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TITLE: G.hs.bis: G.vdsl and Implications to G.hs

ABSTRACT

With recent agreements in G.vdsl, we are now in a position to begin studying the specific requirements and implementation of G.hs in a VDSL environment

1 Introduction:

This contribution addresses the following Issues for G.hs (BA-U16R1):

1.1	Agreed (04/99)	that future enhancements to existing ITU-T DSL Recommendations and future ITU-T xDSL Recommendations (e.g., G.shdsl and G.vdsl) shall be negotiated through G.994.1 (or a revision of G.994.1).	PO-070, MA-067
2.2	Open	Considering robustness and complexity, what symbol rate should be specified to support G.vdsl?	PO-070, MA-067
2.3	Open	Which signalling family in G.994.1 should be used for G.vdsl?	MA-067, MA-077
3.1	Open	What duplexing method should be used for G.vdsl?	PO-070, MA-067, MA-077

This contribution addresses the following Issues for G.vdsl (BA-U11R4):

2.10.19	Agreed (21-Jun-00)	The band between 25kHz and 138 kHz may be used for either upstream or downstream direction in the VDSL application. The G.hs handshake mechanism signals one of: 1. If the capability exists 2. If the band is to be used for upstream 3. If the band is to be used for downstream Other uses of this band are for further study.	BA-021, BA-041, BA-047, BA-081, BA-093

With recent agreements in G.vdsl spectral allocation, the committee is now in a position to develop the specifics of a the G.hs mechanism that can accommodate G.vdsl. As a general goal, it is prudent to reuse as many of the existing G.hs components as possible. Some of these components include:

- Upstream/Downstream spectral allocation

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- Carrier frequency selection
- Modulation
- Startup mechanism
- Message format
- Transaction
- Duplexing

In the case of G.991.2, half duplexing, new spectral allocation, and new carrier frequencies were developed. Additionally to accommodate the G.991.2 activation, new transactions were added.

2 Discussion

To initiate a handshake session for devices that include G.vdsl modems, communication must occur in some predetermined manner on some communication channel. Due to the legacy G.hs components and spectral compatibility considerations, the design space of a new way for handshaking is significantly limited. We briefly discuss some of the G.hs component areas to help identify and prioritize different design criteria that may depend on the system installation and usage environment.

2.1 Spectrum

Figure 1 illustrates the spectrum used by various xDSL technologies. VDSL technologies may use more than a single upstream and single downstream bands for transmission. In Figure 1 and Table 1, example VDSL technology spectral allocations are shown.

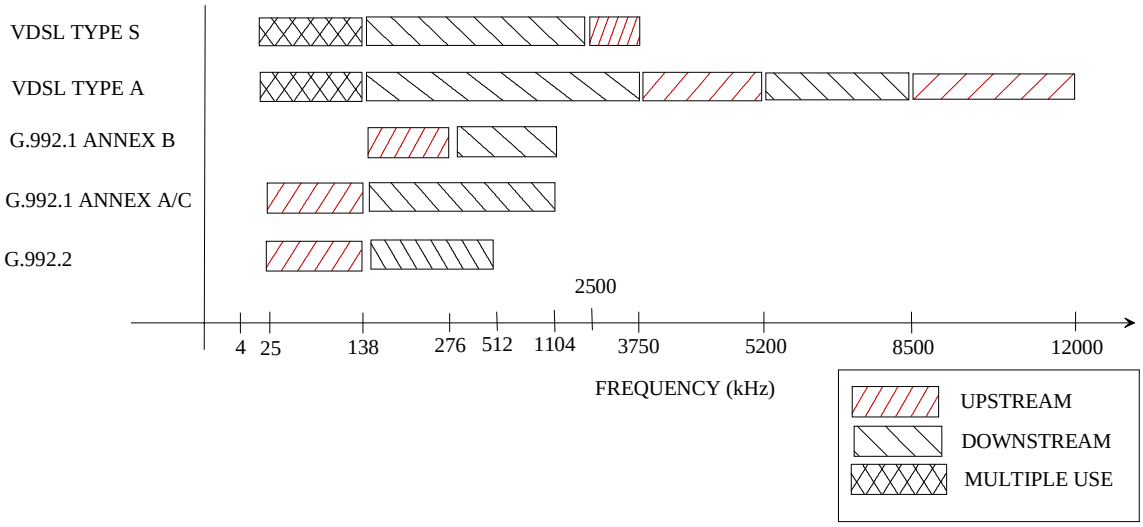


Figure 1. Spectral usage by various xDSL technologies

Table 1 Sample spectral allocations by VDSL Type

	Optional Use	Downstream	Upstream	Downstream	Upstream
Type A	25-138	138-3750	3750-5200	5200-8500	8500-12000
Type E	25-138	138-3000	3000-5100	5100-7050	7050-12000
Type S		138-2500	2500-3750		

In some cases, VDSL equipment may transmit energy in the band from 25 kHz to 138 kHz. The direction of transmission may be upstream or downstream and must be negotiated by G.hs. The ability to transmit and the direction of transmission must be identified and selected in G.hs. (G.vdsl Agreed Issue 2.10.19)

Observations:
In previous xDSL technologies, a transceiver system did not have the option of selecting whether a band was upstream or downstream. Since G.vdsl has different spectral allocations than previous xDSL technologies and since some spectrum is not allocated to be strictly upstream only or strictly downstream only, a new method may need to be developed to handshake G.vdsl while still retaining compatibility with existing G.hs

2.2 Carrier Frequencies

The G.994.1 frequency carriers for ADSL (G.992.x) are shown in Table 2. Since there are overlapping portions of spectrum between G.992.x and G.vdsl, some of the carrier frequencies may be reused.

Table 2 Frequency Carrier sets for G.992.1 and G.992.2

Carrier set designation		Upstream Carrier frequencies (kHz)	Downstream Carrier frequencies (kHz)
A43	G.992.1 Annex A G.992.2	38.8125 73.3125 107.8125	172.5 241.5 276.0
B43	G.992.1 Annex B	159.5625 194.0625 228.5625	310.5 379.5 414.0
C43	G.992.1 Annex C	30.1875 38.8125	51.75 60.375 276.0

It is observed that the received power of higher frequency carriers is reduced due to the frequency dependent attenuation of the communication channel. Thus, if any new carrier frequencies need to be selected , they should be selected to be as low frequency as possible in order to increase the effective distance of possible communication.

3 Proposals

Some proposals for extending G.hs to include G.vdsl:

3.1 G.hs downstream for G.vdsl

As can be seen, the downstream carriers of the various types of G.vdsl shown in Table 1 have the band from 138 to 3000 kHz in common. Further, the band from 276 to 512 kHz is a common downstream band for many xDSL technologies. Those characteristics make the band suitable for G.hs downstream communication for G.vdsl

Thus, downstream carriers are should be selected from the set of carriers for G.992.1 Annex B and G.992.1 Annex A/C. These downstream carrier frequencies lie in the downstream spectral allocation of the various types of VDSL. G.992.1 Annex B carriers are in complete common downstream spectral allocation however the use of G.992.1 Annex A/C must be considered for legacy devices. At the time of a handshake sequence, the selection of used carriers is based upon the recommendation in Notes 1 and 3 of Section 6.1 in G.994.1:

> NOTE 1 – In the interest of explicitly indicating the presence of HSTU-x which might not have common modes, the initial transmission should use as many carriers as possible, and HSTU-x are encouraged to detect all carriers from all signaling families.
> NOTE 3 – It is advised to monitor for existing services prior to transmitting signals to avoid interfering with them.

3.2 G.hs upstream for G.vdsl

The selection of VDSL upstream handshaking carrier frequencies is more problematic since the various types do not always have common upstream spectral allocation and the frequencies are quite high. For the Annexes in G.992.1, this type of problem has been sub-optimally addressed by allocating different carrier frequencies for the different types of spectral allocations.

A few ideas are proposed below. Some of the ideas be used simultaneously to increase the chances of detection or sequentially in time similar to Annex A/G.994.1.

3.2.1 Upstream using 3-5 MHz.

Briefly ignoring previous definitions for Type S, upstream carriers for use with Type A and E G.vdsl systems are selected from the range of 3750 to 5100 kHz. Use of this frequency range allows dedicated frequencies at full transmission power. Table 3 shows some suggested carrier frequencies that are multiples of both 4 kHz and 4.3125 kHz.

Table 3 Upstream Frequencies

Carrier set designation	Upstream Carrier frequencies (kHz)
VDSL Type A and E	3864.0 4416.0 4968.0

Observations:

Unfortunately, there is no common spectrum with legacy G.992.x upstream spectrum which is limited to 552 kHz or 1104 kHz. Additionally, use of such high frequencies for carriers is sub optimal for long loop lengths.

3.2.2 Upstream using Spread Spectrum

G.vdsl systems may want to use the spectrum from 25 to 138 kHz with reduced power and limited interfering spread spectrum upstream signals. Essentially this means that the upstream modulation is different while retaining the other G.hs components. This allows handshake message to be transmitted from the HSTU-R to the HSTU-C but uses a modulation that is spectrally compatible with other communication services. This may also be used in installation environments in which the G.vdsl optional band is used for downstream signals.

Observations:

However , this proposal is not backwards compatible with previous xDSL handshaking devices and some VDSL systems may be installed with a splitter that prevents communication

3.2.3 Specialized Signaling - C-TONES-UP

Use and directionality of the G.vdsl optional 25 -138 kHz band is to be negotiated by G.hs. Due to the nature of the optionally, the HSTU-R must indicate it's capabilities, but the HSTU-C must make the final selection for usage and direction. In the current G.hs, such capability indications and selections are almost exclusively communicated through messages and transactions. One noticeable exception is the selection of G.hs duplexing by the transmission of R-TONE1 or R-FLAG1.

The capability indications and selection states for usage and directionality of the band between 25 to 138 kHz may be used for higher power communication by the xTU-R and xTU-C. is shown in Table 4. While there are many capability and selection states, it is notable that there is only one set (case #4) where the optional band is uniquely chosen for upstream usage.

Table 4 VDSL optional band usage

HSTU-C						HSTU-R			Operation	Case #
Capability			Select			Capability				
Use	Up	Down	Use	Up	Down	Use	Up	Down		
0	X	X	X	X	X	X	X	X	None	1
0	X	X	X	X	X	1	X	X	None	2
1	X	X	X	X	X	0	X	X	None	3
1	1	X	1	1	0	1	1	X	Up	4
1	X	1	1	0	1	1	X	1	Down	5

Some implications of HSTU-C versus HSTU-R initiated handshake will now be discussed.

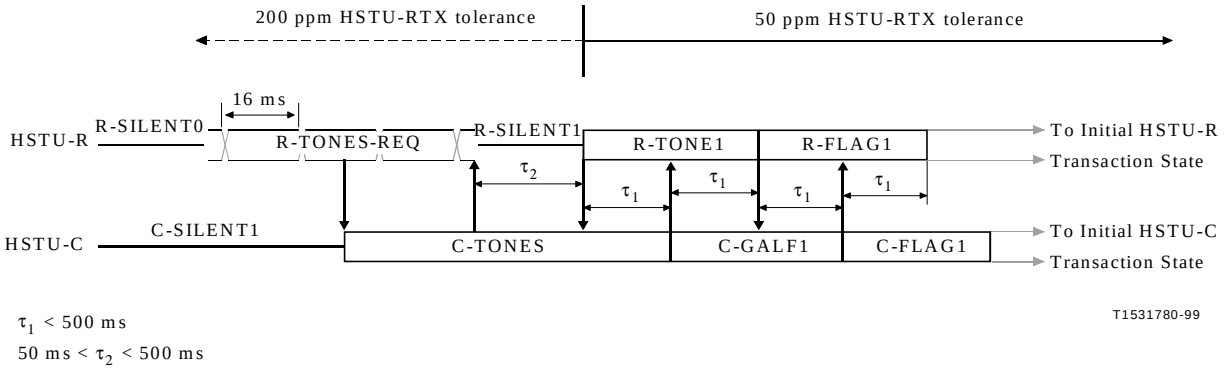
From section 3.1, HSTU-C initiated handshake may use the existing downstream carriers without concern for ADSL backwards compatibility, spectral compatibility nor availability of the VDSL optional band.

However, in many cases, handshake will be initiated by the HSTU-R. In the case of HSTU-R initiation of handshake, ADSL backwards compatibility, spectral compatibility, signal reach, and availability of the VDSL optional band must be considered.

Before the HSTU-R may use the G.vdsl optional band for upstream handshaking transmission, the HSTU-C must indicate usability and upstream directionality. To preserve as much of the existing procedures and to have the information conveyed as early as possible to reduce handshaking duration, it is proposed to use a information exchange prior to the transaction message exchange. In other words the exchange should occur during the startup signaling. The first opportunity the HSTU-C has to communicate with the HSTU-R is during C-TONES. C-TONES must retain enough signal characteristics to be detectable by legacy HSTU-R yet have a signal characteristic that indicates the HSTU-C is prepared to respond to VDSL optional band usability and downstream directionality.

A new signal C-TONES-UP is defined that has identical characteristics to C-TONES except that it is amplitude modulated. The period of modulation is 16 ms of amplitude at 1.2 times nominal power followed by 16 ms of 0.75 times nominal power. Other amplitudes, periods and characteristic modifications may be used as long as C-TONES-UP retains characteristics so as to be detectable as C-TONES by legacy G.hs equipment.

An HSTU-C may transmit C-TONES-UP instead of C-TONES (in Figure 2) to indicate to the HSTU-R that it may use the VDSL optional band for upstream transmission during handshake. If the HSTU-R has the optional band upstream transmission capability it must respond using the upstream carriers for A43 or C43 (See Table 2). If it does not have G.vdsl optional band upstream capability, it "NAKS" by responding in a method such as proposed in section 3.2.1 or 3.2.2. The various scenarios are outline below.



$\tau_1 < 500$ ms

50 ms $< \tau_2 <$ 500 ms

Figure 2 HSTU-R initiated duplex start-up procedure

HSTU-R initialization procedure (both HSTU-R and HSTU-C implement C-TONES-UP):

- HSTU-R transmits R-TONES-REQ by some way such as section 3.2.1 or 3.2.2.
- HSTU-C responds with C-TONES-UP
- HTSU-R transmitsR-TONE1 using G.992.1 ANNEX A/C carrier frequencies instead of modulation used to transmit R-TONES-REQ.
- Handshake progresses as in legacy procedures using legacy modulation.

HSTU-R initialization procedure (only HSTU-C implements C-TONES-UP):

- HSTU-R transmits R-TONES-REQ using legacy modulation for non-VDSL or by section 3.2.1 or 3.2.2 for VDSL .
- HSTU-C responds with C-TONES-UP
- HTSU-R transmitsR-TONE1 using legacy modulation for non-VDSL or by section 3.2.1 or 3.2.2 for VDSL .
- Handshake progresses with legacy procedures but non-legacy modulation for VDSL.

HSTU-C initialization procedure (both HSTU-R and HSTU-C implement C-TONES-UP):

- HSTU-C sends C-TONES-UP
- HTSU-R transmitsR-TONE1 using G.992.1 ANNEX A/C carrier frequencies
- Handshake progresses as in legacy procedures using legacy modulation.

HSTU-C initialization procedure (only HSTU-C implements C-TONES-UP):

- HSTU-C sends C-TONES-UP
- HTSU-R transmitsR-TONE1 using legacy modulation for non-VDSL or by section 3.2.1 or 3.2.2 for VDSL .
- Handshake progresses with legacy procedures but non-legacy modulation for VDSL.

Table 5 Upstream method highlights

Method in Section	Upstream Spectrum (kHz)	Modulation	Power	ADSL compatibility
3.2.1	3750 to 5100	DPSK	Full Power	Spectrum - no
3.2.2	25- 138	Spread Spectrum	Reduced Power	Spectrum - Yes: Modulation - no
3.2.3	25- 138	DPSK	Full Power	Full

4 Summary:

This section, **is required**, and in addition to summarizing the points of your paper it shall contain:

1. This paper will be presented in G.hs but will also be discussed in G.vdsl

2. Expectations:
   - Discuss the paper, possibly in Ad Hoc
   - Receive feedback on the priorities for which components should be reused in G.hs and how the G.vdsl optional band may be used during G.hs (especially if different than SHOWTIME).