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SOURCE[1]: Matsushita Electric Industrial Co. Ltd. (Japan)

TITLE: Spectrum considerations for G.hs

ABSTRACT

This contribution begins with a review of the upstream and downstream PSD requirements of xDSL services co-mingled with POTS or ISDN services. Implications of the xDSL PSDs on the G.hs PSD are discussed. Spectrum allocation for G.hs signals as well as modulation parameters are proposed.

1. Introduction:

G.hs will be used to initiate or activate many types of existing and future xDSL services, therefore requirements from the various xDSL services should be carefully considered in the design of G.hs. This contribution addresses two inter-related considerations: spectrum and activation methods. For G.hs, suitable bands must be selected for transmission of the negotiation and user data channels. Those bands need to be selected with consideration to the existing overall PSDs of the xDSL services and also to the activation signals of existing xDSL services.

This contribution is organized as follows: Section 2 reviews the spectra of several xDSL services. Section 3 is a discussion of the spectra and assumptions. Section 4 contains specific proposals for the G.hs spectrum.

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This contribution addresses the three spectrum open issues in CI-082:

			NF-045 section
2.2	Open	What spectrum(s) should be used by G.hs?	5
2.3	Open	Should the spectrum be similar to the xDSL (spectrum) bands?	3.2
2.4	Open	Should the spectrum respect both the upstream and downstream bands of existing modulation schemes?	3.4

2. Preliminary Survey of Existing Spectra and Activation

Various spectra of xDSL and existing services that might be negotiated by G.hs are shown in Table 1. These number are based on the referenced documents with example PSDs shown in Figure 1 through Figure 7.
For the purposes of this contribution (and possibly later in G.hs) we indicate the "upstream" and "downstream" directions using the nomenclature from the various xDSL services in Table 2.
Table 3 lists the initiating activating sequences.

Things to do for the Tables:

- fill-in and correct the applicable xDSL services
- fill-in the effective bandwidths (BW) in Table 1.
- provide (better) reference documents for national items

Table 1. Preliminary survey of existing spectra

Item	Modulation (Document)	Total Bandwidth		Upstream Bandwidth		Down Stream Bandwidth	
		Lower (kHz)	Upper (kHz)	Lower (kHz)	Upper (kHz)	Lower (kHz)	Upper (kHz)
P-1	G.dmt above POTS	26	1,104	26	138	26	1,104
I-1	G.dmt above ISDN-MMS-43 (G.961 Appendix I)	? 150	1,104				
I-2	G.dmt above ETR 080 Annex B (4B3T)	? 300	1,104				
I-3	G.dmt above ETR 080 Annex A (2B1Q)	? 300	1,104				
I-4	G.dmt above NA ISDN-2B1Q (G.961 Appendix II) (North America)	? 90	1,104				
I-5	G.dmt next to ISDN-TCM (G.961 Appendix III) (Japan ping pong ISDN)	? 26	1,104	??? 26	?1,104		1,104
I-6	G.dmt next? to ISDN-SU32 (G.961 Appendix IV)						
A-1	T1.413 Cat 1 w/ Analog filters				? 103	? 138	
L-1	G.lite	26	???				
L-2	DMT with only 64 tones	26	276				
L-3	DMT with only 128 tones	26	552				
H-1	G.hdsl						
H-2	G.hdsl CAP one-pair	62	390				
H-3	G.hdsl CAP two-pair	39	237				
H-4	G.hdsl 2B1Q	0	400				
H-5	HDSL2			0	400	0	900
V-1	VDSL (with European ISDN) DTS/TM-06003-1(draft) V0.0.7 (1998-2) Section 8.2 Frequency plan	300	30,000	300	30,000	300	30,000

2.1 4B3T Power spectrum

Information is available from G.961 Annex I.12.4 and ETR-080 rev 3 draft shown in Figure 1(Figure I.5./G.961) and Figure 2 (B.5/ETR-080rev3).

Figure 1. 4B3T upper bound

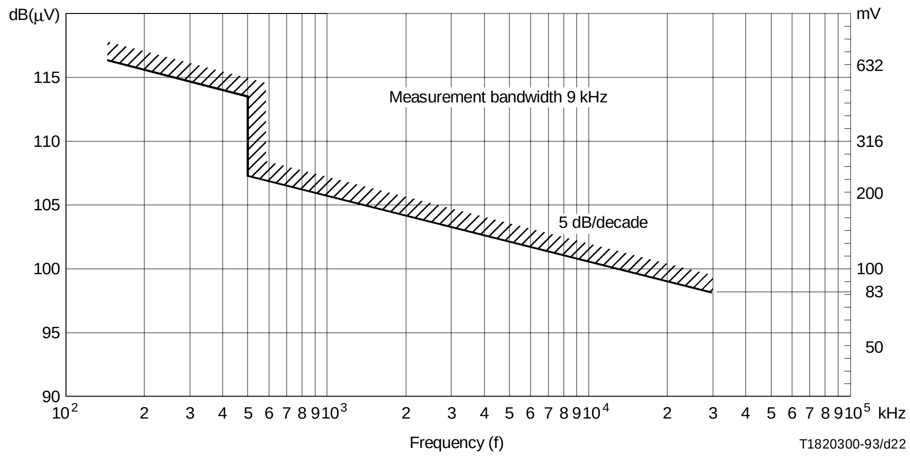


FIGURE I.5/G.961

Limits of transmit power spectrum

Figure 2. Information from ETR 080, Annex B (4B3T)

B.12.4 Power spectrum

The upper bound of the power spectral density shall be limited according to figure B.5. Measurements to verify compliance with this requirement are to use a bandwidth of 9 kHz.

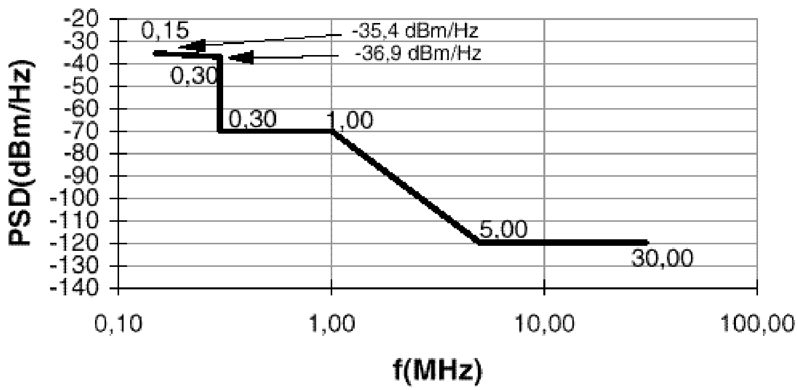


Figure B.5: Upper bound of power spectral density from NT1 and LT.

Systems deployed before January 1, 2000, do not have to meet this PSD requirement but shall meet the PSD requirements as defined in ETR 080 edition 2. It is however expected that these systems will also meet the PSD requirements of TS 080 edition 3. Some narrowband violations could occur and should be tolerated.

2.2 2B1Q Power spectrum

The upper bound of the power spectral density of the transmitted signal is described in(G.961 Annex II.12.4 as shown in Figure 3 (Figure II.12/G.961). Measurements to verify compliance with this requirement are to use a noise power bandwidth of 1.0 kHz. TER-080 also provides some information as shown in Figure 4. Some calculated values are shown in Figure 6.

Figure 3. G.961 2B1Q upper bound

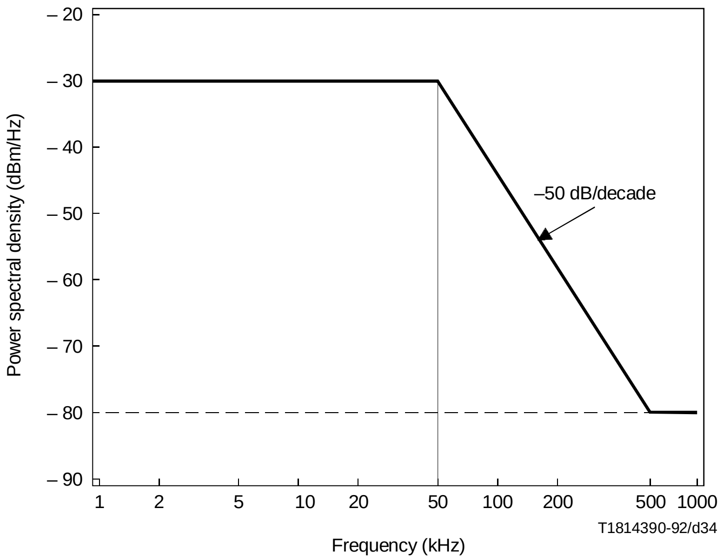


FIGURE II.12/G.961

Upper bound of power spectral density of signal from NT1 and LT

Figure 4. Information from ETR 080, Annex A (2B1Q)

A.12.4 Power spectral density

The upper bound of the power spectral density of the transmitted signal shall be as shown in figure A.12. Measurements to verify compliance with this requirement are to use a noise power bandwidth of 1,0 kHz.

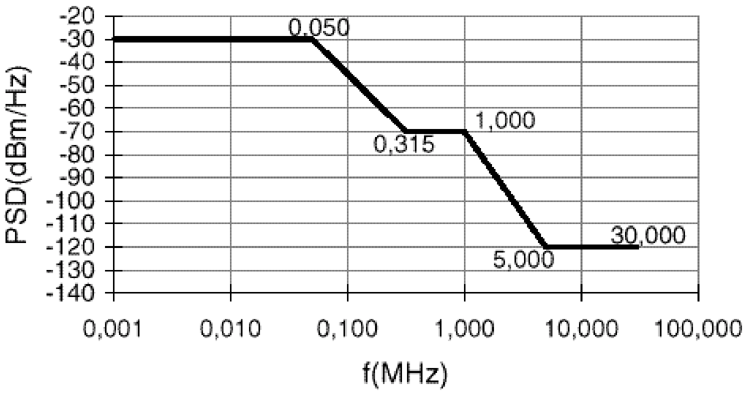


Figure A.12: Upper bound of power spectral density from NT1 and LT.

Systems deployed before January 1, 2000, do not have to meet this PSD requirement but shall meet the PSD requirements as defined in ETR 080 edition 2. It is however expected that these systems will also meet the PSD requirements of TS 080 edition 3. Some narrowband violations could occur and should be tolerated.

2.3 TCM-ISDN (Japan) Power spectrum (G.961 Annex III.12.4)

The upper bound of the power spectral density shall be within the template in Figure III.16/G.961. The "theoretical" plot in Figure 6 is derived from Appendix D in [1] which is also discussed in NF-046. 2B1Q theoretical disturber values can be obtained by using the information in Annex B of T1.413i1 or section 8.1/G.dmt.

Figure 5. G.961 TCM upper bound

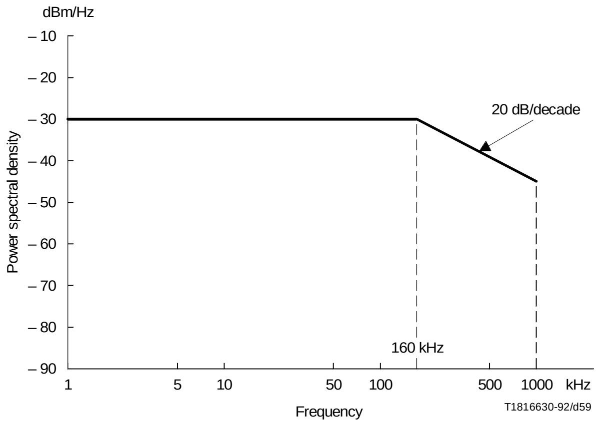
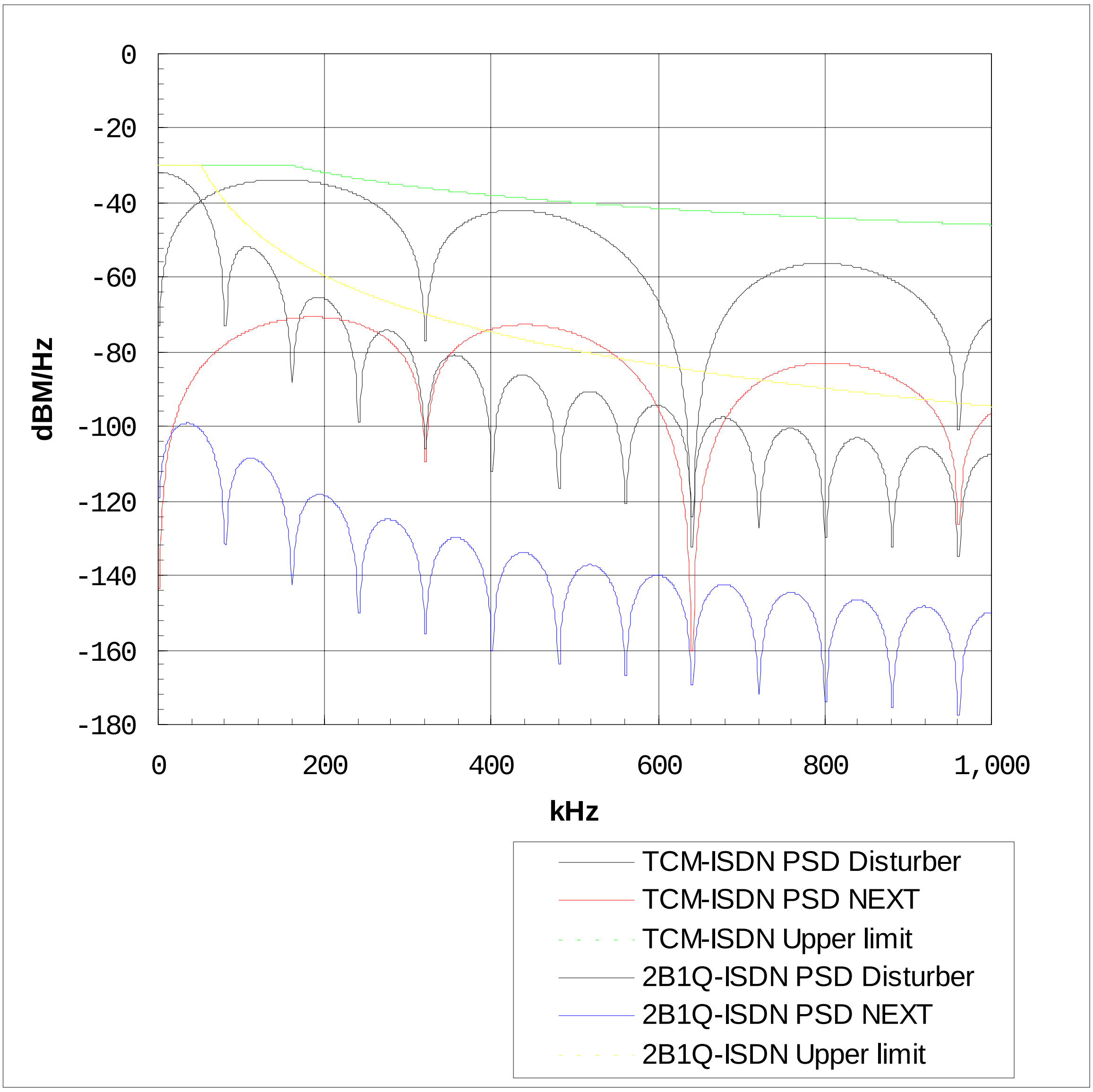


FIGURE III.16/G.961

Upper bound of power spectal density of signal

Figure 6. TCM & 2B1Q-ISDN PSD



2.4 ETSI VDSL Frequency Plan

Figure 7. Information from ETSI DTS/TM-06003-1 (VDSL)

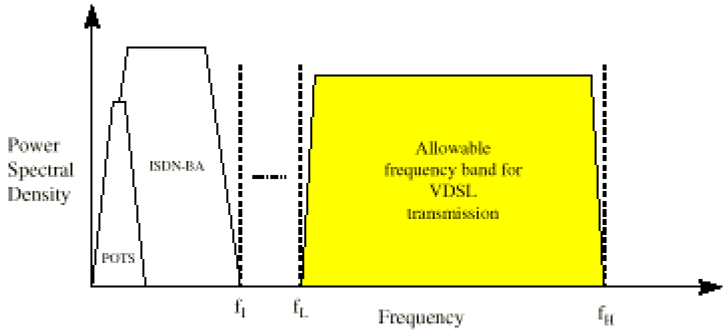


Figure 8 : Frequency plan for VDSL

Table 1 : Upper and lower frequency limits for VDSL

Class of VDSL operation	f_L lower limit (kHz)	f_H upper limit (MHz)
I (asymmetric)	300	30
II (symmetric)	300	30

2.5 Line Attenuation

The line transfer function (ie, line attentuation) has been calculated using Appendix A, table A-1 from [1] and is shown in Figure 8. The wire gauge is 0.4mm.

Figure 8. Line Transfer for 0.4mm gauge wire

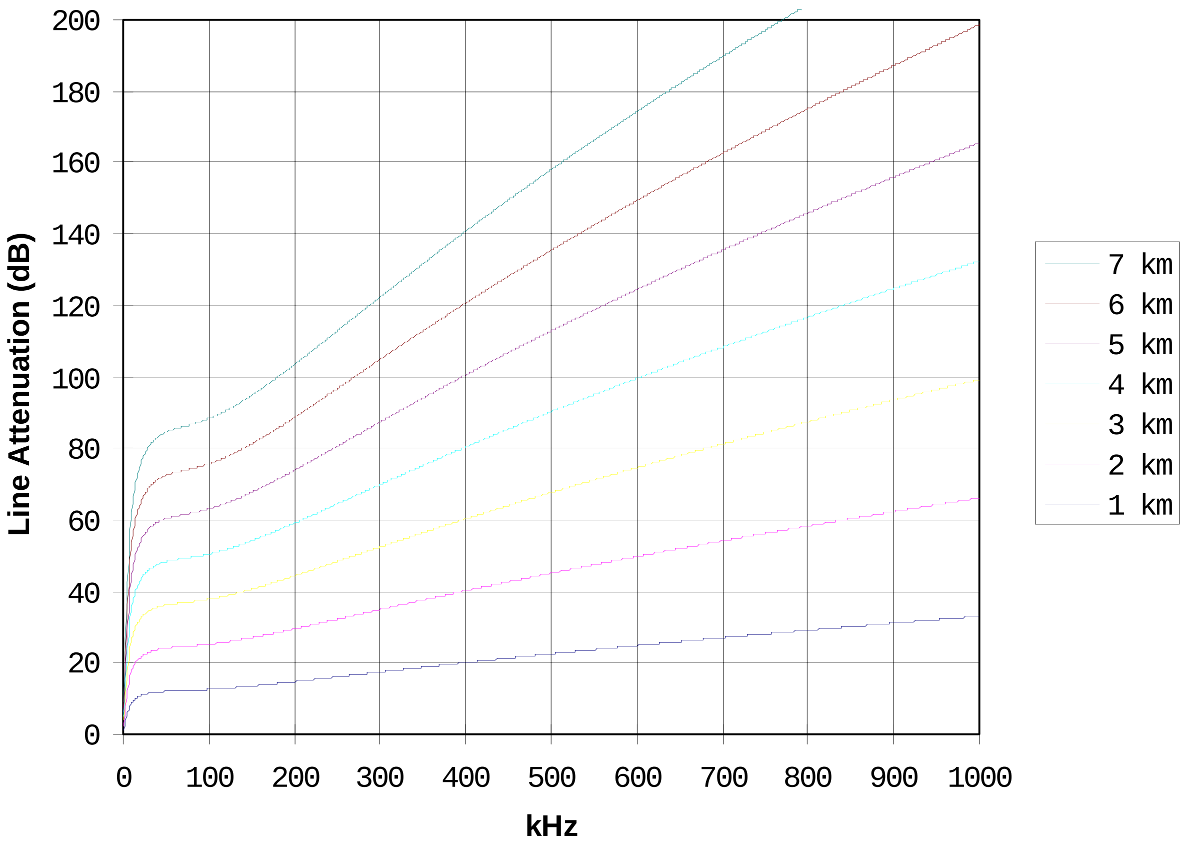


Figure 9. TCM NEXT and Line attenuation

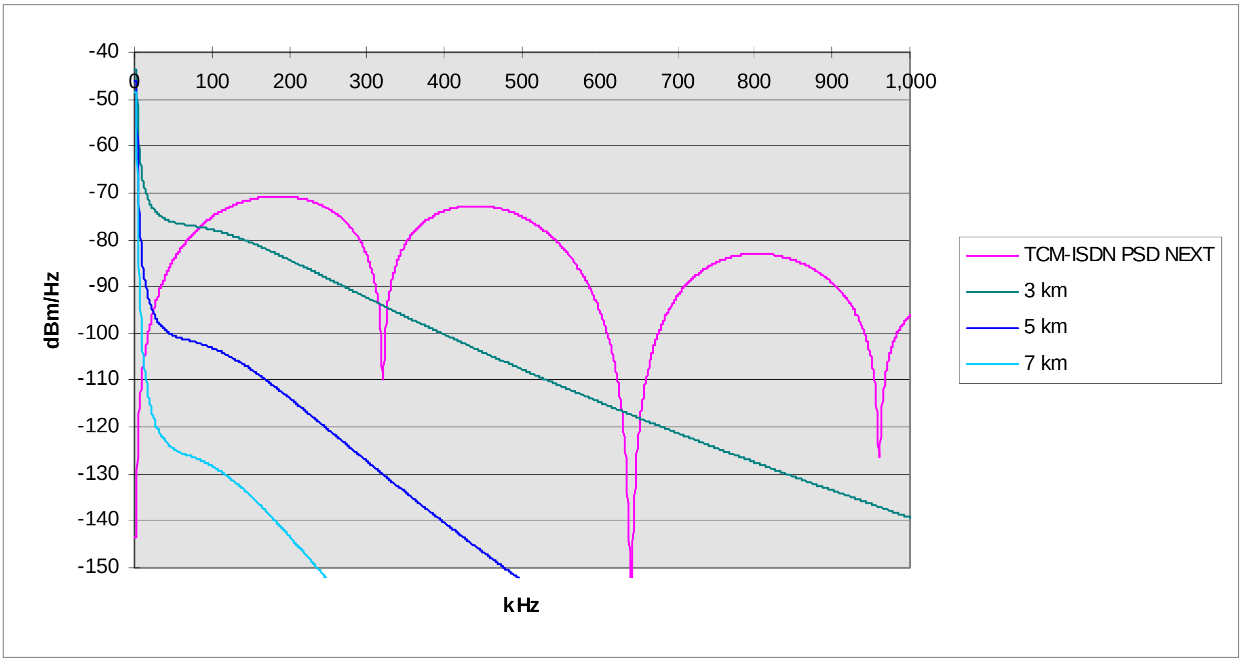


Figure 10. 2B1Q NEXT and Line Attentuation

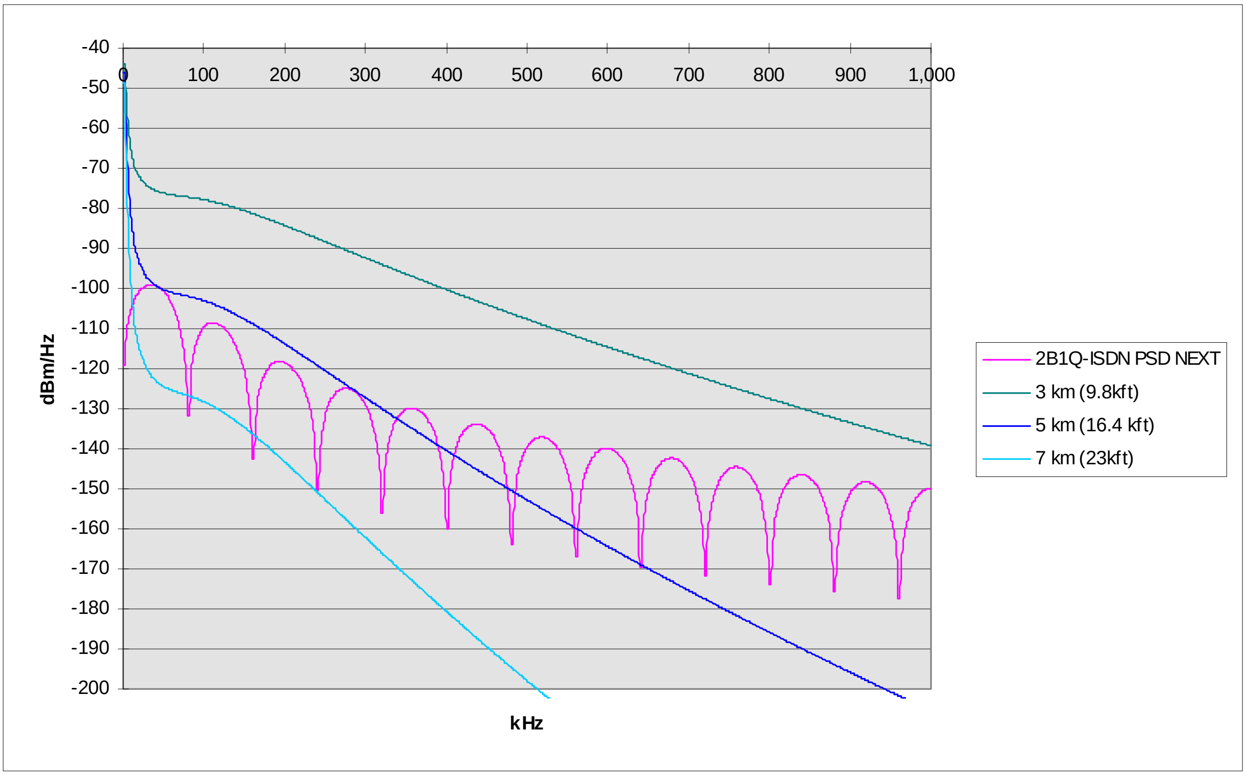


Table 2. Definitions of Upstream and Downstream

Modulation (Document)	Upstream	Downstream
G.dmt	xTU-R → xTU-C	xTU-C → xTU-R
T1.413 Cat 1 w/ Analog filters	ATU-R → ATU-C	ATU-C → ATU-R
G.lite	xTU-R → xTU-C	xTU-C → xTU-R
DMT with only 64 tones	xTU-R → xTU-C	xTU-C → xTU-R
G.hdsl	NTU → LTU	LTU → NTU
HDSL2	NTU → LTU	LTU → NTU
VDSL (with European ISDN) DTS/TM-06003-1(draft) V0.0.7 (1998-2)	NT → ONU (LT)	ONU (LT) → NT-R
Notes: xTU-R, NTU, NT indicate customer side xTU-C, LTU, ONU indicate network side		

Table 3. Activation signals of existing xDSLs

Modulation (Document)	Initiator	Responder	Reference
G.dmt	None - will use G.hs		
G.lite	None - will use G.hs		
T1.413 Issue 1	R-ACT-REQ 34.5 kHz sinusoid with cadence of: 128 symbols on 64 symbol @ –2 dBm (~16ms) 64 symbol @ –22 dBm (~16ms) 896 symbols off (~221ms)		Issue#1 - 12.3.1
T1.413 Issue 2	(same as Issue 1)		Issue #2 Section 9.3.1
RADSL CAP	RTU-R transmits RSO+trailer (pseudo noise at symbol rate)		
G.hdsl (2B1Q)	LTU transmits S0	NTU transmits S0	Figure 11,Section 5.6, draft G.hdsl (TD-38)
G.hdsl (CAP - Annex B)	LTU transmits CS0 3150 symbols of pseudo noise at symbol rate	NTU transmits RS0 3150 symbols of pseudo noise at symbol rate	Section B.5.6
HDSL2	??		
VDSL DTS/TM-06003-1(draft)			Not defined yet

3. Discussion

3.1 G.hs bandwidth requirements

Given the following assumptions for G.hs :

- FSK, DPSK, QPSK or similar modulation (for FSK, NRZI encoding to prevent long strings of 0's to cause loss of synchronization.)
- Frequency Division Multiplexing (FDM) of all channels.
- User data channels are independent of negotiation channel
- each channel having a bit rate of approximately 10k bits/sec

it would seem that G.hs would require four 10kHz bands of spectrum for the upstream and downstream negotiation and user channels.

3.2 Mutually exclusive

Assuming:

- some devices will only implement a single xDSL (so that they have filter very closely specified to the specific PSD)
- there may be requirements for G.hs to adhere to the same PSD as the xDSL
- some of the xDSLs place tighter requirements on the upstream PSD

we see that there is no band common to all of the xDSL configurations.

An extreme example is the combination of the requirements for A-1 and V-1 or I-1. A-1 requires the upstream to be below 103 kHz and V-1 requires the upstream to be above 300 kHz.

If one excludes the requirements for V-1 and I-1, the combination of the requirements for A-1 and I-4 prevent the allocation of two (negotiation and data) upstream channels. I-4 upstream must be greater than 90 kHz and A-1 upstream must be less than 103kHz.

Finally the PSDs for the European ISDN-BA (I-2, I-3) seem to indicate that frequencies above 300 kHz will be necessary.

3.3 Japan TCM-ISDN

The data of Figure 6 and Figure 8 are shown simultaneously assuming a 40dBm/Hz signal experiencing line attenuation at different cable lengths. This is similar to SNR values shown in the "" Figure of NEC contribution ????. As discussed in that paper, for long cable lengths the frequency attenuation is significant enough to cause very narrow ranges of positive SNR. See section 4.1 for more discussion.

3.4 VDSL Requirements.

- At least one set of spctra inside the VDSL plan.
- Some regions might have more relaxed splitter deigns, so at least one set of bands should be above 600 kHz. Frequencies in this range should be usable under any meaningful VDSL

4. Modulation Discussion

Several modulation schemes for G.hs have been suggested.

Modulation	Co.	Doc.	Comment
FSK	MGCS	CI-032	simple and robust
QPSK	Alcatel	CI-068	3db better noise margin than FSK
DPSK (differential BPSK)	3com	CI-044	ease of implementation and portability

For rough calculations, the minimum necessary SNR for a 10^{-4} error rate for each of those modulations can be approximated as:

Modulation	Minimum SNR
FSK	10 dB
QPSK	13 dB
DPSK (differential BPSK)	10 dB

4.1 Impact of TCM-ISDN on G.hs bitrates

As discussed in Delayed Document D.156, Japan's TCM-ISDN based system operates in a ping pong manner with 1.25 ms devoted to upstream transmission followed by 1.25 ms of downstream transmission. The same cross talk that affects G.dmt (and G.lite) could also affect G.hs transmission schemes.

The Dual Bit (DB) map method (D.156, CI-025) is applicable to G.dmt since the bits per symbol, the symbol rate, and the number of carriers of G.dmt is sufficiently high so that many bits (actually frames) are able to be transmitted during a TCM-ISDN downstream burst with cable lengths up to approximately 3 kilometers. However, for cable lengths on the order of 5 kilometers, TCM-ISDN NEXT is so strong that ADSL data cannot be received at most frequencies.

Likewise for the G.hs modulation, we must assume for long cable conditions at higher frequencies that no data would be received during the TCM-ISDN NEXT burst. Thus we want to examine the feasibility of error correction schemes under TCM-ISDN environment. We did a simplistic analysis of assuming some of the modulations and bit rates already suggested for G.hs. Various numbers of bits per burst are shown in Table 4.

Table 4. Bits per burst

	bits per burst			message duration (assuming 100 octets/message)	
symbols/sec	QPSK (2 bits/sym)	DPSK (1 bit/sym)		QPSK	DPSK
10,000	25.0	12.5		40 ms	80 ms
4,313	10.8	5.4		93 ms	186 ms
2,156	5.4	2.7		186 ms	371ms
1,078	2.7	1.4		371 ms	742 ms

From Table 4, it can be seen that there are extremely few bits transmitted per burst segment.

It seems to be impractical to devise a general coding scheme that would be robust with so few continuous good bits.

Thus, reducing the bits per symbol is obviously not feasible for QPSK nor DPSK modulations.

Although the number of octets per message significantly depends on the number of parameters exchange by G.hs, for now we assume that 100 octet messages will not be unusual.

Since G.hs requires equal transmission bit rates in both the upstream and downstream paths

Previous Spectrum proposals:

	Upstream (kHz)	Downstream (kHz)		
MGCS	300-310	360-370		CI-032
3com	91 (#21) 134 (#31)	112 (#26)	downstream subsampling of higher order tones	CI-044
Paradyne	20-40	20-40		CI-060
Alcatel	POTS: 69 (#16) and 104 (#24) ISDN 173 (#48) and 207 (#48)	POTS: 242 (#56) and 345 (#80) ISDN 345 (#80) and 414 (#96)		CI-068
NEC	< 47kHz	< 47 kHz	negative SNR at high frequencies by TCM-ISDN NEXT	NF-???

5. Proposals for G.hs Spectrum and Activation

5.1 Definitions

5.1.1 Voiceband group

The voice band group of frequencies is 0 through 4KHz

5.1.2 Pairing

The upstream and downstream channels for a given are considered as a pair. Thus, there is a negotiation channel upstream and down stream pair. Likewise, A user data channel upstream and downstream pair

5.2 Proposal Points

5.2.1 Relative Frequencies

In the initialization process, the lower frequency band of a pair will be assigned to the upstream channel and the upper frequency band of the pair will be assigned to the downstream channel.

5.2.2 Either terminal initialization

Either terminal can instigate the activation provided that it realizes if it is an customer device or network device so as to correctly assign the upstream and downstream roles

5.2.3 Initialization vis-à-vis groups

When it is within a terminal unit's capability to do so, G.hs initiates and responds to initiation using signals in the primary group of frequencies. If a terminal unit fails to receive a response in the primary group or it is not capable of communication in the primary group, the secondary group should be used. If the secondary group is also unusable, the devices may attempt communication via voice band group protocols such as V.8 or V.8bis. Voice band communication availability can be tested with spread spectrum techniques.

5.2.4 Group Frequency proposals

Table 5 describes several possible sets of the frequencies.. Note that the user and negotiation upstream frequencies have been placed adjacent to each other to facilitate easier filtering. **Error! Reference source not found.** summarizes the spectra information in graphical form.

Table 5. Frequency Plan

Set #	Typical Application	Negotiation Lower (kHz)	Negotiation Upper (kHz)	User Data Lower (kHz)	User Data Upper (kHz)
#1 Upstream	New Equipment, European ISDN	300	310	330	340
#1 Downstream		360	370	390	400
#2 Upstream	Old Equipment	90	100	120	130
#2 Downstream		150	160	180	190
#3 Upstream	TCM-ISDN environment	20	30	?	?
#3 Downstream		40	50	?	?
#4 Upstream	VDSL	600	610	650	660
#4 Downstream		700	710	750	760

5.2.5 Fallback Methods

Specify how to interoperate with existing xDSL specifications. (See Table 3.)

Basically start with the G.hs tones. If no response, try an existing activation signal (implementation dependent).

6. Summary:

1. Agenda Item: G.hs spectrum

2. Expectations: Come to an agreement on the G.hs spectrum/PSD open issue that would become a term of reference.

3. New issues to be added:

Section	Issue	Proposed Answer
Spectrum	How many bands should be used for G.hs negotiation?	It seems 3 or 4 not including nulls from bridge taps
Spectrum / Protocol	What techniques should be used in TCM-ISDN environment?	low frequency spectra
Spectrum / Protocol	Assuming multiple bands, should the transmission be serial, pre-configure, or parallel?	?
Spectrum / Protocol	Assuming multiple bands, should the reception be serial, pre-configured, or parallel?	parallel with noise/interferer detectors

4. Proposals for spectrum open issues in CI-082

		NF-045 section
2.2	What spectrum(s) should be used by G.hs?	5
2.3	Should the spectrum be similar to the xDSL (spectrum) bands?	3.2
2.4	Should the spectrum respect both the upstream and downstream bands of existing modulation schemes?	3.4

References:

[1] Seiichi YAMANO, "The Range of Passband QAM-Based ADSLs in NTT's Local Networks", *IEICE Trans. Communication*, Vol. E78-B, No. 9, September 1995, pp. 1301-1321.