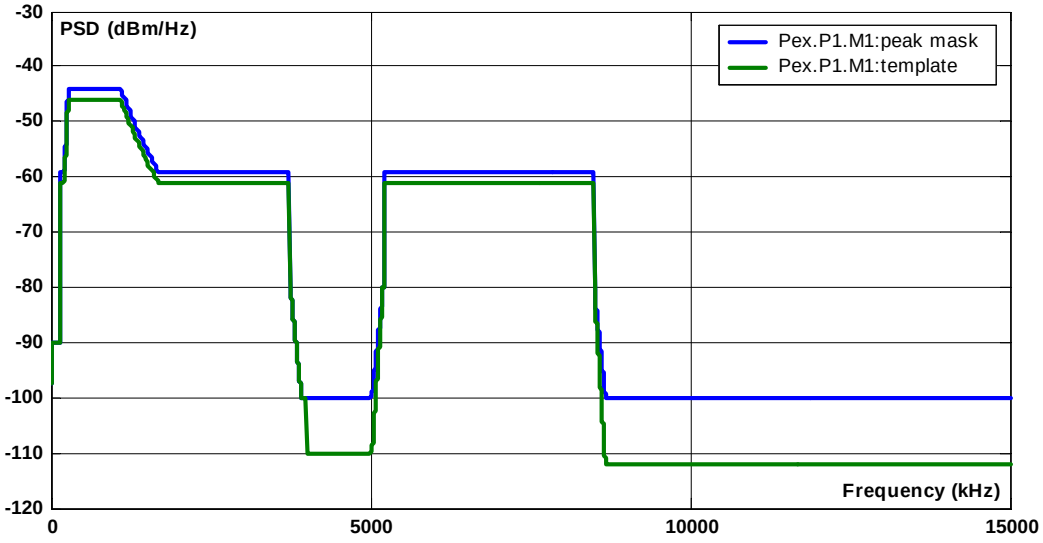
[5] Note that a reduction with Δ > 10 dB requires also the template point at 1394 kHz to change.

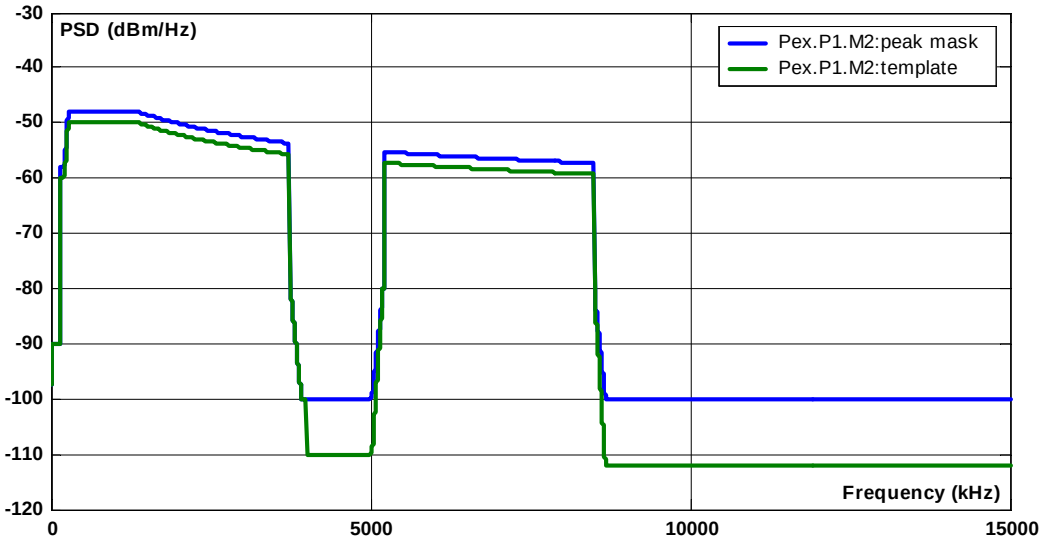

PSD (dBm/Hz)
P.M1:peak mask
P.M1:template
-30
-40
-50
-60
-70
-80
-90
-100
-110
-120
0
5000
10000
15000
Frequency (kHz)

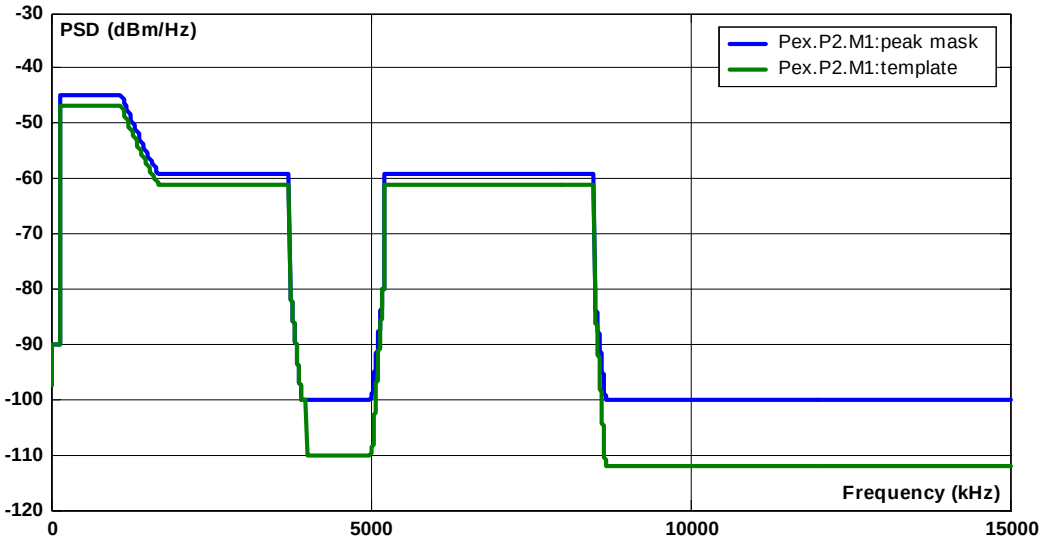

PSD (dBm/Hz)
P.M2:peak mask
P.M2:template
-30
-40
-50
-60
-70
-80
-90
-100
-110
-120
0
5000
10000
15000
Frequency (kHz)

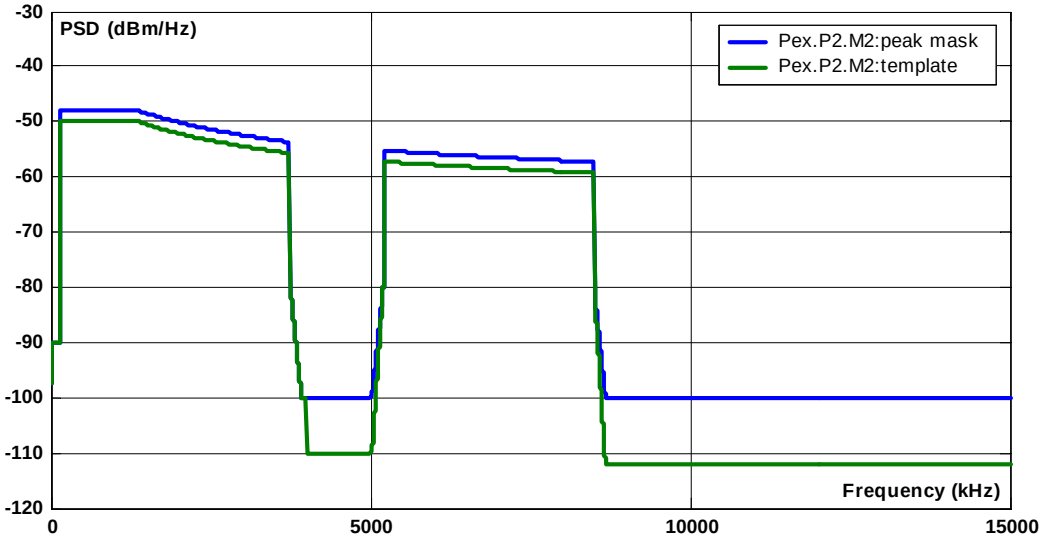

PSD (dBm/Hz)
Pcab.M1:peak mask
Pcab.M1:template
-30
-40
-50
-60
-70
-80
-90
-100
-110
-120
0
5000
10000
15000
Frequency (kHz)


PSD (dBm/Hz)
Pcab.M2:peak mask
Pcab.M2:template
-30
-40
-50
-60
-70
-80
-90
-100
-110
-120
0
5000
10000
15000
Frequency (kHz)


PSD (dBm/Hz)
Pex.P1.M1:peak mask
Pex.P1.M1:template
-30
-40
-50
-60
-70
-80
-90
-100
-110
-120
0
5000
10000
15000
Frequency (kHz)


PSD (dBm/Hz)
Pex.P1.M2:peak mask
Pex.P1.M2:template
-30
-40
-50
-60
-70
-80
-90
-100
-110
-120
0
5000
10000
15000
Frequency (kHz)





********** END OF TEXT PROPOSAL **********

7. References

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[2] ETSI-TS 101 270-2 V1.1.1, "Transmission and Multiplexing (TM); Access transmission systems on metallic access cables; Very high speed Digital Subscriber Line (VDSL); Part 2: Transceiver specification", February 2001.

[3] draft ETSI-TS 101 270-1 V2.0.2,"Transmission and Multiplexing (TM); Access transmission systems on metallic access cables; Very high speed Digital Subscriber Line (VDSL); Part 1: Functional requirements", July 2002, Permanent document m01p06a2.

[4] B.M. van den Heuvel, R. Persico, "Merging of spectral allocation plans and PSD masks for VDSL", TD24 – ETSI TM6 meeting in Stockholm, September 10th – 14th, 2001

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[6] V. Oksman, "VDSL PSD Mask adjustments", WD20—ETSI TM6 meeting in Stockholm, September 10th –14th, 2001

[7] S. Schelstraete, "Transmit PSD masks and ripple", TD46--- ETSI TM6 meeting in Stockholm, September 10th –14th, 2001

[8] V. Oksman, "Proposal on VDSL PSD masks", TD46—ETSI TM6 meeting in Prague, September 9th –13th, 2002.

[9] B.M. van den Heuvel, "Operators' need for nominal and peak PSD masks, as normative requirements", WD13—ETSI TM6 meeting in Prague, September 9th -- 13th , 2002.

[10] R. Persico, et al, "Increasing the VDSL downstream total power in FTTEx is extremely convenient as well as feasible", TD49---ETSI TM6 meeting in Prague, September 9th -- 13th , 2002.

[11] Rapporteur, "Report on break-out session to discuss simulation parameters for VDSL", WD14---ETSI TM6 meeting in Prague, September 9th -- 13th , 2002.

[12] V. Oksman, "Proposal for VDSL PSD mask definition", WD17---ETSI TM6 meeting in Prague, September 9th -- 13th , 2002.