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ABSTRACT

This contribution introduces a new extended Upstream system, named Super Upstream (SU) and checks its spectral compatibility for deployment in the Japan Copper Access Network when combined with the Quad Overlap QOL Downstream system. The Maximum total power of the Super Upstream PSD is 12.5dBm. The overall system is denoted SU_12.5_QOL. The Super Upstream system makes use of the U1 VDSL Upstream bandwidth for small distances and then falls back to a shaped extended U0 bandwidth mode of operation. The determination of the switching point, according to the line conditions, is outside scope of this paper. At small distances, the SU system exhibits a unique capability to significantly enhance the Upstream rate without increasing the impact into G.992.1 downstream, since U1 bandwidth starts at 3.5MHz and thus does not overlap at all the G.992.1 downstream band. After the switching point, the impact of the Shaped Extended U0 system is controlled by the shaping in order to keep the disturbance to not only comply with JJ-100 R2 rules but also remain very close to G.992.1 self disturbance.

Simulations, compliant with JJ-100 R2, prove that is SU_12.5_QOL system is spectrally compatible up to 3.25km.

We recommend that the Super upstream System combined with the Quad overlap SU_12.5_QOL downstream spectrum is allowed to be deployed in the same quad as protected systems in the Copper Japan access network, up to 3.25km.

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1 Introduction

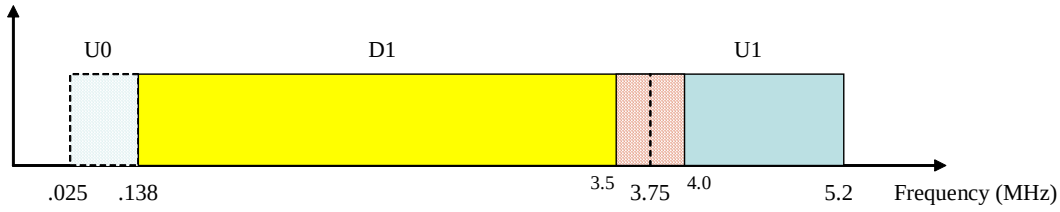
This contribution introduces a new extended Upstream system, named Super Upstream (SU) and checks its spectral compatibility for deployment in the Japan Copper Access Network when combined with the Quad Overlap QOL Downstream system. The Maximum total power of the Super Upstream PSD is 12.5dBm. The overall system is denoted SU_12.5_QOL. The Super Upstream system makes use of the U1 VDSL Upstream bandwidth for small distances and then falls back to a shaped extended U0 bandwidth mode of operation. The determination of the switching point, according to the line conditions, is outside scope of this paper. At small distances, the SU system exhibits a unique capability to significantly enhance the Upstream rate without increasing the impact into G.992.1 downstream, since U1 bandwidth starts at 3.5MHz and thus does not overlap at all the G.992.1 downstream band. After the switching point, the impact of the Shaped Extended U0 system is controlled by the shaping in order to keep the disturbance to not only comply with JJ-100 R2 rules but also remain very close to G.992.1 self disturbance.

Section 2 defines the Super Upstream Occupation Band Plan. Section 3 introduces the Upstream/Downstream combination inherent to SU_12.5_QOL system. Section 4 Details the Upstream masks. Section 5 is dedicated to Downstream masks. Spectral Compatibility tables are provided in section 6.

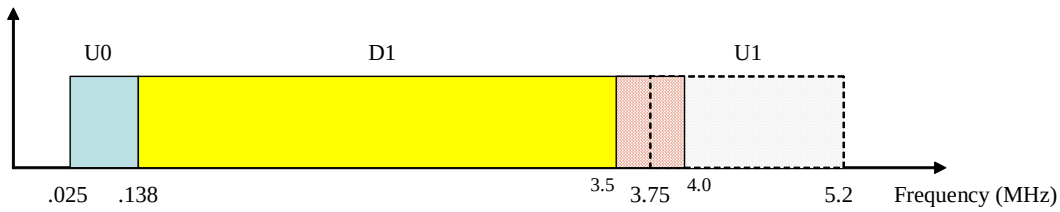
2 Super Upstream Band Occupation

The band plan in Annex A of G.993.1 defines upstream channel transmission in the band from 3.75 to 5.2 MHz. The draft VDSL1 specification also defines an international amateur radio band notch in the band from 3.5 to 4.0 MHz. When this amateur band is notched, the frequency band of 4.0 to 5.2 MHz remains available for upstream channel transmission. A resulting 1.1 MHz band may be utilized with 256 tones of 4.3125 kHz spacing. Figure 1 shows the frequency plan transmission up to 5.2 MHz, including the notched frequencies of the international amateur radio band from 3.5 to 4.0 MHz.

For the shorter distances, upstream channel transmission may be provided in the U1 band of 4.0 – 5.104 MHz using NSCus=256 tones. On the longer distances, upstream channel transmission may be provided using the U0 band. In any case, upstream transmission is provided in either the U1 or U0 band depending on the loop signal attenuation; not both simultaneously. Note that the U0 band may also be used for downstream transmission in overlap mode.



(a) Upstream transmission on shorter loops using band U1 only



(b) Upstream transmission on longer loops using band U0 only

Figure 1: Super Upstream Band Plan.

3 Definition on Super Upstream 12.5 masks, U0 Band and U1 Band

The system we consider hereafter combines the Super Upstream as defined per the principles in section 2 and the Quad overlap Downstream.

3.1 Super Upstream, U0 Band_12.5dBm Mask

Figure 2 and Table 3-1 give the definition of the Super Upstream U0 Band_12.5dBm Mask. The total power of 12.5dBm is obtained by integration between 25.875KHz and 276KHz.

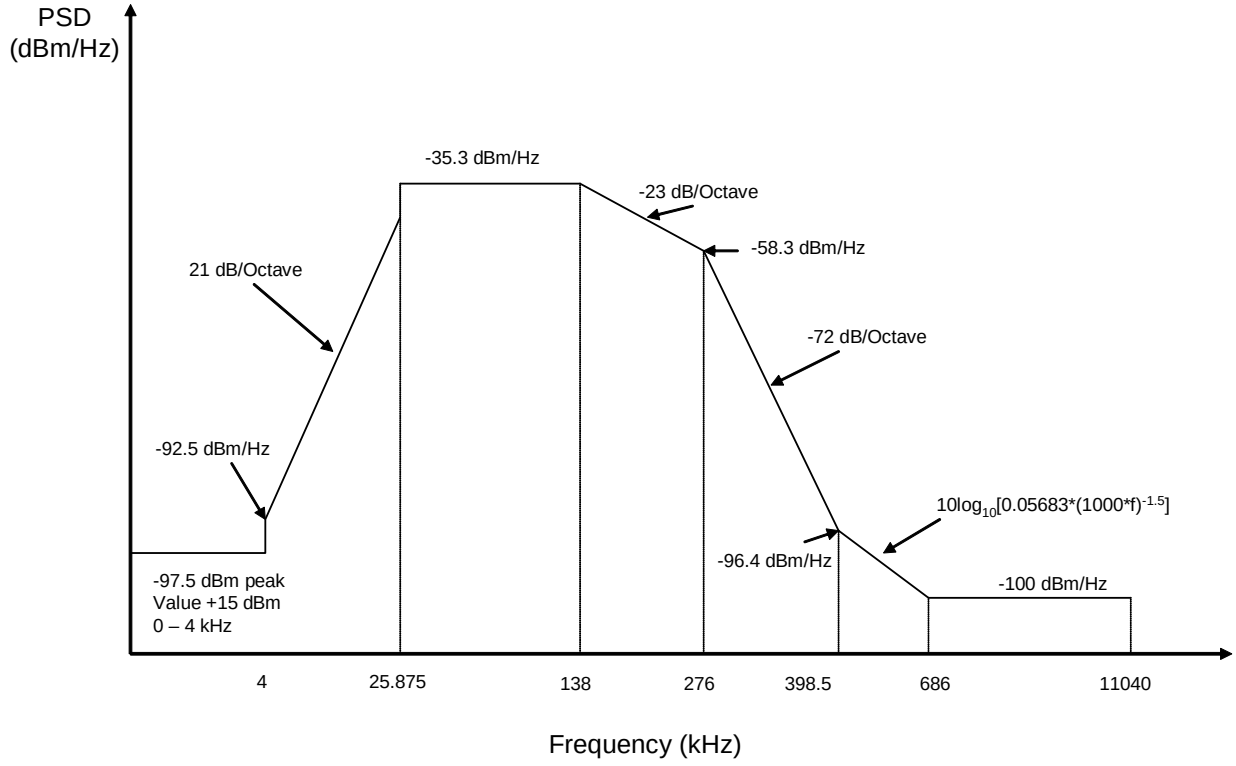


Figure 2: Super Upstream U0 Band_12.5dBm Mask Plot, Peak values.

Table 3-1: Super Upstream Mask, U0 Band_12.5dBm, Peak values, frequency in KHz**.**

Frequency (kHz)	PSD (dBm/Hz) Peak values
0<f<4	-97.5
4<f<25.875	"-92.5 + 21log2.(f/4)"
25.875<f<138	-35.3
138<f<276	"-35.3 - 23.log2.(f/138)"
276<f<398.5	"-58.3 - 72.log2.(f/276)"
398.5<f<686	10log10(0.05683*(1000f)^(-1.5))
f>686	-100

3.2 Super Upstream, U1 Band Mask Definition

Figure 3 and Table 4-2 give the features of Super Upstream U1 Band Mask, based on the peak values. The u1 PSD complies with the -80dBm/Hz Notch between 3.5MHz and 4MHz. The U1 PSD complies also with the VDSL spectrum management recommendations. The total power of the U1 mask described in figure 3 is 7.3dBm based on integration between 4MHz and 5.2MHz. Therefore the maximum total power of the Super Upstream is equal to 12.5dBm, since U1 and U0 are never used together in this analysis.

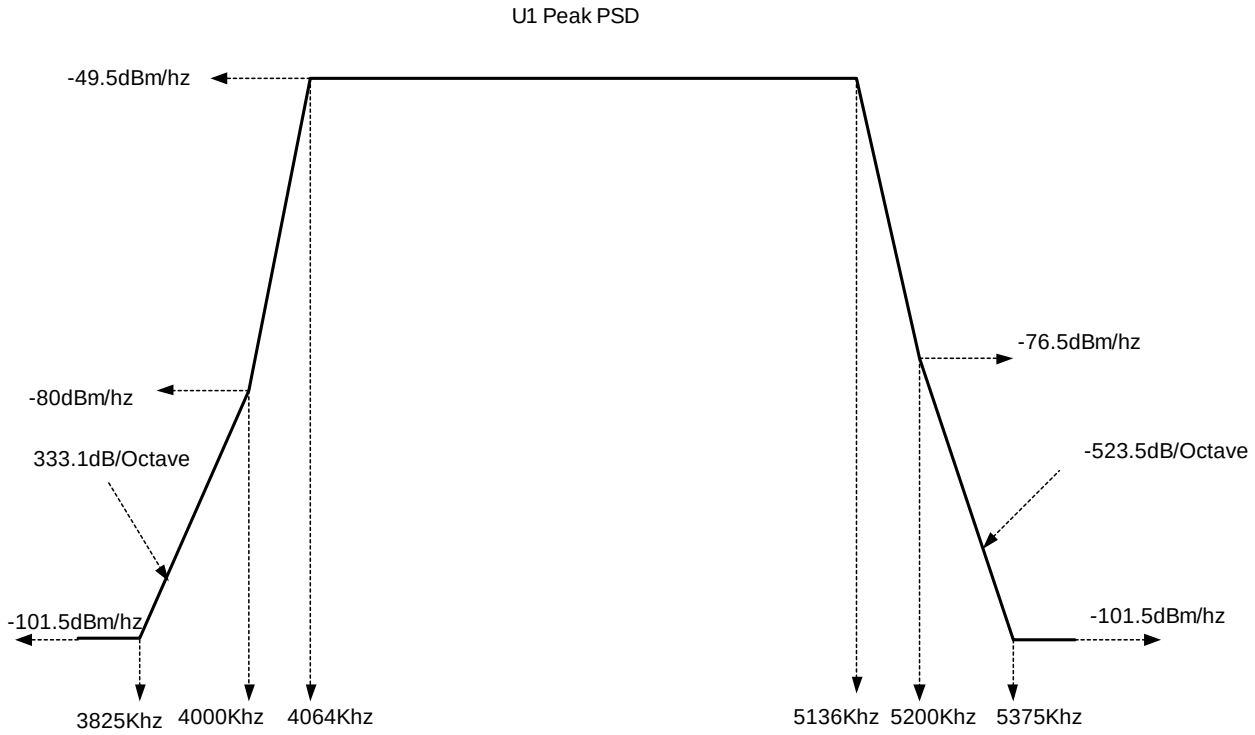


Figure 3: Super Upstream, U1 Band Mask Plot, Peak values.

Table 3-2: Super Upstream, U1 Band Mask Values, Peak values.

Frequency Khz	PSD Peak value dBm/Hz
f <= 3825	-101.5
3825 <= f <= 4000	"-101.5 + 333.1 log2(f/3825)"
4000 <= f <= 4064	"-80 + 1332 log2(f/4000)"
4064 <= f <= 5136	-49.5
5136 <= f <= 5200	"-49.5-1511 log2(f/5136)"
5200 <= f <= 5375	"-76.5 - 523.5 log2(f/5200) "
5375 <= f	-101.5

4 Quad Spectrum Overlap Mask Definition

Figure 4 and table 5-1 give the features of the Quad Spectrum overlap Mask, based on peak values.

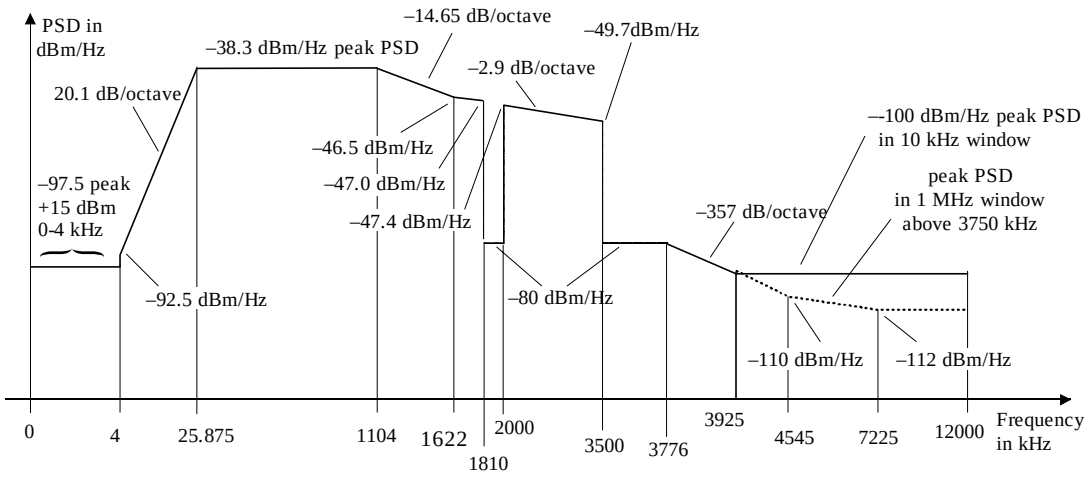


Figure 4: Quad Spectrum Overlap Plot (peak values).

Table 4-: Quad Spectrum Overlap Mask using Peak Values.

(kHz)	**PSD(dBm/Hz)**
0	-97.5
4	-97.5
4	-92.5
10	Interpolated
25.875	-38.3
1104	-38.3
1622	-46.5
1810	-47.0
1810	-80.0
2000	-80.0
2000	-47.4
3500	-49.7
3500	-80.0
3776	-80.0
3925	-100
4545	-110
7225	-112
12000	-112

5 Super Upstream 12.5 & Quad Spectrum Overlap Spectral Compatibility

5.1 Simulation Tunings, JJ-100-R2

The simulations tunings are consistent with JJ-100-02:

- Upstream & Downstream Net Coding Gain: 3dB

- Upstream margin: 4dB

- Downstream margin: 6dB

- Minimum Bit Loading: 2bits

- Maximum Bit Loading: 8 bits.

- Interferers: 1 Intra-Quad plus 4 Inter-Quad.

- Coupling 99%, NEXT = 50dB, FEXT= 51.5dB

5.2 Reference SC Tables

Table 5-1 gives the spectral compatibility reference numbers, according to JJ-100 R2. it is recalled that Annex C FBM reference numbers are given for information only. Based on the last JJ-100 R2 Rules, Annex C FBM is no more a protected system.

Table 5-1. Spectral Compatibility Table according to JJ-100 R2.

	TCM-ISDN		G.992.1 Annex A		G.992.2 Annex A		G.992.1 Annex C				G.992.2 Annex C			
Dist			(FDM)				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	2592	288	2944	832	1088	288
1	144	144	5952	832	2624	832	6368	832	2528	288	2752	832	1088	288
1.25	144	144	4896	800	2272	800	5696	800	2496	288	2528	800	1088	288
1.5	144	144	3840	768	1824	768	5024	800	2432	288	2272	800	1088	288
1.75	144	144	2496	736	1440	736	4192	768	2400	288	2016	768	1088	288
2	144	144	1696	704	960	704	3680	736	2336	288	1696	736	1088	288
2.25	144	144	1088	640	640	640	3296	704	2240	288	1504	704	1088	288
2.5	144	144	704	576	352	576	3008	672	2080	288	1312	672	1056	288
2.75	144	144	480	512	160	512	2720	640	1856	288	1216	640	1056	288
3	144	144	320	448	96	448	2368	576	1536	288	1184	576	1024	288
3.25	144	144	224	352	64	352	1984	512	1280	288	1152	512	992	288
3.5	144	0	128	288	32	288	1632	480	1056	288	1120	480	928	288
3.75	0	0	64	224	32	224	1344	448	832	256	1088	448	832	256
4	0	0	32	192	0	192	1088	416	640	256	1024	416	704	256
4.25	0	0	0	160	0	160	928	416	480	256	928	416	576	256
4.5	0	0	0	128	0	128	768	384	352	224	832	384	416	224
4.75	0	0	0	96	0	96	608	352	224	224	704	352	288	224
5	0	0	0	64	0	64	416	352	128	224	544	352	192	224

5.3 Super Upstream SU_12.5_QOL SC tables

Table 5-2 gives the "spectral compatibility rates" of SU_12.5_QOL system. It is recalled that these rates are the protected systems rates in the presence of 5 (*1 intra-Quad 4 inter-Quad*) SU_12.5_QOL disturbers. Simulations are based on section 6.1 tunings.

Table 5-2. Spectral Compatible Table of SU_12.5_QOL system

	TCM-ISDN		G.992.1 Annex A		G.992.2 Annex A		G.992.1 Annex C				G.992.2 Annex C			
Dist			(FDM)				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	144	144	7072	832	3008	832	7072	832	2592	288	3008	832	1088	288
1.25	144	144	6944	832	3008	832	6944	832	2560	288	3008	832	1088	288
1.5	144	144	6848	832	2976	832	6848	832	2528	288	2976	832	1088	288
1.75	144	144	6752	832	2976	832	6752	832	2496	288	2976	832	1088	288
2	144	144	6560	800	2912	800	6560	800	2432	288	2912	800	1056	288
2.25	144	144	6336	768	2848	768	6336	768	2336	288	2848	768	1056	288
2.5	144	144	5984	704	2720	704	5984	704	2208	256	2720	704	992	256
2.75	144	144	5440	672	2592	672	5440	672	2016	224	2592	672	960	224
3	144	144	4704	608	2432	608	4704	608	1728	224	2432	608	896	224
3.25	144	144	3680	512	2304	512	3680	512	1344	192	2304	512	832	192
3.5	144	0	2816	448	2048	448	2816	448	1024	160	2048	448	736	160
3.75	0	0	1984	352	1728	352	1984	352	736	128	1728	352	640	128
4	0	0	1376	288	1344	288	1376	288	512	96	1344	288	480	96
4.25	0	0	896	224	1024	224	896	224	320	64	1024	224	384	64
4.5	0	0	544	160	736	160	544	160	192	32	736	160	256	32
4.75	0	0	288	96	416	96	288	96	96	32	416	96	128	32
5	0	0	96	64	192	64	96	64	32	32	192	64	64	32

Table 6-3 displays the delta rates between Table 6-1 and Table 6-2. To be spectrally compatible, a system should not impact a protected system to lower rates than the reference rates, given in table 6-1. Therefore, for qualification purposes up to a certain distance the numbers exhibited in table 6-3 should be negative.

Table 5-3: Delta between Table 5-1 and Table 5-2**.**

	TCM-ISDN		G.992.1 Annex A		G.992.2 Annex A		G.992.1 Annex C				G.992.2 Annex C			
Dist			(FDM)				DBM		FBM		DBM		FBM	
	DS	US	DS	US	DS	US	DS	US	DS	US	DS	US	DS	US
0.5	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0.75	0	0	-320	0	-64	0	-192	0	-32	0	-64	0	0	0
1	0	0	-1120	0	-384	0	-704	0	-64	0	-256	0	0	0
1.25	0	0	-2048	-32	-736	-32	-1248	-32	-64	0	-480	-32	0	0
1.5	0	0	-3008	-64	-1152	-64	-1824	-32	-96	0	-704	-32	0	0
1.75	0	0	-4256	-96	-1536	-96	-2560	-64	-96	0	-960	-64	0	0
2	0	0	-4864	-96	-1952	-96	-2880	-64	-96	0	-1216	-64	32	0
2.25	0	0	-5248	-128	-2208	-128	-3040	-64	-96	0	-1344	-64	32	0
2.5	0	0	-5280	-128	-2368	-128	-2976	-32	-128	32	-1408	-32	64	32
2.75	0	0	-4960	-160	-2432	-160	-2720	-32	-160	64	-1376	-32	96	64
3	0	0	-4384	-160	-2336	-160	-2336	-32	-192	64	-1248	-32	128	64
3.25	0	0	-3456	-160	-2240	-160	-1696	0	-64	96	-1152	0	160	96
3.5	0	0	-2688	-160	-2016	-160	-1184	32	32	128	-928	32	192	128
3.75	0	0	-1920	-128	-1696	-128	-640	96	96	128	-640	96	192	128
4	0	0	-1344	-96	-1344	-96	-288	128	128	160	-320	128	224	160
4.25	0	0	-896	-64	-1024	-64	32	192	160	192	-96	192	192	192
4.5	0	0	-544	-32	-736	-32	224	224	160	192	96	224	160	192
4.75	0	0	-288	0	-416	0	320	256	128	192	288	256	160	192
5	0	0	-96	0	-192	0	320	288	96	192	352	288	128	192

We conclude from Table 5-3 that SU-12.5_QOL is spectrally compatible up to 3.25km.

6 Conclusion

This contribution proves that SU_12.5_QOL system is spectrally compatible up to 3.25km, according to JJ_100.01 R2.

7 Recommendation

We recommend that the Super Upstream System combined with the Quad overlap SU_12.5_QOL be allowed for deployment in the same quad as protected systems in the Copper Japan access network, up to 3.25km.

8 References

[1] Conexant Systems, Inc., “An alternative approach to increasing upstream channel capacity for G.992.5 Annex C Quad Spectrum,” MC-069, March 8-12, 2004. This is also contained in TTC contribution SKS-06-CNXT-01, 24-26 March 2004.