情報通信技術委員会 SMS-02-CTL-01
スペクトル管理 **SWG** 第 2 回会合

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提出元[1]： Centillium Communications

題名： G.992.3 Annex C 長延化 – 代替PSD

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## 概要

本寄書は、オレゴン州ポートランドにおいて 7 月 7 日から 11 日まで開催される ITU-T Q4/15 会合へ提出した寄書（添付）の拡張である。その寄書では、G.992.1 Amd 1 の Profile 3 の性能を改善した、G992.3 Annex C のための代替 PSD を提案している。ここでは JJ100.01 の改訂において、遠距離サービスにおけるスペクトル管理標準の緩和が行われた場合に使用可能な代替下り PSD の検討を行う。現時点では本寄書は ITU-T への提出のためではなく、TTC 内部での議論のためのものである。

## 1. 代替 PSD

JJ100.01 では 5 km までの線路長を対象としたスペクトル適合性のための基準を定めている。添付の寄書の Figure 2 で提案されている下り PSD は、既存の JJ100.01 に規定された 5 km までの線路長でのスペクトル適合性を有している。また既存の JJ100.01 においては 5 km 以上の線路長でのスペクトル適合性は定義されていない。現在 JJ100.01 の改訂が議論されており、また 4 月 24 日のスペクトル管理に関する事業者間協議において、5 km 以遠はスペクトル適合性を考慮しないフリーゾーンとすることが合意されている。もしこの合意が JJ100.01 の改訂に盛り込まれる場合、さらなる下り性能の向上のための代替 PSD の使用が考えられる。

Figure 1 は、送信電力を 20dBm 以下とした EFBM5（5km以遠のための拡張 FBMsOL）の PSD を示している。Figure 1 には FBM (G.992.1 Amd 1 Profile 3)の下り PSD 及び EFBM（添付の寄書）も EFBM5 とともに示してある。Table 1 にはその PSD マスクを示す。

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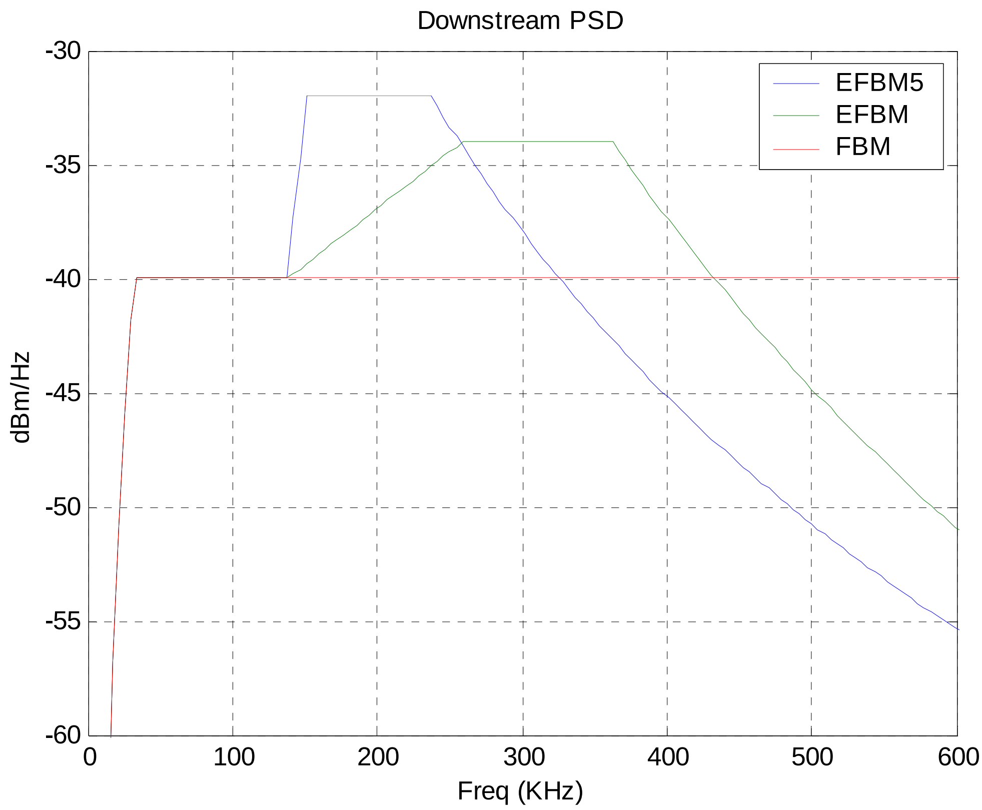


Figure 1: 拡張 FBMsOL (EFBMsOL)の下り PSD

Table 1: Figure 1 に示す EFBM5 の PSD マスク

| Frequency f (KHz) | PSD (dBm/Hz) Peak values |
|---|---|
| 0< *f* < 4 | -97.5, with max power in the in 0-4 kHz band of +15 dBrn |
| 4< *f* < 5 | -92.5+18.64log2(*f*/4) |
| 5<f<5.25 | -86.5 |
| 5.25<f<16 | -86.5+15.25log2(f/5.25) |
| 16< *f* < 32 | -62+25.5log2(*f*/16) |
| 32< *f* < 138 | -36.5 |
| 138 < f ≤ 150.94 | -28.5 + 0.6184*(f-150.94) |
| 150.94 < f ≤ 237.19 | -28.5 |
| 237.19 < f ≤ 1012 | $-28.5 – 17.43 \times \log_2$ (f/237.19) |
| 1012 < *f* ≤ 1800 | -65 |
| 1800 < *f* ≤ 2290 | $-65 - 72 \times \log_2$ (*f*/1800) |
| 2290 < *f* ≤ 3093 | –90 |
| 3093 < *f* ≤ 4545 | –90 peak, with max power in the [*f*, *f* + 1 MHz] window of (–36.5 – 36 × $\log_2$ (*f*/1104) + 60) dBm |
| 4545 < *f* ≤ 11 040 | –90 peak, with max power in the [*f*, *f* + 1 MHz] window of –50 dBm |

NOTE 1 – All PSD measurements are in 100 Ω; the POTS band total power measurement is in 600 Ω.
NOTE 2 – The breakpoint frequencies and PSD values are exact; the indicated slopes are approximate.
NOTE 3 – Above 25.875 kHz, the peak PSD shall be measured with a 10 kHz resolution bandwidth.
NOTE 4 – The power in a 1 MHz sliding window is measured in a 1 MHz bandwidth, starting at the measurement frequency.
NOTE 5 – The step in the PSD mask at 4 kHz is to protect V.90 performance. Originally, the PSD mask continued the 21 dB/octave slope below 4 kHz hitting a floor of –97.5 dBm/Hz at 3400 Hz. It was recognized that this might impact V.90 performance, and so the floor was extended to 4 kHz.
NOTE 6 – All PSD and power measurements shall be made at the U-C interface (see Figure 5-4 and Figure 5-5); the signals delivered to the PSTN are specified in Annex E.

Figure 2 及び 3 は漏話の無い場合及び ISDN からの漏話環境下での下り速度を示す。

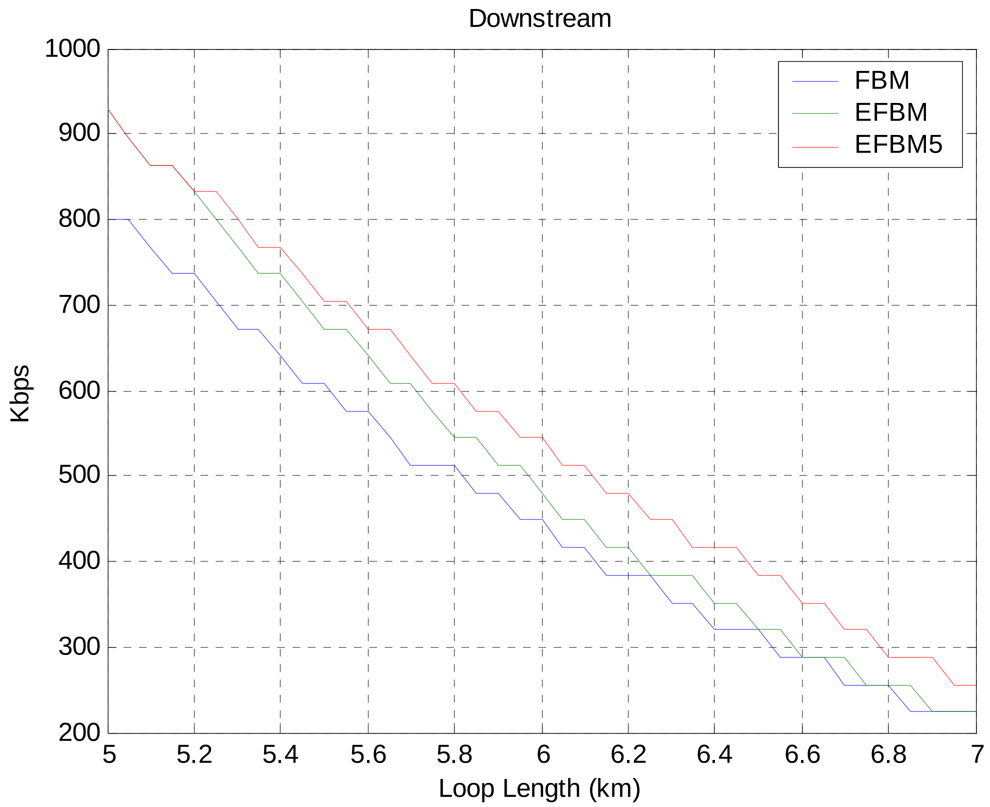


Figure 2: AWGN 環境下での下り速度

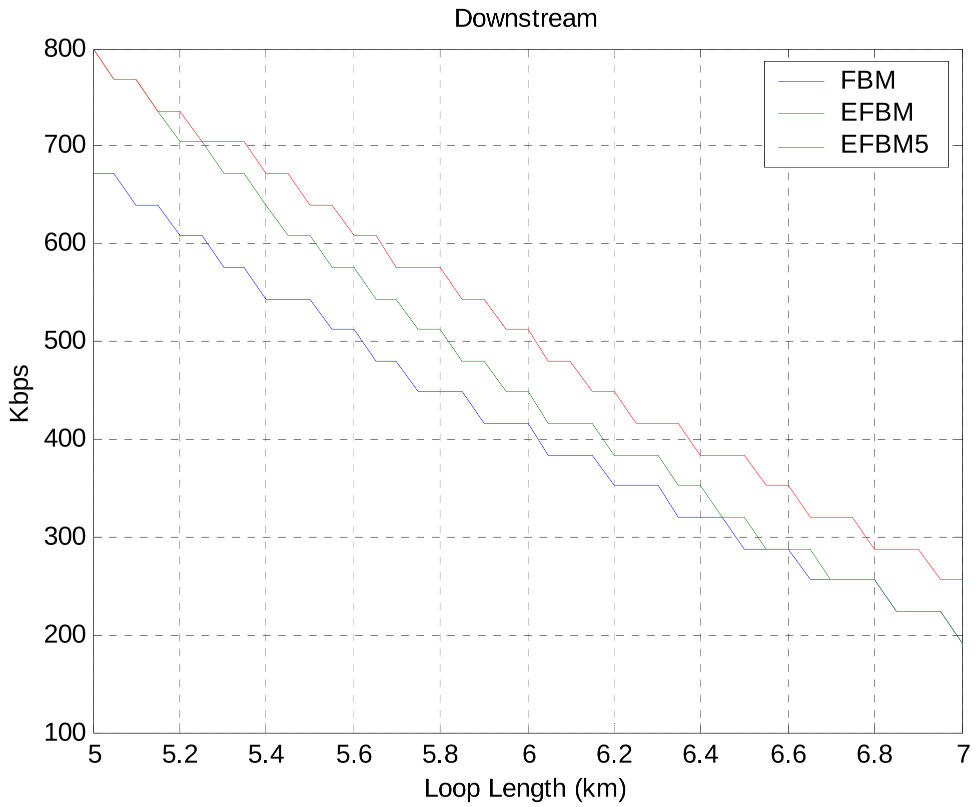


Figure 3: 同一カッドを含む24 TCM-ISDN 干渉源からの漏話環境下での下り速度

## 2. 結論

もしスペクトル適合性の条件が 5 km より長い線路長において緩和されるならば、Figure 1 に示す EFBM5 の PSD の使用により 5 km より長い線路長での下り速度をさらに改善することが可能であり、また G.992.3 Annex C の一部として ITU-T Q4/15 に提案可能である。このような長距離向け技術に関する議論を行う必要がある。

(添付)

**ITU - Telecommunication Standardization Sector** **OP-xx**

STUDY GROUP **15**

Portland, Oregon, July 7 – 11, 2003

Question: 4/15

SOURCE*: Centillium Communications

TITLE: ADSL2: Annex C Long Reach PSD - updated

**ABSTRACT**

In this contribution, we investigate the possibility of enhancing the long reach solution for Japan. This contribution is an update of DC-071. The performance simulation assumptions are modified and the results are updated.

## 1. Introduction

Currently FBM-sOL (Profile 3) is designed for long reach in Japan. Recently, some new PSD's were designed for G.992.3 Annex L (READSL), not to be confused with G.992.5 Annex L (extended upstream). The main concept of Annex L is to focus on lower bins with boosted PSD. Since the high bins are not used (they are not useful on long loops anyway), the PSD can be boosted without exceeding the total power limit. This contribution examines some of the ideas in Annex L to see if they can be used to enhance the performance of Annex C FBM-sOL.

To use the boosted PSD for Annex C as an enhancement to FBM-sOL for long loops, we need to make sure that the proposed PSD's meet the minimum requirement for spectral compatibility. Our study shows that it is possible to boost PSD without creating spectrum compatibility problems.

We then consider performance. Simulations show that an enhancement to FBM-sOL based on a boosted PSD provides higher downstream data rate than the original FBM-sOL.

## 2. Discussion

Annex L includes two upstream PSDs (Narrow and Wide), and two downstream PSDs (OV and NOV). Narrow upstream uses bins 6-14 and Wide upstream uses bins 6-24. The total power is about the same as the original ADSL upstream using bins 6-

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31. Since fewer bins are used, the PSD level is higher. For downstream on long loops, bins above 127 are not useful due to higher loop attenuation. Therefore, OV and NOV are limited to bin 127. OV and NOV are similar in bins 32-127, with only a slight variation. The PSD level is about –40dbm/Hz at bin 32, linearly increasing to –37dbm/Hz at bin 82 for OV and bin 64 for NOV. OV uses bins 6-23 as well. These PSDs are shown in Figure 1. The left figure shows Narrow upstream and OV downstream while the right figure shows Wide upstream and NOV downstream. Note that 4 different combinations of Wide, Narrow, and OV, NOV are possible.

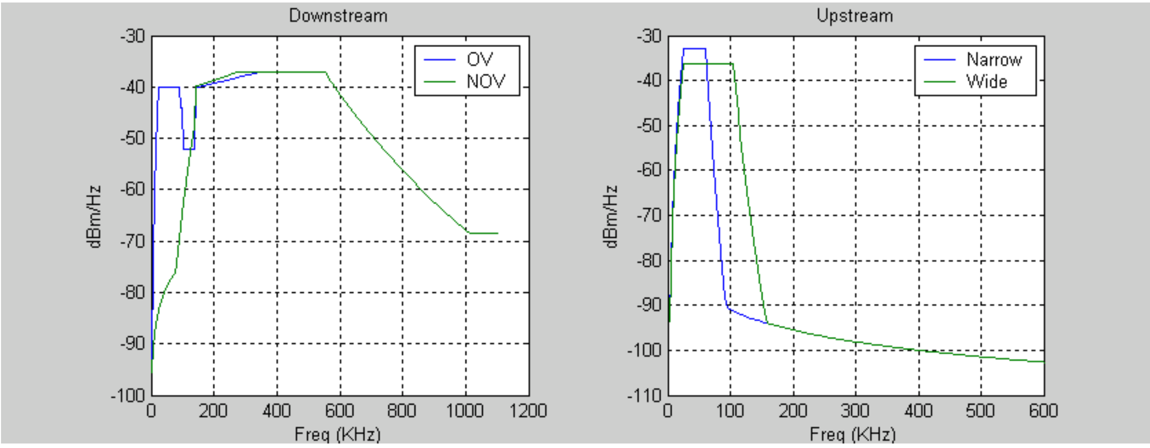


**Figure 1: Annex L PSDs**

For FBM-sOL, the downstream uses bins 6-255, with shaping to reduce the PSD at bins 6-7. Since FBM-sOL is for long loop applications, similar to Annex L, bins above 127 are basically not useful. Therefore, similar to Annex L, we should limit the downstream to bin 127 and boost the PSD. Since Japan has its special spectrum management requirement, the optimal downstream PSD has to be chosen based on the compromise between spectrum compatibility and performance. Our study leads to the proposal that is a slightly modified version of the Annex L downstream PSD for bins 32 and above, and keeps the original FBM-sOL PSD for bins below 32. For bins above 32, the PSD ramps up from –40dbm/Hz at bin 32 to –34dbm/Hz at bin 60, and stays at –34dbm/Hz from bin 60 to 84. Bins above 84 are not used. This PSD is slightly higher than either the OV PSD or NOV PSD in the band from 138 to 362.25kHz. The simulation shows that the performance based on the proposed PSD is slightly better than the ones based on Annex L. As we will show later, this PSD meets the spectrum compatibility requirement.

For upstream, we have simulated various options such as the original upstream PSD (6-31), Annex L Wide and Narrow. The simulations show that Wide and Narrow do not provide performance improvement over the original ADSL upstream.

Figure 2 shows the downstream PSD of the proposed enhanced FBM-sOL (EFBM-sOL) as well as the upstream PSD. Table 1 contains the definition of the proposed downstream PSD mask. The downstream total power is 20dbm. Upstream is the same as the original ADSL upstream using bins 6-31.

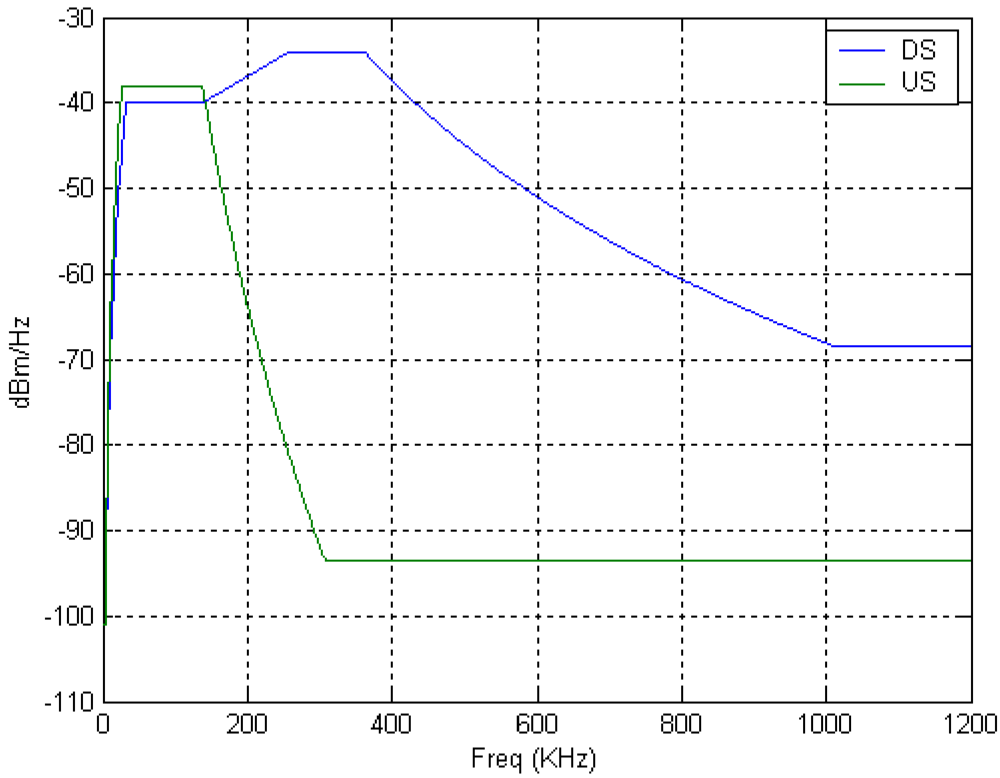


**Figure 2: PSD’s of EFBM-sOL**

**Table 1: Tabulation of the PSD Mask of the downstream in Figure 2**

| Frequency f (KHz) | PSD (dBm/Hz) Peak values |
|---|---|
| $0<f<4$ | -97.5, with max power in the in 0-4 kHz band of +15 dBrn |
| $4<f<5$ | $-92.5+18.64\log2(f/4)$ |
| 5<f<5.25 | -86.5 |
| 5.25<f<16 | -86.5+15.25log2(f/5.25) |
| $16<f<32$ | $-62+25.5\log2(f/16)$ |
| $32<f<138$ | -36.5 |
| $138 < f \leq 258.75$ | $-36.5 + 0.0497*(f-138)$ |
| $258.75 < f \leq 362.25$ | -30.5 |
| $362.25 < f \leq 1012$ | $-30.5 - 23.27 \times \log_2 (f/362.25)$ |
| $1012 < f \leq 1800$ | -65 |
| $1800 < f \leq 2290$ | $-65 - 72 \times \log_2 (f/1800)$ |
| $2290 < f \leq 3093$ | –90 |
| $3093 < f \leq 4545$ | –90 peak, with max power in the $[f, f + 1$ MHz$]$ window of $(–36.5 – 36 \times \log_2 (f/1104) + 60)$ dBm |
| $4545 < f \leq 11\,040$ | –90 peak, with max power in the $[f, f + 1$ MHz$]$ window of –50 dBm |

NOTE 1 – All PSD measurements are in 100 Ω; the POTS band total power measurement is in 600 Ω.
NOTE 2 – The breakpoint frequencies and PSD values are exact; the indicated slopes are approximate.
NOTE 3 – Above 25.875 kHz, the peak PSD shall be measured with a 10 kHz resolution bandwidth.
NOTE 4 – The power in a 1 MHz sliding window is measured in a 1 MHz bandwidth, starting at the measurement frequency.
NOTE 5 – The step in the PSD mask at 4 kHz is to protect V.90 performance. Originally, the PSD mask continued the 21 dB/octave slope below 4 kHz hitting a floor of –97.5 dBm/Hz at 3400 Hz. It was recognized that this might impact V.90 performance, and so the floor was extended to 4 kHz.
NOTE 6 – All PSD and power measurements shall be made at the U-C interface (see Figure 5-4 and Figure 5-5); the signals delivered to the PSTN are specified in Annex E.

## 3. Performance simulations

Performance is calculated based on the following assumptions.

- SNR Gap = 9.75dB
- Gross Coding Gain = 7.5dB before subtracting trellis and RS overhead
  - Trellis and RS overhead is deducted and the payload is shown.
- Maximum Number of bits per bin = 15
- Minimum Number of bits per bin = 1
- 0.4mm paper-insulation cable
- -140dBm/Hz AWGN along with 99% worst case same Quad ISDN crosstalk.

Figure 3 shows the downstream performance of this solution as compared with the original FBM-sOL. Simulation shows that the downstream is always slightly better than the original FBM-sOL on loops longer than 3km. The performance comparison is shown for loops 5km or longer since FBMsOL is mainly used for long loops.

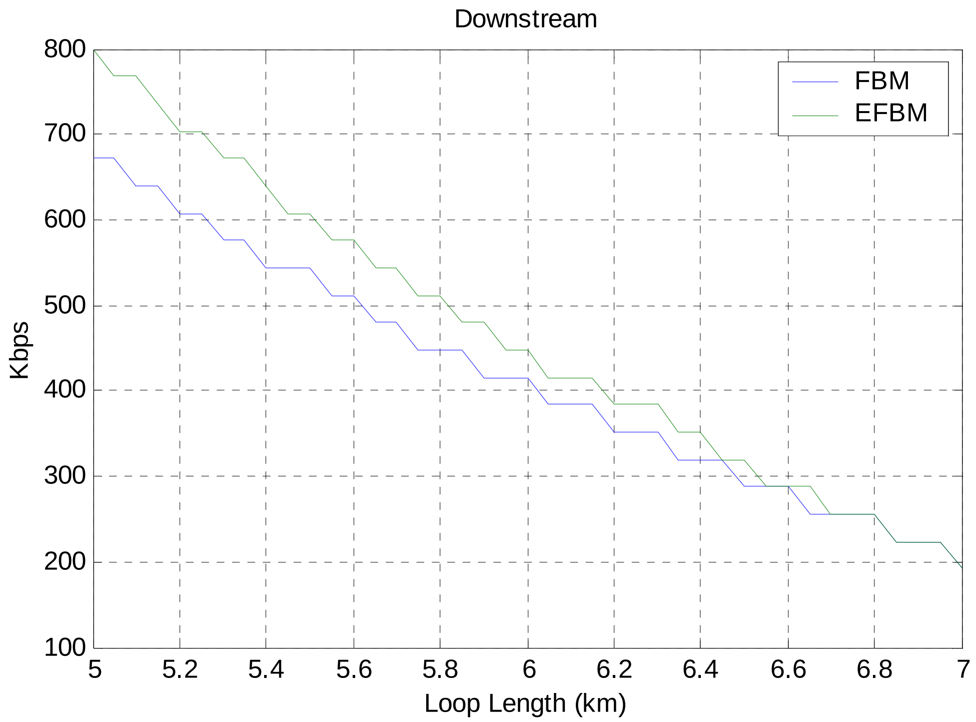


**Figure 3: Downstream Performance of EFBM-sOL and the original FBM-sOL with same quad ISDN crosstalk**.

Figure 4 compares the upstream performance based on the original ADSL upstream PSD (bins 6-31), Annex L Narrow (bins 6-14) and Annex L Wide (bins 6-24). Figure 4 shows that the Annex L Narrow and Wide upstream are worse than the original ADSL US, except the very limited improvement only in loops above 7.5km, which is not practical.

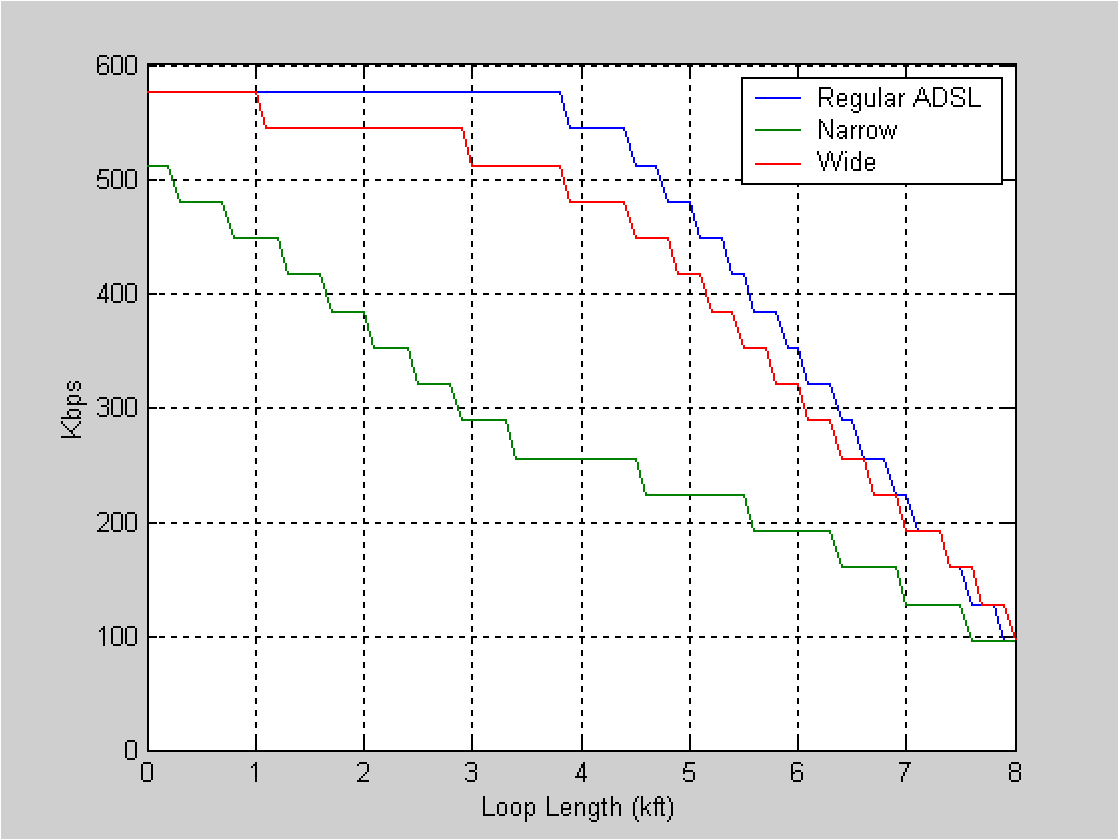


**Figure 4: Upstream Performance of the original FBM-sOL and Annex L Narrow and Wide**

## 4. Spectral compatibility

Figure 5 shows the result of spectral compatibility testing that qualifies the EFBM-sOL PSD shown in Figure 2. The performance of the TCM-ISDN, ADSL Annex C DBM and FBM with crosstalk from this new PSD is compared with the minimum requirement in JJ100.01 (August 2002 version).

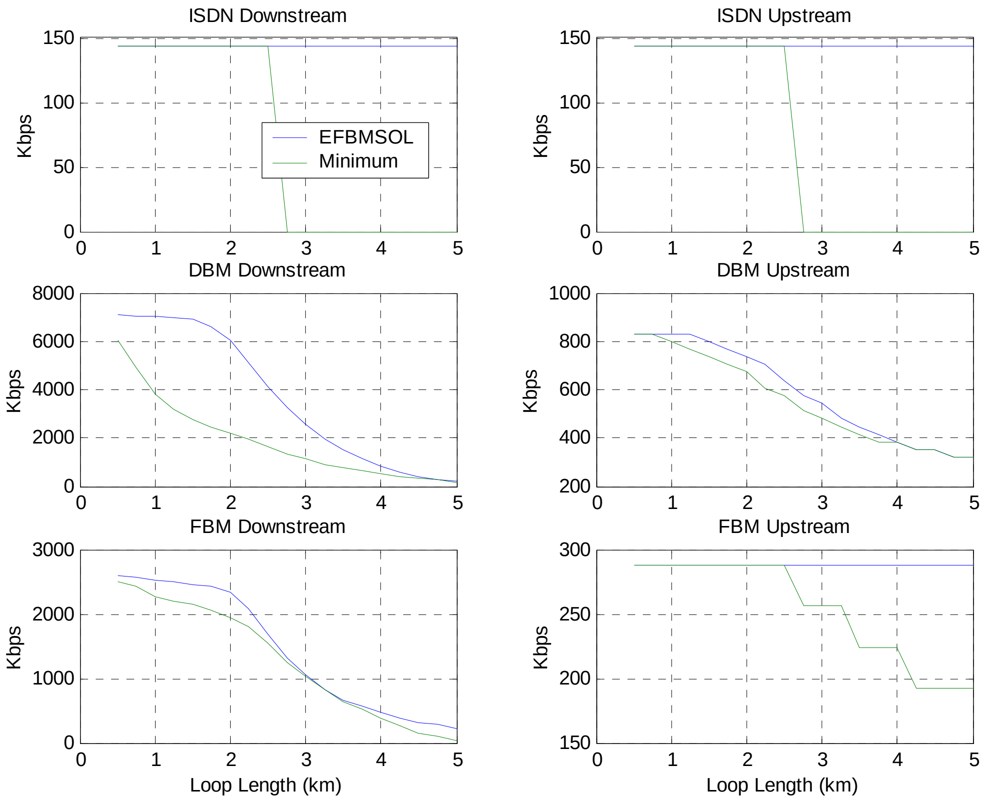


**Figure 5: Spectral Compatibility of Proposed EFBM-sOL**

**In Table 2, tentative spectrum compatibility minimum requirement based on the new spectrum management requirement is shown. Table 3 shows the spectrum compatibility of EFBMsOL. The calculation uses 0.4mm poly cable with 5 disturbers. Only G.992.1 Annex C FBM is 1 notch below the minimum requirement on 1.75km loop.**

**Table 2: Minimum Requirement for Poly Cables Number of Disturbers = 5**

| Length [km] | ISDN | | G.992.1 Annex A | | G.992.2 Annex A | | G.992.1 Annex C | | | | G.992.2 Annex C | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | DBM | | FBM | | DBM | | FBM | |
| | DS | US | DS | US | DS | US | DS | US | DS | US | DS | US | DS | US |
| **0.5** | 144 | 144 | 7104 | 832 | 3008 | 832 | 7104 | 832 | 2624 | 288 | 3008 | 832 | 1088 | 288 |
| **0.75** | 144 | 144 | 6784 | 832 | 2944 | 832 | 6912 | 832 | 2624 | 288 | 2944 | 832 | 1088 | 288 |
| **1.0** | 144 | 144 | 5952 | 832 | 2624 | 832 | 6368 | 832 | 2624 | 288 | 2752 | 832 | 1088 | 288 |
| **1.25** | 144 | 144 | 4896 | 800 | 2272 | 800 | 5696 | 800 | 2624 | 288 | 2528 | 800 | 1088 | 288 |
| **1.5** | 144 | 144 | 3808 | 768 | 1824 | 768 | 5024 | 800 | 2624 | 288 | 2272 | 800 | 1088 | 288 |
| **1.75** | 144 | 144 | 2496 | 736 | 1440 | 736 | 4192 | 768 | 2624 | 288 | 2016 | 768 | 1088 | 288 |
| **2.0** | 144 | 144 | 1664 | 704 | 960 | 704 | 3680 | 736 | 2528 | 288 | 1696 | 736 | 1088 | 288 |
| **2.25** | 144 | 144 | 1088 | 640 | 640 | 640 | 3296 | 704 | 2464 | 288 | 1504 | 704 | 1088 | 288 |
| **2.5** | 144 | 144 | 704 | 576 | 320 | 576 | 3008 | 672 | 2368 | 288 | 1312 | 672 | 1088 | 288 |
| **2.75** | 144 | 144 | 480 | 512 | 160 | 512 | 2720 | 640 | 2208 | 288 | 1216 | 640 | 1088 | 288 |
| **3.0** | 144 | 144 | 320 | 448 | 96 | 448 | 2400 | 576 | 1984 | 288 | 1184 | 576 | 1056 | 288 |
| **3.25** | 144 | 144 | 224 | 352 | 64 | 352 | 2016 | 544 | 1696 | 256 | 1152 | 544 | 1056 | 256 |
| **3.5** | 144 | 144 | 128 | 288 | 32 | 288 | 1664 | 480 | 1408 | 256 | 1120 | 480 | 1024 | 256 |
| **3.75** | 144 | 0 | 64 | 256 | 32 | 256 | 1376 | 448 | 1152 | 256 | 1088 | 448 | 960 | 256 |
| **4.0** | 144 | 0 | 32 | 192 | 0 | 192 | 1120 | 416 | 928 | 256 | 1024 | 416 | 896 | 256 |
| **4.25** | 0 | 0 | 0 | 160 | 0 | 160 | 928 | 416 | 736 | 224 | 928 | 416 | 800 | 224 |
| **4.5** | 0 | 0 | 0 | 128 | 0 | 128 | 768 | 384 | 576 | 224 | 832 | 384 | 672 | 224 |
| **4.75** | 0 | 0 | 0 | 96 | 0 | 96 | 640 | 352 | 448 | 224 | 704 | 352 | 512 | 224 |
| **5.0** | 0 | 0 | 0 | 64 | 0 | 64 | 512 | 352 | 320 | 192 | 576 | 352 | 384 | 192 |

**Table 3: EFBMsOL Spectral Compatibility for Poly (5 disturbers)**

| Length [km] | ISDN | | G.992.1 Annex A | | G.992.2 Annex A | | G.992.1 Annex C | | | | G.992.2 Annex C | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | DBM | | FBM | | DBM | | FBM | |
| | DS | US | DS | US | DS | US | DS | US | DS | US | DS | US | DS | US |
| **0.5** | 144 | 144 | 7104 | 832 | 3008 | 832 | 7104 | 832 | 2624 | 288 | 3008 | 832 | 1088 | 288 |
| **0.75** | 144 | 144 | 7104 | 832 | 3008 | 832 | 7104 | 832 | 2624 | 288 | 3008 | 832 | 1088 | 288 |
| **1.0** | 144 | 144 | 7104 | 832 | 3008 | 832 | 7104 | 832 | 2624 | 288 | 3008 | 832 | 1088 | 288 |
| **1.25** | 144 | 144 | 7104 | 832 | 3008 | 832 | 7104 | 832 | 2624 | 288 | 3008 | 832 | 1088 | 288 |
| **1.5** | 144 | 144 | 7072 | 832 | 2976 | 832 | 7072 | 832 | 2624 | 288 | 2976 | 832 | 1088 | 288 |
| **1.75** | 144 | 144 | 7040 | 800 | 2976 | 800 | 7072 | 800 | **2592** | 288 | 2976 | 800 | 1088 | 288 |
| **2.0** | 144 | 144 | 6976 | 768 | 2976 | 768 | 7040 | 800 | 2592 | 288 | 2976 | 800 | 1088 | 288 |
| **2.25** | 144 | 144 | 6656 | 736 | 2944 | 736 | 6848 | 768 | 2592 | 288 | 2976 | 768 | 1088 | 288 |
| **2.5** | 144 | 144 | 6080 | 672 | 2880 | 672 | 6432 | 736 | 2528 | 288 | 2944 | 736 | 1088 | 288 |
| **2.75** | 144 | 144 | 5280 | 608 | 2848 | 608 | 5760 | 672 | 2368 | 288 | 2912 | 672 | 1088 | 288 |
| **3.0** | 144 | 144 | 4320 | 544 | 2784 | 544 | 4928 | 640 | 2112 | 288 | 2880 | 640 | 1088 | 288 |
| **3.25** | 144 | 144 | 3488 | 480 | 2688 | 480 | 4096 | 608 | 1760 | 288 | 2816 | 608 | 1056 | 288 |
| **3.5** | 144 | 144 | 2784 | 384 | 2496 | 384 | 3328 | 544 | 1440 | 288 | 2688 | 544 | 1056 | 288 |
| **3.75** | 144 | 144 | 2208 | 288 | 2208 | 288 | 2720 | 480 | 1184 | 288 | 2464 | 480 | 992 | 288 |
| **4.0** | 144 | 144 | 1728 | 224 | 1888 | 224 | 2176 | 448 | 992 | 288 | 2208 | 448 | 960 | 288 |
| **4.25** | 144 | 144 | 1312 | 192 | 1568 | 192 | 1696 | 416 | 800 | 288 | 1888 | 416 | 864 | 288 |
| **4.5** | 144 | 144 | 960 | 128 | 1152 | 128 | 1312 | 384 | 704 | 288 | 1504 | 384 | 768 | 288 |
| **4.75** | 144 | 144 | 640 | 96 | 800 | 96 | 992 | 352 | 576 | 288 | 1184 | 352 | 640 | 288 |
| **5.0** | 144 | 144 | 384 | 64 | 512 | 64 | 736 | 352 | 480 | 288 | 864 | 352 | 544 | 288 |

## 5. Conclusion

Downstream performance using the PSD in Figure 2 is always better than the original FBM-sOL downstream PSD on loops longer than 3km. Therefore, this PSD is proposed for EFBM-sOL to achieve higher downstream rates on long loops.

The upstream PSDs Wide and Narrow in Annex L do not help FBM-sOL upstream. Therefore the original upstream PSD should still be used.

## 6. Summary

This contribution addresses Issue T.3.14 on the Issues List, OP-U17, and proposes the following agreement:

- that an enhancement to Profile 3 (FBM-sOL) shall be defined for inclusion in G.992.3 Annex C
    - that this enhancement shall use the downstream PSD shown in Figure 2 of this contribution (same as Figure 2 of DC-071).